Handbook & Selection Guide for Computer-Based Data Acquisition & Control Systems

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NEFF INSTRUMENT CORPORATION

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Summary of Neff Products

Low-Level Multiplexed Systems

Model	Max. Channels	Aggregate Throughput	Computer Interface
System 470	512 analog	10KHz	SCSI, GPIB or Ethernet

Amplifier-Per-Channel Multiplexed Systems

Model	Max. Channels	Aggregate Throughput	Computer Interface
System 620 / Series 600*	512	100KHz	SCSI or Parallel
System 471 w /471058 Isolated Amplifier	1024	10KHz	SCSI or GPIB
System 472 w /472060 Preamplifier	2048	50KHz	SCSI, GPIB or Ethernet

* Requires System 620 /Series 500 Measurement and Control System

Summary of Neff Products (Continued)

Amplifier-Per-Channel Non-Multiplexed Systems (continuous recording)

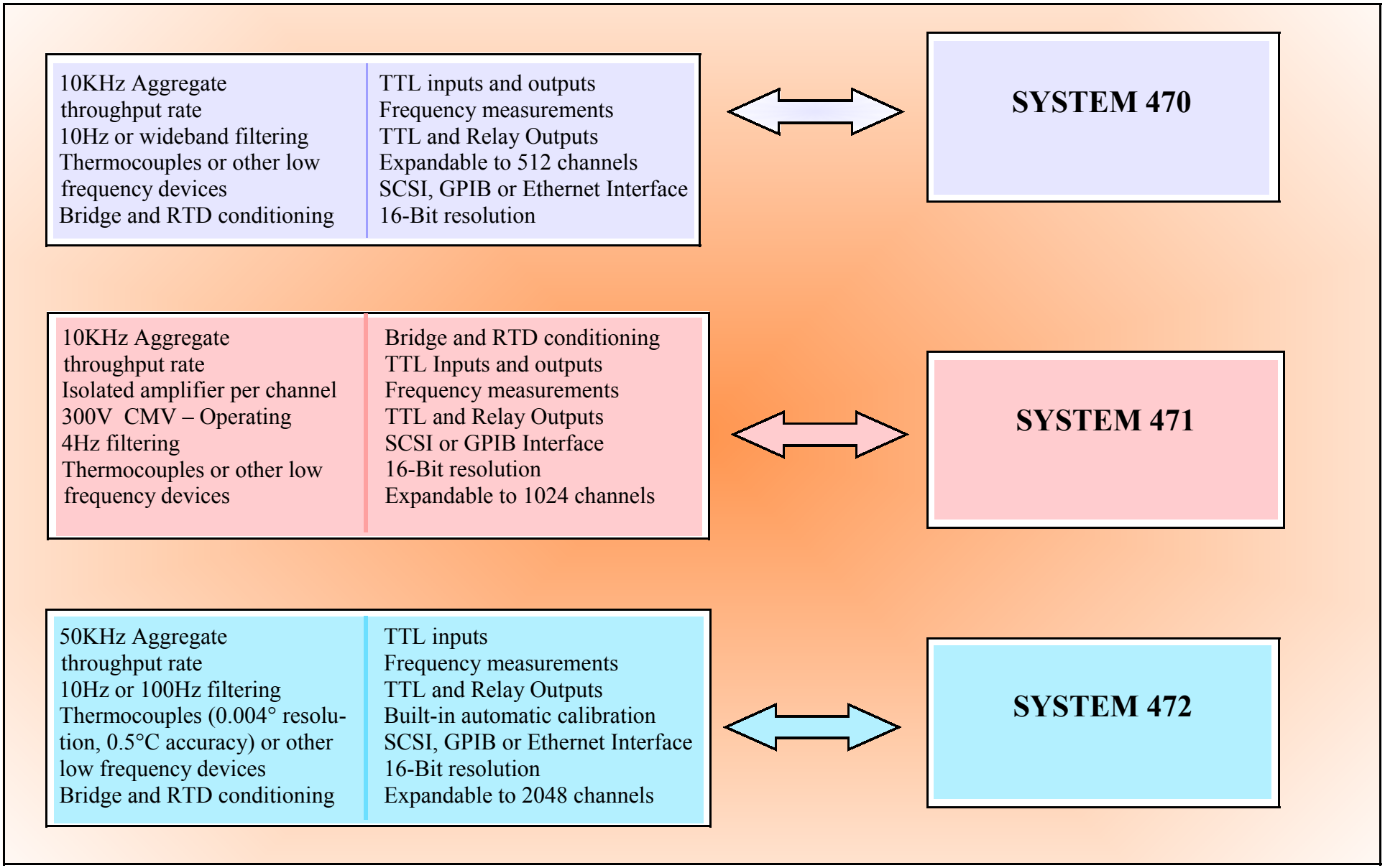
Model	Max. Channels	Aggregate Throughput	Computer Interface
System 730	512	2MHz	SCSI

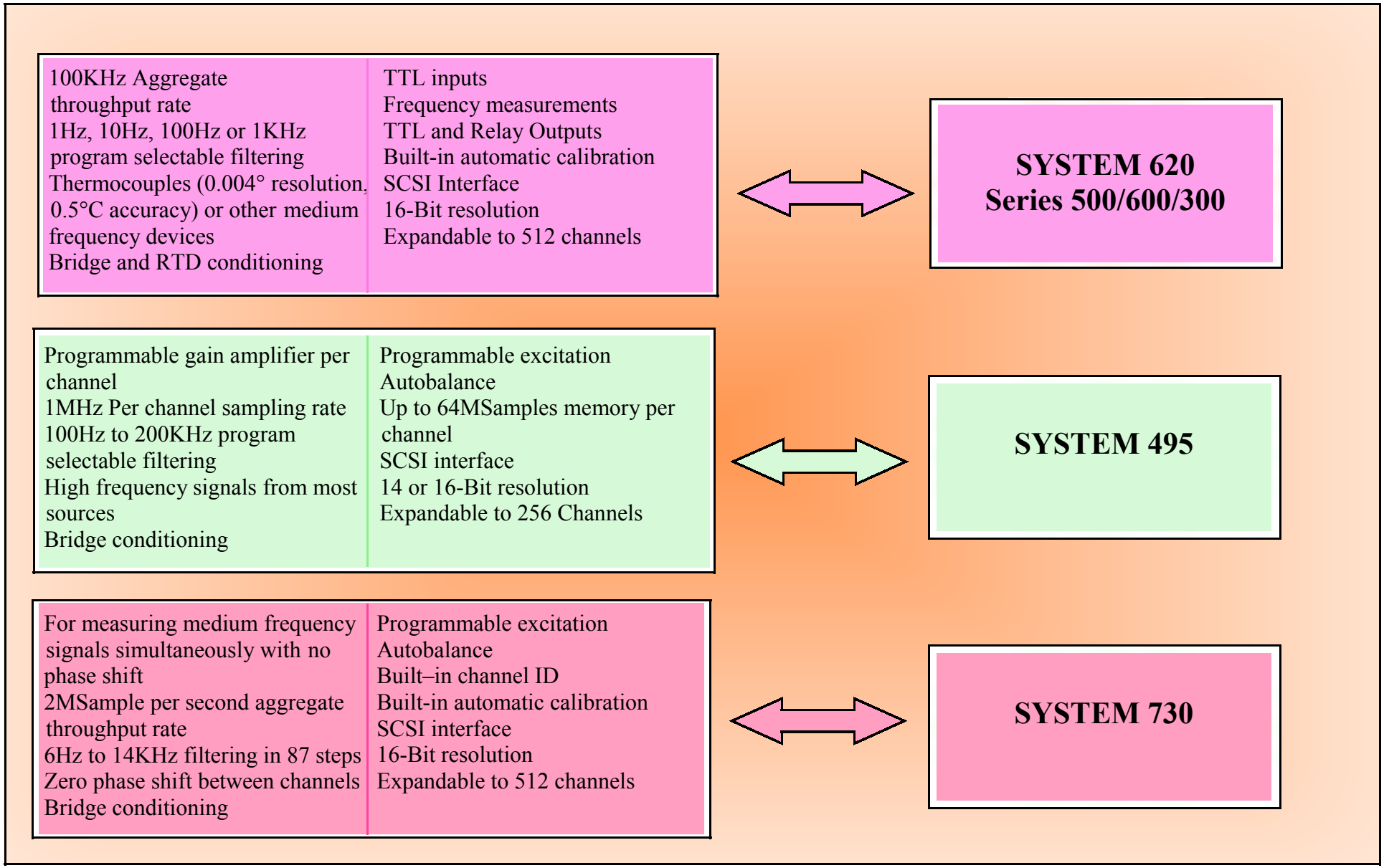
Transient (high speed) Systems

Model	Max. Channels	Max. Channel Sample Rate	Max. On-Board Storage	Computer Interface
System 495	256	1MHz	64MSamples/channel	SCSI, GPIB

Transducer Conditioning (Stand alone)

Model	Comments
System 620/Series 300	General purpose conditioning with constant voltage, constant current excitation, bridge completion, shunt and R-Cal
System 470, 471, 495 and 730	These systems include transducer conditioning without additional hardware.


10KHz Aggregate throughput rate
10Hz or wideband filtering
Thermocouples or other low frequency devices
Bridge and RTD conditioning
TTL inputs and outputs
Frequency measurements
TTL and Relay Outputs
Expandable to 512 channels
SCSI, GPIB or Ethernet Interface
16-Bit resolution
SYSTEM 470
10KHz Aggregate throughput rate
Isolated amplifier per channel
300V CMV – Operating
4Hz filtering
Thermocouples or other low frequency devices
Bridge and RTD conditioning
TTL Inputs and outputs
Frequency measurements
TTL and Relay Outputs
SCSI or GPIB Interface
16-Bit resolution
Expandable to 1024 channels
SYSTEM 471
50KHz Aggregate throughput rate
10Hz or 100Hz filtering
Thermocouples (0.004° resolution, 0.5°C accuracy) or other low frequency devices
Bridge and RTD conditioning
TTL inputs
Frequency measurements
TTL and Relay Outputs
Built-in automatic calibration
SCSI, GPIB or Ethernet Interface
16-Bit resolution
Expandable to 2048 channels
SYSTEM 472


100KHz Aggregate throughput rate
1Hz, 10Hz, 100Hz or 1KHz program selectable filtering
Thermocouples (0.004° resolution, 0.5°C accuracy) or other medium frequency devices
Bridge and RTD conditioning
TTL inputs
Frequency measurements
TTL and Relay Outputs
Built-in automatic calibration
SCSI Interface
16-Bit resolution
Expandable to 512 channels
SYSTEM 620
Series 500/600/300
Programmable gain amplifier per channel
1MHz Per channel sampling rate
100Hz to 200KHz program selectable filtering
High frequency signals from most sources
Bridge conditioning
Programmable excitation
Autobalance
Up to 64MSamples memory per channel
SCSI interface
14 or 16-Bit resolution
Expandable to 256 Channels
SYSTEM 495
For measuring medium frequency signals simultaneously with no phase shift
2MSample per second aggregate throughput rate
6Hz to 14KHz filtering in 87 steps
Zero phase shift between channels
Bridge conditioning
Programmable excitation
Autobalance
Built–in channel ID
Built-in automatic calibration
SCSI interface
16-Bit resolution
Expandable to 512 channels
SYSTEM 730

System 470

Parameter/Prod	Signal Bandwidth	MAX Sample Rate — Aggregate or Per Channel	Amplifier Per Channel	Built-in Calibration	Programmable or Fixed Filter	On-Board Memory	Bridge and RTD Conditioning	Comments
System 470	10Hz	10KHz Aggreg.	No	No	Fixed 10Hz	Ping-Pong	Yes	
470010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Digital Input
470011	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Digital Input
470012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Frequency In
470013	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Digital I/O
470014	N/A	N/A	N/A	N/A	N/A	N/A	N/A	ARINC-429
470015	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Frequency In
470030	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Digital Output
470031	N/A`	N/A	N/A	N/A	N/A	N/A	N/A	Relay Output
470050	10Hz	10KHZ Aggreg	No	No	Fixed Filter	No	No	16-Chl Mux
470051	10Hz	10KHz Aggreg	No	No	Fixed Filter	No	No	Mux w/open source
470052	10Hz	10KHZ Aggreg	No	No	Fixed Filter	No	No	4-20mA
470054	10Hz	10KHz Aggreg	No	No	Fixed Filter	No	Bridge Cond.	4-Channel
470055	10Hz	10KHz Aggreg	No	No	Fixed Filter	No	RTD Cond	4-Channel
470056	10Hz	10KHz Aggreg	No	No	Fixed Filter	No	N/A	1000V CMV
470070	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Analog Output 2-Chl 16-Bit
470071	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Analog Output 16-Chl 12-Bit
470081	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Isothermal Connector
470085	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Calibration Card
470104	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Control Panel

System 471

Parameter/Prod	Signal Bandwidth	MAX Sample Rate — Aggregate or Per Channel	Amplifier Per Channel	Built-in Calibration	Programmable or Fixed Filter	On-Board Memory	Bridge and RTD Conditioning	Comments
System 471	4Hz	10KHz Aggreg.	Yes	No	Fixed 4Hz	Ping-Pong	Yes	
470010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Digital Input
470011	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Digital Input
470012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Frequency In
470013	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Digital I/O
470015	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Frequency In
470030	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Digital Output
470031	N/A`	N/A	N/A	N/A	N/A	N/A	N/A	Relay Output
470058	4Hz	10KHz Aggreg	Yes – Prog Gain	No	Fixed 4Hz	No	Yes	4-Chl 300V CM
470070	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Analog Output 2-Chl 16-Bit
470071	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Analog Output 16-Chl 12-Bit
470085	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Calibration Card
471104	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Control Panel

System 472

Parameter/Prod	Signal Bandwidth	MAX Sample Rate — Aggregate or Per Channel	Amplifier Per Channel	Built-in Calibration	Programmable or Fixed Filter	On-Board Memory	Bridge and RTD Conditioning	Comments
System 472	10Hz, 100Hz	50KHz Aggreg.	No	No	Fixed 10Hz, 100Hz	Ping-Pong	Yes	
472010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Digital Input
472011	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Digital Input
472012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Frequency In
472013	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Digital I/O
472015	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Frequency In
472030	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Digital Output
472031	N/A`	N/A	N/A	N/A	N/A	N/A	N/A	Relay Output
472052	10Hz	10KHZ Aggreg	No	No	Fixed,10Hz	No	No	4-20mA
472060	10Hz	50KHz Aggreg	Yes – Prog. Gain	Yes	Fixed, 10Hz	No	No	16-Chl
472064	100Hz	50KHZ Aggreg	Yes – Prog. Gain	Yes	Fixed, 100Hz	No	No	16-Chl
472070	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Analog Output 2-Chl 16-Bit
472071	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Analog Output 16-Chl 12-Bit
472081	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Isothermal Connector
472104	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Control Panel

System 495

Parameter/Prod	Signal Bandwidth	MAX Sample Rate — Aggregate or Per Channel	Amplifier Per Channel	Built-in Calibration	Programmable or Fixed Filter	On-Board Memory Per Channel	Bridge and RTD Conditioning	Comments
System 495	To 200KHz	1MHz Per Chl	Yes	No	Programmable	To 64MS/Chl	Bridge	
495070	To 200KHz	250KHz Per Chl	Yes	R-Shunt	Programmable	1MSample	Bridge	Auto-balance
495071	To 200KHz	250KHz Per Chl	Yes	R-Shunt	Programmable	16MSample	Bridge	Auto-balance
495072	To 200KHz	250KHz Per Chl	Yes	R-Shunt	Programmable	32MSample	Bridge	Auto-balance
495073	To 200KHz	250KHz Per Chl	Yes	R-Shunt	Programmable	64MSample	Bridge	Auto-balance
495080	To 200KHz	1MHz Per Chl	Yes	R-Shunt	Programmable	1MSample	Bridge	Auto-balance
495081	To 200KHz	1MHz Per Chl	Yes	R-Shunt	Programmable	16MSample	Bridge	Auto-balance
495082	To 200KHz	1MHz Per Chl	Yes	R-Shunt	Programmable	32MSample	Bridge	Auto-balance
495083	To 200KHz	1MHz Per Chl	Yes	R-Shunt	Programmable	64MSample	Bridge	Auto-balance

System 620

Parameter/Prod	Max Signal Bandwidth	MAX Sample Rate — Aggregate or Per Channel	Amplifier Per Channel	Built-in Calibration	Programmable or Fixed Filter	On-Board Memory	Bridge and RTD Conditioning	Comments
System 620								
Series300	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Transducer Cond
620300	N/A	N/A	N/A	N/A	N/A	N/A	Exc Supply	V or I
620350	N/A	N/A	N/A	N/A	N/A	N/A	Exc. Regulators	4 – Channels
620360	N/A	N/A	N/A	N/A	N/A	N/A	Bridge Mode Cd	1 – Channel
620361	N/A	N/A	N/A	N/A	N/A	N/A	RTD Mode Cd	1 – Channel
Series 600	1KHz	100KHz Aggreg	Yes	Yes	N/A	No	No	Control Assy
620650	1KHZ	N/A	Yes – Prog Gain	Yes	Prog. 2-Pole	No	No	4 – Channel
620654	1KHz	N/A	Yes – Prog Gain	Yes	Prog. 6-Pole	No	No	4 – Channel
Series 500	N/A	300KHz Aggreg	N/A	N/A	N/A	N/A	N/A	Controller
620530	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Digital Output
620531	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Relay Output
620534	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Clock
620540	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Analog Output
620541	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Isol Analog Out
620560	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Digital Input
620561	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Isol DC Sense
620562	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Frequency Card
620563	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Isol Dig Latch
620564	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Isol Dig Input

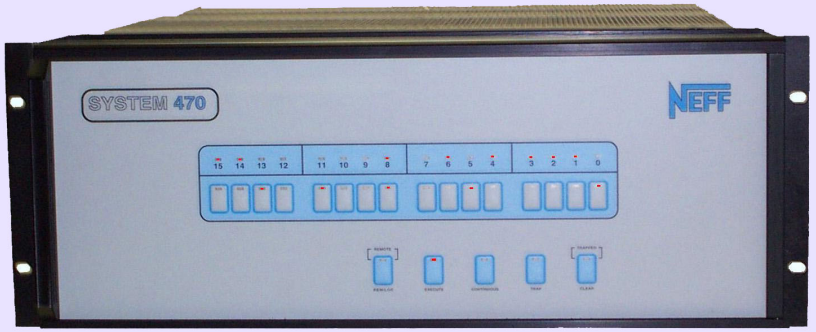
System 730

Parameter/Prod	Max Signal Bandwidth	MAX Sample Rate — Aggregate or Per Channel	Amplifier Per Channel	Built-in Calibration	Programmable or Fixed Filter	On-Board Memory	Bridge and RTD Conditioning	Comments
System 730		2MS/Sec Aggreg	Yes	Yes	Programmable	Ping-Pong	Yes	
730060	14KHz	37KHz/Chl	Yes	Yes	Programmable 108 Steps Digital Filter	No	Bridge Conditioning	Zero phase shift between channels
730011	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Digital Input

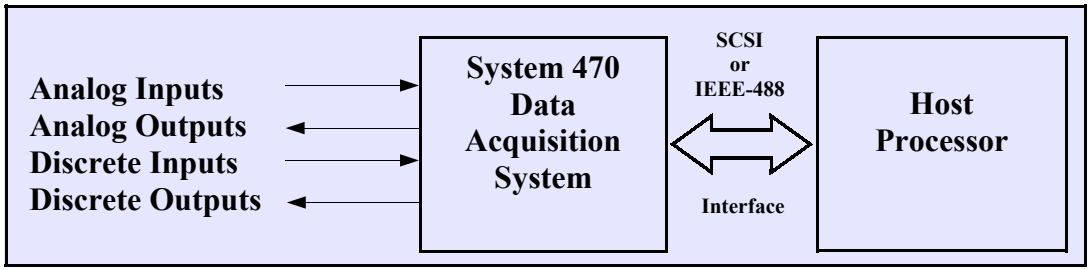
Section II

System 470

Data Acquisition System



System 470 Data Acquisition System



- o Low-Level Multiplexed System
- o 256 Analog Inputs; Expandable to 512
- o Throughput Rates to 10 KHz
- o Fully Guarded Differential Inputs
- o Analog and Digital Function Cards
- o 10 Megohm Input Impedance, Power On or Off
- o 16-Bit Resolution Including Sign
- o Full scale Inputs from ±5 mV to ±10.24 V
- o Voltage Insertion Calibration
- o SCSI, IEEE-488 or Ethernet Interface

Introduction

The Neff System 470 Data Acquisition System is a complete moderate-speed data acquisition system for use in computer-based applications. The System 470 is designed primarily for computer automated data acquisition in test facilities, laboratories, and industrial plants or wherever a moderate-speed data acquisition system is required.

The System 470 is designed to accept analog inputs ranging from ±5 mV to ±10.24 V full scale. Sensors such as strain gauges, RTDs, potentiometers and thermocouples can be input directly to one of the System 470 function cards thus eliminating any need for external signal conditioning.

System 470 consists of a seven-inch high, 19-inch wide enclosure with power supply, backplane wiring, I/O Control Logic printed circuit card, Analog Subassembly printed circuit card, and 16 I/O card slots that accept any combination of System 470 function cards. A Control/Display panel is optional and an expansion assembly is available to extend function card capacity to 32. The maximum number of channels or data points to be serviced depends on the type of function cards used. Thirty-two 16-channel Multiplexer cards, for example, provide 512 channels of analog input while a full complement of
32-bit TTL Input cards accommodate 1024 single data points.
Most analog input cards have filters to reject superimposed noise and unwanted signal frequencies. The filtered signals are multiplexed onto the analog function card bus by CMOSFET switch packages.

System 470 Data Acquisition System (Continued)

Function Cards

470010 32-Bit TTL Input
470011 16-Bit Isolated Digital Input
470012 Two Channel Frequency or Period Input
470013 32-Bit TTL Input/Output
470014 ARINC - 429 Controller
470015 2-Chl Wide Range Frequency or Period Input
470030 32-Bit TTL Output
470031 Eight-Point Form-C Relay Output
470032 Scanivalve Controller
470050 16-Channel Differential Multiplexer
470051 16-Channel Differential Multiplexer with Open Source Detection
470052 16-Channel Differential Multiplexer with Conditioning for 4-20mA Input
470054 Four-Channel Bridge Conditioning
470055 Four-Channel RTD Conditioning Multiplexer
470056 16-Channel Transformer-Coupled Multiplexer
470059 16-Channel Mux, Direct Input
470070 Two-Channel 16-Bit DAC Output
470071 16-Channel 12-Bit DAC Output
470085 Calibration Card

Front Access to all Cards

Function cards are accessed by opening the hinged front panel and can be changed or moved without disturbing I/O cabling. All I/O connections are made at the rear panel of the system. Both solder type and screw type input connectors are available.

Guarded Input

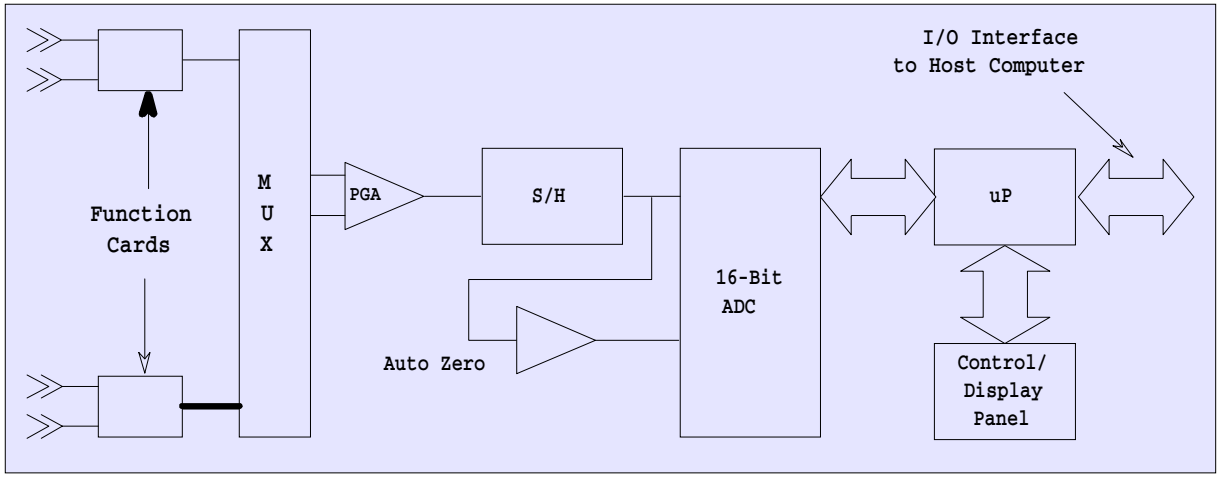
The input guard environment--containing the function cards, input programmable gain amplifier (PGA), associated address logic, and input power supply--is driven at a common-mode potential derived from the input signal. This technique provides 120 dB common mode rejection without shields. The common mode potential is taken from the input signal by an amplifier having very high input impedance to ensure that common mode impedance is not degraded. Digital addresses, gain codes, and control signals are optically coupled to maintain high common mode isolation.

Programmable Gain Amplifier

The multiplexed analog input signals are applied to the PGA. This is a differential amplifier set to a gain of either 1 or 64 by the decoded gain bits of the input control word and located within the input guard environment to enhance common mode rejection.

A second-stage differential amplifier, with gains of 1, 2, 4, 8, 16, or 32 (programmed simultaneously with the PGA) is responsible for maintaining common mode isolation. Overall system gain is the product of the gain of the two amplifiers. Input ranges of ±5 mV to ±10.24 V can be individually programmed for each channel.

System 470 Data Acquisition System (Continued)



Post Filter

Sample rates of 1 KHz or 10 KHz are switch selectable. As the sampling rate is changed, the post filter adjusts the bandwidth to minimize output noise and optimize performance at each sample rate. Aggregate throughput rate is controlled by programming the scan period.

Sample & Hold

For accurate conversion of the input signal, a sample and hold amplifier is positioned ahead of the analog-to-digital converter. At a fixed time in the conversion cycle, the amplifier switches to hold mode to provide a constant input to the ADC.

Auto-Zero

An automatic zero circuit compensates for zero offset error generated by the PGA or sample and hold amplifiers. The circuit tracks the output of the sample and hold amplifier and generates an equal and opposing voltage that is effectively subtracted from the sample and hold output voltage for input to the ADC.

Internal I/O Bus

A 16-bit internal I/O bus interconnects the ADC, digital I/O serial-to-parallel converter, and the microcomputer. Two connectors are used to extend the internal I/O bus to an expansion assembly and another links the bus to the optional Display/Control panel.

Operating Modes

System 470 provides two basic data acquisition operating modes to read input data:

1. Single Buffer Mode
2. Continuous or "Ping-Pong" Buffer Mode

In addition, an output mode is provided to output data from the system.

Each data buffer is "stamped" with the current real-time (or scan time being kept by the firmware). Mode usage will depend on host computer capability, the interface used, and the application requirements. Following are basic mode descriptions.

Single Buffer Mode. The single buffer mode of data acquisition is a start-stop synchronous configuration wherein the host computer initiates each data acquisition cycle.

Initially, the host computer downloads a channel scan list to System 470. The scan list consists of the channel numbers of the devices to be read (function cards) as well as the PGA gain codes required for analog input channels. The scan list defines one scan or pass through the block of input channels to be read.

The host computer then defines a number of scans to be run and a scan period that determines the rate at which the scans are initiated. System 470 then partitions a data buffer area in RAM for storing the returned data.

After this initial setup phase, the host computer issues a start command to System 470 to begin. System 470 executes the specified number of scans and places the resultant data into the data buffer. When the last data word has been loaded into the data buffer, System 470 halts further data acquisition and signals the host that the data buffer is ready. The host reads the data buffer and may then issue a go-again command to repeat the cycle.

The single buffer mode is adequate for many applications. Because the host starts each data acquisition cycle, there is no danger that it will be overrun. However, there are gaps in the data while System 470 is waiting for the host to read the data buffer. Maximum data sampling rate is also limited by the time required for the host to read the data buffer.

Ping Pong Buffer Mode. The Ping Pong mode of operation permits faster sample rates by overcoming the timing limitations of the single buffer mode. In this mode, System 470's RAM is partitioned into two data buffers. A/D data and digital data are returned to one data buffer. When that buffer is filled, System 470 signals the host that the buffer is ready. Without waiting for the host to read the buffer, System 470 loads the uninterrupted input data into the second buffer. The host can transfer the data from the first buffer at any time prior to the completion of the second buffer or it may choose to ignore a buffer and allow it to be overwritten by subsequent data. Because of the time stamping feature, data integrity is maintained even when buffers are skipped.

Output Mode. Output lists, defining control functions to be output by System 470, are block transferred from the host to the System 470. The system's microcomputer executes the list immediately or, if a scan list is in progress, when the current scan is completed.

32 Bit TTL Input - 470010

This card reads 32 bits of input TTL data

as two groups of 16 bits each. A Hold output signal handshakes with the device being read. Hold is a 10 uS pulse of selectable polarity asserted when either 16-bit group is to be read. This feature is especially useful when reading digitally-coded levels from a counter, DVM, clock, etc., which, if read in its transitional state, would result in ambiguous data.

An Enable input allows the user to decide when to update the card's input register.

All inputs and outputs interface with either standard or low power TTL logic. Jumper wires select positive true or negative true logic levels.

Specifications

Inputs	
High-Level Input Voltage:	2.0 V min; 5.0 V max
Low-Level Input Voltage:	0.0 V min; 0.8 V max
High-Level Input Current:	20 uA max
Low-Level Input Current:	- 400 uA max
Enable:	1000 ohm pull-up resistor
Outputs	
High-Level Output Voltage:	5.25 V max
Low-Level Output Voltage:	0.4 V max
High-Level Output Current:	250 uA max
Low-Level Output Current:	40 mA max

16 - Bit Isolated AC/DC Input - 470011

The 16-Point AC/DC Input card provides isolated inputs for 16 channels with voltage levels from 12 V to 48 V, ac or dc. Inputs are read as a 16-bit digital word with positive-true or zero-true logic selected by jumper placement. Up to 1000 V common mode can be applied between inputs and ground.

Specifications

Input Current:	21 mA @ 48 V 8.1 mA @ 24 V 1.4 mA @ 12 V
Common Mode Voltage:	1000 V max
Response Time:	50 mS

32 Bit TTL Input/Output - 470013

The 32-Point TTL Input/Output card provides a 32-bit TTL level bus for user definition. The bus is divided into four bytes, each of which may be programmed separately as either input or output.

Output data is loaded in word form. Writing to Channel 08 will load output data into output bytes 0 and 1, where byte 0 is equivalent to bits 0-7 and byte 1 is equivalent to bits 8-15. Writing to Channel 09 will load output data into output bytes 2 and 3.

Specifications

Inputs:

High Level Vin:	3.15 V min, 5 V max
Low Level Vin:	-1.5 V min, - 0.9 V max

Outputs:

High Level V_{out}:	2.4V min
High Level I_{out}:	-2.6 mA max
Low Level V_{out}:	0.5V max
Low Level I_{out}:	24 mA max

Frequency, Period and Counter Input

Two-Channel Frequency or Period Input 470012

The Two-Channel Frequency or Period Input card accommodates inputs from tachometers, flowmeters, or other frequency-related devices. Frequency or period measurements or straight event counting are selectable by switches on the card.

For flexibility, each channel accepts two types of inputs. One set of input terminals, for TTL logic levels, is optically coupled. The other input is intended for use with signal levels that vary with frequency. An event zero-crossing detector accepts inputs from ±200 mV to ±100 V at frequencies to 100 KHz.

A crystal-controlled clock provides accurate time bases for measurements on both channels while each channel has its own 32K counter. After each measurement, the counter is reset. Frequency measurement involves counting the number of input pulses occurring between clock pulses.

By means of manual switches on each channel, the user can select measurement mode, clock frequency, and select counting to occur on the leading or trailing edge of an input pulse.

Specifications

Accuracy

Frequency Mode: ±0.01% Of reading ±1 count

Period Mode: ±0.01% of reading ± input risetime (0.6 to 4 V) transition)

Ranges

Mode	Time Base	FS Range	Resolution (1 count =)
Frequency	0.1 sec 1 Sec 10 Sec	327 KHz 32.7 KHz 3.27 KHz	10 Hz 1 Hz 0.1 Hz
Period	100 KHz 10 KHz 1 KHz	327 mSec 3.27 Sec 32.7 Sec	10 µSec 100 µSec 1.0 mSec
Count	Counts 0 to 32767		

Isolated TTL Input

Input Voltage: ±5.25 V max
Sink Current: 16 mA max
Common Mode: ±300 V max
Frequency: dc to 350KHz

Non-isolated Input

Input Voltage: ±200 mV min; ±100 V max
Input Impedance: 50KOhms
Frequency: dc to 100 KHz

Frequency, Period and Counter Input (Continued)

Two-Channel Frequency or Period Input 470015

The Two-Channel Frequency or Period Input card accommodates inputs from tachometers, flowmeters, or other frequency-related devices. Operating modes include frequency measurement, period measurement and pulse counting. Selection of mode, clock frequency, number of periods included in the measurement and desired polarity are all programmable.

For flexibility, each channel accepts two types of inputs. One set of input terminals, for TTL logic levels, is optically coupled. The other input is intended for use with signal levels that vary with frequency. An event zero-crossing detector accepts inputs from ±100 mV to ±100 V at frequencies to 100 KHz.

Frequency Mode

Gate Time	Range*	Resolution
1.0 Sec	8.388607 MHz	1.0 Hz
10.0 Sec	838.8607 KHz	0.1 Hz

*Theoretical full-scale range. Limited by input response.

Event Counter Mode

Full scale range, 8,388,607

Period Mode

Clock Frequency	Periods	Range	Resolution
10.0 MHz	1	838.87 mSec	100 ηSec
10.0 MHz	10	83.887 mSec	10 ηSec
1.0 MHz	1	8388.7 mSec	1 µSec

Specifications:

Accuracy:

- **Internal Time Base:** 0.01% of nominal
- **Frequency Mode:** 0.01% of reading ±1 count.
- **Period Mode:** 0.1% of reading to 100mS.
  0.01% of reading to 1.0mS
- **Event Counting Mode:** ±1 count

Input Characteristics:

- **Isolated TTL Input:**
  - **Input Voltage:** ±5.25V, maximum
  - **Sink Current:** 16mA, maximum
  - **Common-mode:** ±300V, maximum
  - **Frequency Range:** dc to 350 KHz
- **Level Detector Input:**
  - **Input Voltage:** 100 mV, minimum to 100V, max.
  - **Frequency Range:** dc to 100KHz

Controller Cards

ARINC-429 Controller
470014

ARINC-429 Controller, 470014, is used to interface the System 470 to the ARINC-429, Mark 33 Digital Information Transfer System (DITS) bus. It mounts in a standard System 470 function card slot and provides 4 receiver and 4 transmitter channels for communication with compatible devices.

Features;

* Four receiver channels
* Four transmitter channels
* Received data sorted by Label
* Data packet for interdependent Labels
* Received data read by 470 scan list
* SDI support
* Both fast and slow bit rates supported

Discrete Output Cards

32-Bit TTL Output--470030

The 32-Bit TTL Output card provides two 16-bit outputs for driving TTL-compatible loads or other loads not exceeding output capability (30 V maximum; 40 mA maximum). Dual-rank registers permit the simultaneous updating of all outputs.

All outputs are open-collector gates with pull-up resistors to the internal 5 V supply for driving standard TTL or 5 V CMOS loads. Placement of a jumper permits use of an external voltage source up to 28 V. Outputs can then interface to high voltage CMOS logic or be used to drive relay coils, lamps, or other loads not exceeding 40 mA.

Output polarity of each group of eight outputs is determined by jumper placement. This allows the user to arrange logic polarity to any desired power-up/reset condition required by the application.

Specifications

Open Circuit Voltage:	+30 V max
Sink Current:	-40mA max

Eight-Point Form-C Relay Output--470031

The Eight-Point Form-C Relay Output card provides eight three-wire form-C outputs (normally open, normally closed, and common) to drive various control devices. Each relay has a "set" and "reset" coil and is magnetically latches in its current state at power down. Eight control bits are used to address and control the relays individually. Dual-rank registers permit simultaneous updating of all relay states.

Specifications

Initial Contact Resistance:	30 milliOhm, max
Maximum Contact Switching Power:	2000 VA, 150 W (resistive)
Maximum Switching Voltage:	250 VAC
Maximum Switching Current:	8 Amperes
Breakdown Voltage:	1000 V between open contacts, 1000 V between contacts and ground
Set/Reset Time:	8 ms (approximately)

16-Channel Differential Multiplexer Cards

System 470 offers four types of Differential Multiplexer cards. Three feature input filter, CMOS/FET multiplexer switch and 16 different inputs. Input ranges from ±5 mV to ±10.24 V full scale.

Card 470050 is the basic differential multiplexer; the others offer alternate input configurations. Card 470051 provides open source detection, 470052 is equipped with shunt resistors for measuring 4-20 mA inputs, 470059 has direct input (w/o filter).

Except for 470059, the cards are equipped with two-pole, passive R-C filters having a terminal rolloff of 12 dB/octave. The -6 dB corner frequency of 10 Hz provides greater than 25 dB attenuation of input noise components at the 60 Hz power line frequency.

The open source detection feature recognizes open thermocouples, broken wires and high resistance or open input connections. A 10 nA current is output at the channel input terminals causing an overload indication (off scale) reading if an open or high resistance input circuit is present. Card 470052 has 250 ohm shunt resistors on each channel for sensing 4-20 mA input.

Specifications: (System 470 with 47005X Cards Installed)

Number of Channels: 16 guarded differential input channels per card.Input sources may begrounded or floating.

Input Impedance: 10 MegOhms; power on or off.

Input Filter: Passive RC filter on each channel; 2-pole, low-pass with 12 dB/octave terminal slope; -6dB at 10 Hz and -30 dB at 100 Hz.

Maximum Input Voltage: ±30 V differential or common mode

Common Mode Rejection: 120 dB (80 dB plus gain in dB to 120 dB max); dc to 60 Hz with 350 Ohm source imbalance.

Common Mode Voltage: ±10 V operating.

ADC Resolution: 16-bits, including sign.

Gain Accuracy: ±0.05%.

Gain Stability: ±(0.01% + 0.003%/°C).

Linearity: ±(0.02% + ½LSB).

Static Crosstalk: 120 dB between channels, dc to 1 KHz with 350 ohm source; 10 V maximum non-overloaded input.

Zero Offset: ±10 uV, channel-to-channel.

Zero Stability: ±(5 uV RTI + 1.25 mV RTO)
±(0.5 uV/°C RTI + 0.1 mV/°C RTO).

Noise:

Noise = $[(\text{RTI} \times \text{Gain})^2 + \text{RTO}^2]^{1/2}$

Throughput Rate	RTI	RTO
10 KHz	8.5 uV	1.5 mV
1 KHz	3.7 uV	1.5 mV

Bridge Conditioner/Multiplexer

4 Channel Conditioner/Multiplexer 470054

For bridge measurements using one, two, or four active arms, this card provides a precision excitation supply, balance control, and terminals for bridge completion, balance limit, and calibration resistors on each channel. Bridge completion resistor kits are available, see below.

The card includes multiplexer switches and a standard two-pole RC filter, providing the same performance specifications as the 470050 16-Channel Multiplexer. One step shunt resistor calibration is programmable. Up to eight input leads plus shield can be used, giving the user the option of local or remote sensing.

Specifications - Excitation Supply

Voltage: Selectable; 5 V or 10 V.
Current: 100 mA max/channel; short circuit protected. 3.2 Amperes per control or expansion assembly.
Line Regulation: Less than 0.01% or 200 uV, whichever is greater, for ±10% line voltage variation.
Load Regulation: Less than 0.01% or 200 uV,whichever is greater, for a no-load to full load change.
Stability: ±0.01% at constant temperature; ±0.005%/°C.
Noise: Less than 200 uV pk-pk in 10KHz bandwidth.
Bridge Completion: Terminals provided for four completion resistors.
Test Points: Front mounted jacks for monitoring excitation and output voltages.

Bridge Completion Resistor Kits: 350 Ohm or 120 ohm resistor kit: includes three bridge completion and one balance limit resistor.

Specifications - System 470

ADC Resolution: 16-bits, including sign.
Gain Accuracy: ±0.05%.
Gain Stability: ±(0.01% + 0.003%/°C).
Linearity: ±(0.02% + ½LSB).
Static Crosstalk: 120 dB between channels, dc to 1KHz with 350 ohm source; 10 V maximum non-overloaded input.
Zero Offset: ±10 uV, channel-to-channel.
Zero Stability: ±(5 uV RTI + 1.25 mV RTO) ±(0.5 uV/°C RTI + 0.1 mV/°C RTO).
Noise:

$$\text{Noise} = [(\text{RTI} \times \text{Gain})^2 + \text{RTO}^2]^{1/2}$$

Throughput Rate	RTI	RTO
10 KHz	8.5 uV	1.5 mV
1 KHz	3.7 uV	1.5 mV

RTD Conditioner/Multiplexer

Four Channel RTD Conditioner/Multiplexer 470055

The Four Channel RTD Conditioning/Multiplexer provides direct connection of 2, 3, and 4-wire, 100 Ohm RTDs in a balanced bridge configuration. The card can be configured by jumper placement to accommodate current-excited 4-wire RTDs of values to 1 KOhm.

The card includes multiplexer switches, 10 Hz filter, and excitation source adjustment for each channel. Excitation current is 0.5 mA in the bridge configuration, or 1 mA in the constant current configuration, resulting in very low self-heating errors in the RTDs.

Specifications - Excitation Supply

Current: 1.0 mA adjustable +/- 1%
Compliance Voltage: 0 to 3.5 Volts
Line Regulation: Less than 0.01% or 0.1mA, for a ±10% line voltage variation.
Response Time: Output settles to within 1% of setting in less than 50uSec with a no-load to full-load change.
Stability: ±0.01% at constant temperature; ±0.005%/°C.
Output Impedance: 1 MegOhms minimum
Ripple: Less than 0.2uA peak-to-peak over the bandwidth dc to 1KHz.

Test Points: Front mounted jacks for monitoring excitation and output voltages.

Specifications - System 470

ADC Resolution: 16-bits, including sign.
Gain Accuracy: ±0.05%.
Gain Stability: ±(0.01% + 0.003%/°C).
Linearity: ±(0.02% + ½LSB).
Static Crosstalk: 120 dB between channels, dc to 1 KHz with 350 ohm source; 10 V maximum non-overloaded input.
Zero Offset: ±10 uV, channel-to-channel.
Zero Stability: ±(5 uV RTI + 1.25 mV RTO) ±(0.5 uV/ °C RTI + 0.1 mV/°C RTO).

Noise:

$$\text{Noise} = [(\text{RTI} \times \text{Gain})^2 + \text{RTO}^2]^{1/2}$$

Throughput Rate	RTI	RTO
10 KHz	8.5 uV	1.5 mV
1 KHz	3.7 uV	1.5 mV

High Common Mode Voltage Multiplexer

16 Channel Transformer Coupled Multiplexer 470056

The Transformer-Coupled Differential Multiplexer provides 16 channels of analog input for System 470. Each channel is galvanically isolated from other channels and from ground. Common mode voltages of up to ±1000 V are rejected.

Each channel features fully-guarded differential input allowing operation from either grounded or floating input sources. Two-pole, low-pass filters approach 12 dB/octave terminal rolloff on each channel.

Specifications: (System 470 with 470056 Card Installed)

Number of Channels:	16 guarded differential input channels. Input sources may be floating or grounded.
Input Filter:	Passive RC filter on each channel two-pole, low-pass with terminal slope approaching 12 dB/octave; -6 dB at 10 Hz and -30 dB at 100 Hz.
Input Impedance:	5 MegOhms, minimum; power on or off.
Isolation:	Less than 100 pF from any input terminal to ground.
Maximum Input Voltage:	± 30 V differential, without damage.
Common Mode Voltage:	±1000 V dc or peak ac.
Common Mode Rejection:	100 dB + gain in dB to 120 dB max; dc to 60 Hz with up to 350 ohms source imbalance
Full Scale Accuracy:	±0.05% of full scale at constant temperature, ±0.003%/°C.
Linearity:	Less than 0.05% of full scale deviation from best fit straight line through zero and full scale.
Zero Stability:	±(5 uV RTI + 1.25 mV RTO) at constant temperature; ±(0.5 uV/°C RTI ± 0.1 mV/°C RTO).
Zero Offset:	± 10 uV channel-to-channel.
Noise (3 Sigma):	10 uV peak RTI + 1.5 mV RTO.
Resolution:	16-bit resolution; 0.003% FS.
Static Crosstalk:	120 dB between any two channels; dc to 1 KHz.
Dynamic Crosstalk:	110 dB to next channel in scan including over load (up to 30 V input) and full scale range changing.
Sample Rate:	20 samples/second/channel max to meet all specifications, with up to 350 ohm source resistance.

Note: System 470 sample rate must be set to 10 KHz.

Analog Output

Two Channel 16-Bit DAC
470070

The Two Channel DAC Output card provides two channels of analog output from System 470. Each channel consists of a 16-bit digital-to-analog converter (DAC) scaled to deliver ±10.24 V output. Each output can deliver 20 mA of load current with remote sense leads provided to cancel line drops. Dual-rank registers permit simultaneous updating of both channels.

Specifications

Output Voltage: ±10.24 V full scale.

Output Current: ±20 mA.

Accuracy: ±0.02% of full scale.

Stability: ±0.005% of FS at constant temperature; 0.001%/°C over 0 to 50°C.

Resolution: 0.00305% FS/count (1 part in 32,768).

Noise: Less than 500 uV in 10 KHz bandwidth

Sixteen Channel 12-Bit DAC
470071

The 16 Channel DAC Output card provides 16 channels of analog output from System 470. Each channel consists of a 12-bit digital-to-analog converter (DAC) scaled to deliver ±10.24 V output. Each output can deliver 20 mA of load current with remote sense leads provided to cancel line drops.

Specifications

Output Voltage: ±10.24 V full scale.

Output Current: ±20 mA.

Accuracy: ±0.02% of full scale.

Stability: ±0.005% of FS at constant temperature; 0.001%/°C over 0 to 50°C.

Resolution: 0.05% FS/count (1 part in 2,048).

Noise: Less than 500 uV in 10 KHz bandwidth.

I/O Connectors

Screw Terminal I/O Connector 470080

Standard termination of I/O cables is by solder connections to I/O card edge connectors. With the optional screw terminal input card, leads are terminated at "quick plug-in" copper receptacles secured by flush mounted set screws. All terminals are clearly identified for each type of I/O card.

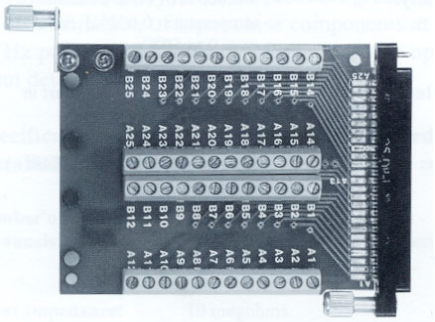
16-Channel Isothermal Connector 470081

The Isothermal Connector provides the means of terminating thermocouple input cables at the rear panel of the System 470. It can be used with any of the following analog input cards.

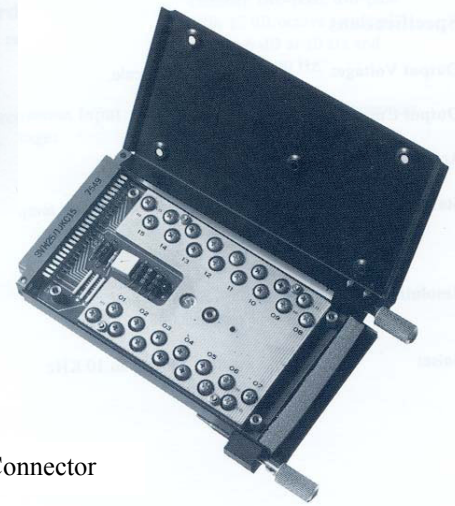
470050 16 Channel Multiplexer
470051 16 Channel Multiplexer with Open Source Detection
470056 16 Channel Transformer-Coupled Multiplexer

The Isothermal Connector plugs directly into the input (edge) connector of the analog input card. Thermocouple cables are brought into 15 sets of screw terminals on the connector, corresponding to multiplexer input channels 1 through 15. A temperature transducer in the connector supplies a reference voltage to channel 0 that is proportional to the termination temperature.

The termination temperature and the type of thermocouple on each channel is the information the CPU requires to convert the thermocouple voltage to temperature. Since the conversion is under control of the CPU, thermocouple types can be mixed.



Screw Terminal Connector



Isothermal Connector

Specifications

Reference Temperature:	1 mV/°C (Channel 00).
Reference Temperature Accuracy:	±0.25°C over the range of 10°C to 45°
Thermocouple Inputs:	Channels 01 through 15.
Temperature Gradient:	0.1°C across terminations.

Calibration Card

Calibration Card
470085

The Calibration Card is a programmable dc voltage source used for calibration of the System 470. It can be installed in any function card connector. The card's output voltage is read through its analog multiplexer and is also output on the user I/O connector for use by external devices.

Output voltage is programmable in three ranges from ±102.4 mV to ±10.24 V full scale. The voltage is derived from an on-board DAC driven by a 15-bit (plus sign) digital word from the host computer. The Calibration Card's address and voltage level is included in the output list formatted by the host and transferred to System 470. The card's address is included in the input scan list to read back the calibration voltage to the system.

Range	Resolution
±10.24 V	312.5 uV
±1.024 V	31.25 uV
± 102.4 mV	3.125 uV

Specifications

Accuracy: ±0.025% FS + 10 uV.

Output Impedance: 50 ohms.

Load Resistance: 500 KOhm minimum for specified accuracy.

System 470 Accessories

Extender Cards
470103

This set of two extender cards is used for calibration and servicing of the printed circuit cards in the system. It allows access to card components and test points under operating conditions.

Control/Display Panel
470104

For normal operation, the front panel's Remote/Local switch is set for remote mode. The Remote indicator is turned on and System 470 operates under control of the host computer. When the Remote/Local switch is pressed again , the indicator turns off and the front panel controls are activated. Local mode is useful for installation, testing, and calibration.

By means of a 16-bit switch register and corresponding LED display, the operator can write addresses and data to the System 470's internal Device I/O bus and read data from the bus. In addition, the user can select continuous scanning or a trap mode in which any channel can be selected for constant monitoring and updating each time the channel is sampled.

System 470 General Specifications

Power Requirements:	105 V to 130 V (220 V to 250 V), 50 to 400 Hz, 250 W.
Environmental Requirements:	0°C to 50°C, 90% relative humidity, non-condensing. Will withstand shock and vibration of normal shipping and handling of laboratory equipment.
Cooling Requirements:	To be mounted in cabinet with unobstructed airflow and equipped with a 300 cfm blower.
Size:	7-inch panel height in 19" rack; 23-inch depth behind front panel. Neff recommends that assemblies be mounted in a 19-inch rack with 30 inch depth to accommodate connector build-up.
Weight:	32 pounds, without function cards installed.

System 470 Ordering Information

Part Number	Description
470100	Input/Control Assembly with IEEE-488 I/O Interface. Includes 16 I/O slots, 16-bit ADC, power supply, Logic Control, and Analog Subassembly cards.
470101	Expansion Input Assembly. Provides 16 additional I/O slots for 470100.
470103	Extender Card Set.
470104	Display/Control Panel for 470100.
470108	SCSI Host Adapter Card – PCI
470110	IEEE-488 Host Adapter Card – PCI, NI
470200	Input/Control Assembly with SCSI I/O Interface. Includes 16 I/O slots, 16-bit ADC, power supply, Logic Control, and Analog Subassembly cards.
470300	Input/Control Assembly with Ethernet I/O Interface. Includes 16 I/O slots, 16-bit ADC, power supply, Logic Control, and Analog Subassembly cards.

Function Cards

Part Number	Description
470010	32-Bit TTL Input.
470011	16-Bit Isolated Digital Input.
470012	Two-Channel Frequency or Period Input.
470013	32-Bit TTL Input/Output.
470014	ARINC -429 Controller
470015	2-Channel Frequency or Period Input Card
470030	32-Bit TTL Output.
470031	Eight-Point Form-C Relay Output.
470032	Scanivalve Controller
470050	16-Channel Differential Multiplexer.
470051	16-Channel Differential Multiplexer with Open Source Detection.
470052	16-Channel Differential Multiplexer with 4-20 mA Input
470054	Four Channel Bridge Conditioning Multiplexer
470055	Four Channel RTD Conditioning Multiplexer
470056	16-Channel Transformer Coupled Multiplexer
470059	16-Channel Differential Mux (Direct Input) w/o Filter
470070	Two Channel, 16-Bit DAC Output
470071	16-Channel 12-Bit DAC

System 470 Ordering Information (Accessories)

Accessories

470080	Screw Terminal Input Connector
470081	15-Channel Isothermal Connector
470085	Calibration Card
470900	Instruction Manual (extra copy, two supplied with system at no charge)
470900	Operation and Maintenance Manual, System 470
470902	Extra System 470 User's Guide

Bridge Completion Resistor Kits

500014	350 Ohm Resistor Kit: Includes three 350 Ohm, .05% resistors for bridge completion, plus one 85KOhm, 0.05% balance limit resistor.
500015	120 Ohm Resistor Kit: Includes three 120 Ohm, .05% resistors for bridge completion, plus one 29KOhm, 0.05% balance limit resistor.

Software

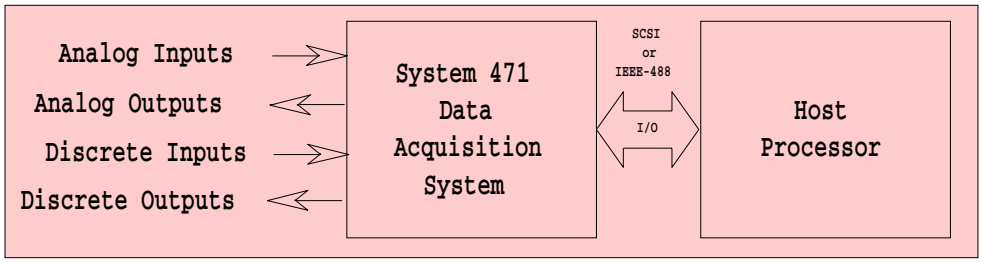
470807	LabVIEW for Windows/470 Demo
470811	WIN470 – SCSI

Section III

System 471

Data Acquisition System

System 471 Data Acquisition System



- o Amplifier - per - Channel Multiplexed System
- o 64 Analog Inputs; Expandable to 1024
- o Throughput Rates to 10 KHz
- o Fully Isolated Differential Inputs
- o Complete Line of Analog and DigitalFunction Cards
- o 10 Megohm Input Impedance
- o 16-Bit Resolution Including Sign
- o Full scale Inputs from ±5 mV to ±10.24 V
- o Voltage Insertion Calibration
- o SCSI or IEEE-488 Interface

Introduction

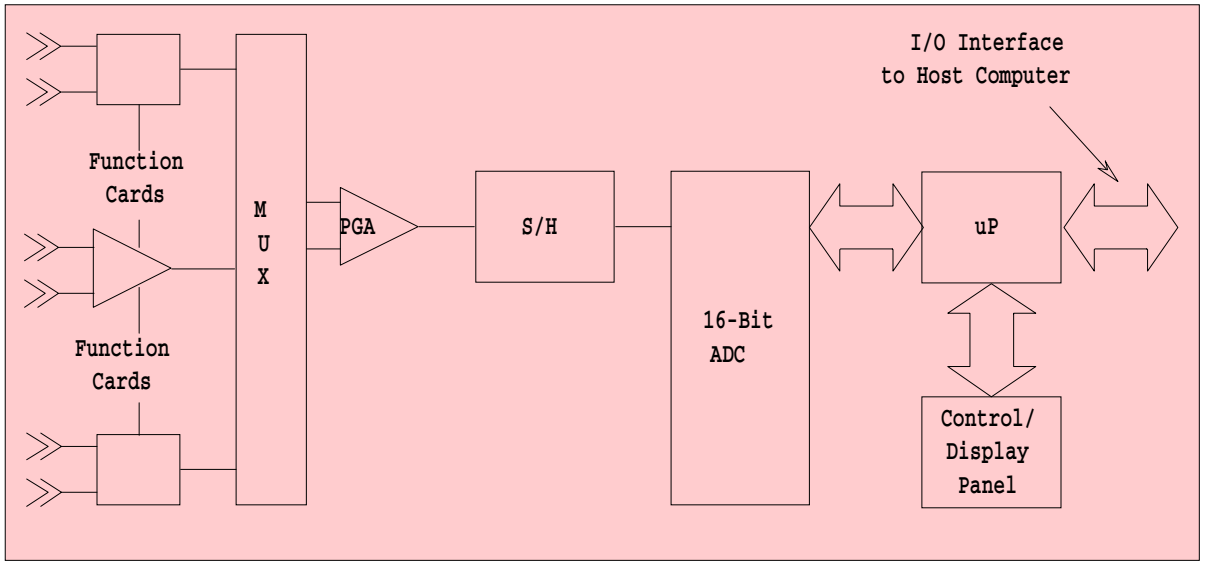
The Neff System 471 Data Acquisition System is a complete moderate-speed data acquisition system for use in computer-based applications. The System 471 is designed primarily for computer automated data acquisition in test facilities, laboratories, and industrial plants or wherever an isolated, moderate-speed data acquisition system is required.

The System 471 is designed to accept analog inputs ranging from ±5 mV to ±10.24 V full scale. Sensors such as strain gages, RTDs, potentiometers, and thermocouples can be input directly to one of the System 471 function cards thus eliminating any need for external signal conditioning.

System 471 consists of a seven-inch high, 19-inch wide enclosure with power supply, backplane wiring, I/O Control Logic printed circuit card, Analog Subassembly printed circuit card, and 16 I/O card slots that accept any combination of System 471 function cards. A Control/Display panel is optional and an expansion assemblies are available to extend function card capacity to 256. The maximum number of channels or data points to be serviced depends on the type of function cards used. Thirty-two 4-channel Isolated Amplifier cards, for example, provide 128 channels of analog input while the same number of 32-bit TTL Input cards accommodate 1024 single data points.

All analog input cards have filters to reject superimposed noise and unwanted signal frequencies. The filtered signals are multiplexed onto the analog function card bus by CMOS/FET switch packages.

System 471 Data Acquisition System (Continued)



Function Cards

470010 32-Bit TTL Input
470011 16-Bit Isolated Digital Input
470012 Two Channel Frequency or Period Input
470013 32-Bit TTL Input/Output
470014 ARINC - 429 Controller
470015 2-Chl Wide Range Frequency or Period Input
470030 32-Bit TTL Output
470031 Eight-Point Form-C Relay Output
470032 Scanivalve Controller
470058 4-Channel Isolation Amplifier/Multiplexer
470070 Two-Channel 16-Bit DAC Output
470071 16-Channel 12-Bit DAC Output
470085 Calibration Card

Front Access to all Cards

Function cards are accessed by opening the hinged front panel and can be changed or moved without disturbing I/O cabling. All I/O connections are made at the rear panel of the system. Both solder type and screw type input connectors are available.

System 471 Data Acquisition System (Continued)

Isolated Amplifier Input

The Isolated Programmable Gain Preamplifiers on the 4-channel
470058 card operate with up to 300V common-mode voltage with 160dB CMRR and accept mode cards to condition each channel separately for strain gauges, RTDs or voltage inputs. In addition to R-Shunt and R-Substitution calibration, voltage substitution is supported using solid-state relays for switching to the appropriate input. Digital addresses, gain codes and control signals are optically coupled to maintain high common mode isolation

Programmable Gain Amplifier

The amplified signals are multiplexed to the Programmable Gain Amplifier, PGA. This is a low noise, wideband differential amplifier located within the input guard environment to enhance common mode rejection.
This differential amplifier, with gains of 1, 2 and 4 in concert with the preamplifiers provides input ranges of ± 5 mV to
± 10.24 V, individually programmed on each channel.

Sample & Hold

For accurate conversion of the input signal, a sample and hold amplifier is positioned ahead of the analog-to-digital converter. At a fixed time in the conversion cycle, the amplifier switches to hold mode to provide a constant input to the ADC.

ADC

Neff's ADC is a state-of-the-art device implemented by several LSI chips. It delivers a 16-bit output (including sign).

Auto-Zero

An automatic zero circuit compensates for zero offset error generated by the PGA or sample and hold amplifiers. The circuit tracks the output of the sample and hold amplifier and generates an equal and opposing voltage that is effectively subtracted from the sample and hold output voltage for input to the ADC.

Internal I/O Bus

A 16-bit internal I/O bus interconnects the ADC, digital I/O serial-to-parallel converter, and the microcomputer. Two connectors are used to extend the internal I/O bus to an expansion assembly and another links the bus to the optional Display/Control panel.

Operating Modes

System 471 provides two basic data acquisition operating modes to read input data:

1. Single Buffer Mode

2. Continuous or "Ping-Pong" Buffer Mode

In addition, an output mode is provided to output data from the system.

Both input scanning modes can be clocked or unclocked. Each data buffer is "stamped" with the current real-time (or scan time being kept by the firmware). Mode usage will depend on host computer capability, the interface used, and the application requirements. Following are basic mode descriptions.

Single Buffer Mode. The single buffer mode of data acquisition is a start-stop synchronous configuration wherein the host computer initiates each data acquisition cycle.

Initially, the host computer downloads a channel scan list to System 471. The scan list consists of the channel numbers of the devices to be read (function cards) as well as the PGA gain codes required for analog input channels. The scan list defines one scan or pass through the block of input channels to be read.

The host computer then defines a number of scans to be run and a scan period that determines the rate at which the scans are run. System 471 then partitions a data buffer area in RAM for storing the returned data.

After this initial setup phase, the host computer issues a start command to System 471 to begin data acquisition. System 471 executes the specified number of scans and places the resultant data into the data buffer. When the last data word has been loaded into the data buffer, System 471 halts further data acquisition and signals the host that the data buffer is ready. The host reads the data buffer and may then issue a go-again command to repeat the cycle.

The single buffer mode is adequate for most applications. Because the host starts each data acquisition cycle, there is no danger that it will be overrun. However, there are gaps in the data while System 471 is waiting for the host to read the data buffer. Maximum data sampling rate is also limited by the time required for the host to read the data buffer.

Ping Pong Buffer Mode. The Ping Pong mode of operation permits faster throughput rates by overcoming the timing limitations of the single buffer In this mode, System 471's RAM is partitioned into two data buffers. A/D data and digital data are returned to one data buffer. When that buffer is filled, System 471 signals the host that the buffer is ready. Without waiting for the host to read the buffer, System 471 loads the uninterrupted input data into the second buffer. The host can transfer the data from the first buffer at any time prior to the completion of the second buffer or it may choose to ignore a buffer and allow it to be overwritten by subsequent data. Because of the time stamping feature, data integrity is maintained even when buffers are skipped.

Output Mode. Output lists, defining control functions to be output by System 471, are block transferred from the host to the System 471. The system's microcomputer executes the list immediately or, if a scan list is in progress, when the current scan is completed.

System 471 Data Acquisition System Function Cards

Shared Function Cards

Discrete function cards are common to the System 470 and the System 471. Analog signals in the System 471 are processed by the 4-Channel Isolation Preamplifier/Multiplexer, 470058 which is unique to the System 471.

4-Channel Isolation Preamplifier/Multiplexer 470058

Isolation Amplifier, 470058, is a four channel analog input signal function card providing highly accurate measurements of signals ranging from ±5 mV full-scale to ±300V full-scale. Each channel is galvanically isolated from ground and from the other channels by means of a transformer coupled multiplexer and isolated power supplies. Plug-on mode cards configure each channel for operation with a particular type of transducer. Mode cards provide excitation, calibration switching and bridge completion.

A common calibration bus is routed to all system channels to allow voltage substitution calibration using an external voltage standard. Mode cards provide additional transducer-specific calibration.

Separate input and output low-pass filter sections provide 4 Hz cutoff frequencies and 24 dB/octave terminal rolloff. Input filtering protects the amplifier from noise components which might cause overload or slew-rate limiting. It also reduces the effects of common-mode to normal-mode voltage conversion. The output section further reduces the bandwidth as well as amplifier generated noise.

Mode Cards

Voltage Mode Card, 470362, configures a channel for voltage inputs. It includes switching for voltage substitution calibration and holes for mounting an input attenuator or shunt resistor for current loop operation.

RTD Mode Card, 470361, configures a channel for RTD operation.

Bridge Mode Card, 470360, configures a channel for operation with bridge type transducers.

Specifications:

Number of Channels:	4 true differential input channels per card. Input sources may be grounded or floating.
Input Configuration:	Floating, galvanically isolated.
Input Impedance:	100 MegOhms at dc. Input may be grounded or floating.
Input Filter:	2 filter sections, each with 2-pole passive RC filters on each channel: 24 dB/octave terminal slope; -3 dB at 4Hz.

4-Channel Isolation Preamplifier/Multiplexer 470058

Maximum Input Voltage: Differential:	±65V dc or peak ac without damage.
Common-mode:	±300 V dc or peak ac without damage.
Common-mode Rejection:	160dB, dc to 60 Hz.
Channel Sample Rate:	200 samples per second maximum to meet all specifications.
System Sample Rate:	10KHz aggregate system sample rate.
Gain Steps:	Isoamp provides four programmable gain steps of x1, x8, x64, and x512.
Full-Scale Ranges:	±5 mV to ±10.24V in 12 steps using PGA gain steps of x1, x2, and x4 with preamp gains of 1, 8, 64 and 512
Offset Error:	±(35 uV at 23°C + 0.5uV/°C RTI) or ±(2.0 mV at 23°C + 0.1 mV/°C, RTO) whichever is greater, uncalibrated.
Gain (Slope) Error:	±(0.1% FS at 23°C + 0.002% FS/°C), uncalibrated.
Source Current:	±(1.0 nA at 23°C + 0.1 nA/°C)
Noise:	±(0.5 uV RTI + 1.0 mV RTO)
Crosstalk:	Less than 0.006% FS between channels.
Stability:	±(0.02% FS + 2.0 uV RTI) for 120 hours at constant temperature. Includes effects of gain stability, offset stability, non-linearity and crosstalk.
Resolution:	16 bits. (15 Bits plus sign)

System 471 Ordering Information

471100	Input/Control Assembly with IEEE-488 Interface. Includes 16 I/O slots, 16-bit ADC, power supply, Logic Control, and Analog Subassembly cards.
471200	Input/Control Assembly with SCSI Interface. Includes 16 I/O slots, 16-bit ADC, power supply, Logic Control, and Analog Subassembly cards.
471101	Expansion Input Assembly. Provides 16 additional I/O slots for 470100.
471104	Display/Control Panel for 471100.
470108	SCSI Host Adapter Card – PCI
470110	IEEE-488 Host Adapter Card – PCI, NI

Function Cards

470010	32-Bit TTL Input.
470011	16-Bit Isolated Digital Input.
470012	Two-Channel Frequency or Period Input.
470013	32-Bit TTL Input/Output.
470014	ARINC -429 Controller
470015	2-Channel Wide-Range Frequency or Period Input Card
470030	32-Bit TTL Output.
470031	Eight-Point Form-C Relay Output.
470058	4-Channel Isolation Amplifier
470360	Single Channel Bridge Mode Card (for 470058)
470361	Single Channel RTD Mode Card (for 470058)
470362	Single Channel Voltage Mode Card (for 470058)
470070	Two Channel, 16-Bit DAC Output
470071	16-Channel 12-Bit DAC

Accessories

470080	Screw Terminal Input Connector
471103	Extender Card Set.
471900	Instruction Manual (extra copy, two supplied with system at no charge)

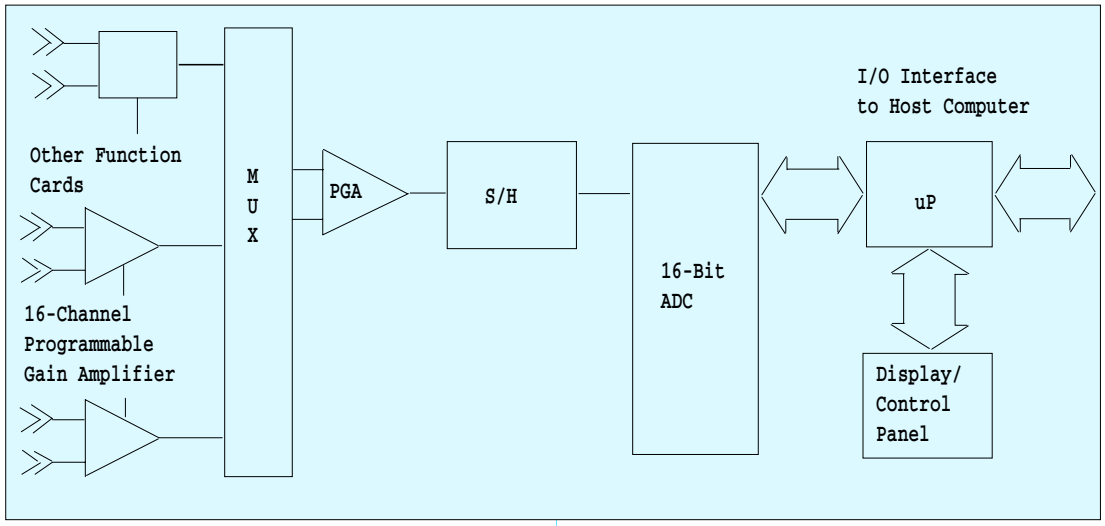
Barrier Strip/ Cable Sets	For Use With:
31017	32-Bit TTL Output Card 470030
31018	Two Channel, 16-Bit DAC Card 470070
31019	16-Bit Isolated Input Card 470011
31020	Two Channel Frequency or Period Input Card 470012/470015
31021	Eight Point Form-C Relay Output Card 470031
31025	32-Bit TTL Input Card 470010
31027	16-Channel, 12-Bit DAC Card 470071
31029	32-Bit TTL Input/Output Card470013
31032	4-Channel Isolation Amplifier 471058

Section IV

System 472

Data Acquisition System

System 472 Data Acquisition System



- o Amplifier - per - Channel Multiplexed System
- o Built-in Automatic Calibration
- o ± 3µV Accuracy
- o I/O cards for all analog and digital signals.
- o Includes IEEE-4888, SCSI or Ethernet interfaces for your PC or workstation.

- o Instrumentation quality amplifier per channel
- o Throughput rates to 50 KHz
- o 12 Input Ranges: ± 5 mV to ± 10.24 V Full Scale
- o Greater than 120dB CMRR
- o 16-Bit ADC Expandable to 2048 analog input channels

High Performance — Low Cost

Compatible with the discrete I/O cards of the System 470, the System 472 equipped with the 472060 programmable gain preamplifier per channel card raises low cost system performance to a new level.

I/O Cards for All Signals — Signal Conditioning

Your chassis gives you access to System 472's full complement of dedicated function cards to accommodate your analog and digital signals and to provide signal conditioning for your transducers.

System 472 Data Acquisition System (Continued)

System 472 Hardware — Easy to Configure, Easy to Use

System 472 comprises a 7 inch high, 19 inch wide enclosure with power supply, backplane wiring, I/O Control Logic care, Analog Subassembly card and 16 I/O card slots that accept any combination of System 472 function cards. Seven expansion chassis may be used to extend function card capacity to 128.

Front Access To All Cards

Function cards are accessed by opening the hinged front panel and can be changed or moved without disturbing I/O cabling. All I/O connections are made at the rear panel of the system with both solder and screw-type input connectors available.

Part Number	Description
472010	32-Bit TTL Input
472011	16-Point Isolated Digital Input
472012	2-Channel Frequency or Period Input
472013	32-Bit TTL Input/Output
472015	2-Channel Widerange Frequency or Period Input
472030	32-Bit TTL Output
472031	8-Point Form “C” Relay Output
472059	16-Channel Differential Mux W/O Filtering, ± 2.56V to ± 10.24 V Full Scale
472060	16-Channel Programmable Gain Preamplifier W/10 Hz Filters. ± 5 mV to ± 10.24 V Full Scale
472064	16-Channel Programmable Gain Preamplifier W/100 Hz Filters ± 5 mV to ± 10.24 V Full Scale
472070	2-Channel 16-Bit DAC
472071	16-Channel 12-Bit DAC
472081	15-Channel Isothermal Connector W/Reference

System 472 Data Acquisition System (Continued)

Functional Description

System 472 is a high performance multiplexed system featuring automatic calibration, a 50 KHz throughput rate and programmable gain amplifiers on each channel. Amplified signals are filtered then switched to a postamplifier which is common to all channels. With preamp gains of 1, 8, 64 and 512 and postamp gains of 1, 2 and 4, the full range of gains between 1 and 2048 is accomplished in 12 programmable binary steps.

Analog input cards, except for the 472059, are equipped with filters to reject superimposed noise and unwanted signal frequencies. The filtered signals are amplified then multiplexed onto the analog function card bus by CMOS/FET switch packages.

Interfaces

System 472 can be configured with a SCSI, GPIB or Ethernet interface.

Scan Mode

System 472's on-board buffer is partitioned into 2 equal data buffers providing continuous, gap-free acquisition as they operate in a ping-pong fashion., A/D and digital input data are directed to one of the buffers until it reaches a programmed limit.

The host computer is notified that a buffer of data is ready and new data are diverted to the alternate buffer.

To avoid losing data the host must download the first buffer before the second is filled. Unloaded buffers will be overwritten and the fact reported.

Output Mode

Output lists, defining control functions to be output by System 472, are block transferred from the host to the 472. If a scan is in progress, the transfer will be delayed until the end of the next scan.

Calibrate

Calibration may be initiated when the Scan Mode is inactive. Two separate commands are required: the first, to calibrate the Postamplifier, the second to calibrate the 472060 and 472064 Programmable Gain Preamplifiers. An internal programmable precision calibration supply output is routed throughout the System 472 under the control of internal firmware.

Correction constants are stored in nonvolatile memory and applied during subsequent measurements. The entire calibration procedure requires approximately 3 minutes for up to 256 channels.

System 472 Discrete Input Cards

32 Bit TTL Input - 472010

This card reads 32 bits of input TTL data as two groups of 16 bits each. A Hold output signal handshakes with the device being read. Hold is a 10 uS pulse of selectable polarity asserted when either 16-bit group is to be read. This feature is especially useful when reading digitally-coded levels from a counter, DVM, clock, etc., which, if read in its transitional state, would result in ambiguous data.

An Enable input allows the user to decide when to update the card's input register.

All inputs and outputs interface with either standard or low power TTL logic. Jumper wires select positive true or negative true logic levels.

Specifications

Inputs

High-Level Input Voltage:	2.0 V min; 5.0 V max
Low-Level Input Voltage:	0.0 V min; 0.8 V max
High-Level Input Current:	20 uA max
Low-Level Input Current:	- 400 uA max
Enable:	1000 ohm pull-up resistor

Outputs

High-Level Output Voltage:	5.25 V max
Low-Level Output Voltage:	0.4 V max
High-Level Output Current:	250 uA max
Low-Level Output Current:	40 mA max

16 - Bit Isolated AC/DC Input - 472011

The 16-Point AC/DC Input card provides isolated inputs for 16 voltage levels from 12 V to 48 V, ac or dc. Inputs are read as a 16-bit digital word with positive-true or zero-true logic selected by jumper placement. Up to 1000 V common mode can be applied between inputs and ground.

Specifications

Input Current:	21 mA @ 48 V 8.1 mA @ 24 V 1.4 mA @ 12 V
Common Mode Voltage:	1000 V max
Response Time:	50 mS

32 Bit TTL Input/Output - 472013

The 32-Point TTL Input/Output card provides a 32-bit TTL level bus for user definition. The bus is divided into four bytes, each of which may be programmed separately as either input or output.

Output data is loaded in word form. Writing to Channel 08 will load output data into output bytes 0 and 1, where byte 0 is equivalent to bits 0-7 and byte 1 is equivalent to bits 8-15. Writing to Channel 09 will load output data into output bytes 2 and 3.

Specifications

Inputs:

High Level Vin:	3.15 V min, 5 V max
Low Level Vin:	-1.5 V min, - 0.9 V max

Outputs:

High Level V_{out}:	2.4V min
High Level I_{out}:	-2.6 mA max
Low Level V_{out}:	0.5V max
Low Level I_{out}:	24 mA max

System 472 Discrete Input Cards (Continued)

Two-Channel Frequency or Period Input 472012

The Two-Channel Frequency or Period Input card accommodates inputs from tachometers, flowmeters, or other frequency-related devices. Frequency or period measurements or straight event counting are selectable by switches on the card.

For flexibility, each channel accepts two types of inputs. One set of input terminals, for TTL logic levels, is optically coupled. The other input is intended for use with signal levels that vary with frequency. An event zero-crossing detector accepts inputs from ±200 mV to ±100 V at frequencies to 100 KHz.

A crystal-controlled clock provides accurate time bases for measurements on both channels while each channel has its own 32K counter. After each measurement, the counter is reset. Frequency measurement involves counting the number of input pulses occurring between clock pulses.

By means of manual switches on each channel, the user can select measurement mode, clock frequency, and select counting to occur on the leading or trailing edge of an input pulse.

Specifications

Accuracy

Frequency Mode: ±0.01% of reading ±1 count

Period Mode: ±0.01% of reading ± input rise time (0.6 to 4 V transition)

Ranges

Mode	Time Base	FS Range	Resolution (1 count =)
Frequency	0.1sec 1 Sec 10 Sec	327 KHz 32.7 KHz 3.27 KHz	10 Hz 1 Hz 0.1 Hz
Period	100 KHz 10 KHz 1 KHz	327 mSec 3.27 Sec 32.7 Sec	10 uSec 100 uSec 1.0 mSec
Count	Counts 0 to 32767		

Isolated TTL Input

Input Voltage: ±5.25 V max

Sink Current: 16 mA max

Common Mode: ±300 V max

Frequency: dc to 350 KHz

Non-isolated Input

Input Voltage: ±200 mV min; ±100 V max

Input Impedance: 50 KOhms

Frequency: dc to 100 KHz

System 472 Discrete Input Cards (Continued)

Two-Channel Frequency or Period Input 472015

The Two-Channel Frequency or Period Input card accommodates inputs from tachometers, flowmeters, or other frequency-related devices. Operating modes include frequency measurement, period measurement and pulse counting. Selection of mode, clock frequency, number of periods included in the measurement and desired polarity are all programmable.

For flexibility, each channel accepts two types of inputs. One set of input terminals, for TTL logic levels, is optically coupled. The other input is intended for use with signal levels that vary with frequency. An event zero-crossing detector accepts inputs from ±100 mV to ±100 V at frequencies to 100 KHz.

Frequency Mode

Gate Time	Range*	Resolution
1.0 Sec	8.388607 MHz	1.0 Hz
10.0 Sec	838.8607 KHz	0.1 Hz

*Theoretical full-scale range. Limited by input response.

Counter Mode

Full scale range, 8,388,607

Period Mode

Clock Frequency	Periods	Range	Resolution
10.0 MHz	1	838.87 mSec	100 nSec
10.0 MHz	10	83.887 mSec	10 nSec
1.0 MHz	1	8388.7 mSec	1 uSec

Event Specifications:

Accuracy:

- **Internal Time Base:** 0.01% of nominal
- **Frequency Mode:** 0.01% of reading ±1 count.
- **Period Mode:** 0.1% of reading to 100mS. 0.01% of reading to 1.0mS
- **Event Counting Mode:** ±1 count

Input Characteristics:

Isolated TTL Input:

- **Input Voltage:** ±5.25V, maximum
- **Sink Current:** 16mA, maximum
- **Common-mode:** ±300V, maximum
- **Frequency Range:** dc to 350 KHz

Level Detector Input:

- **Input Voltage:** 100 mV, minimum to 100 V, max
- **Frequency Range:** dc to 100 KHz

System 472 Discrete Output Cards

32-Bit TTL Output--472030

The 32-Bit TTL Output card provides two 16-bit outputs for driving TTL-compatible loads or other loads not exceeding output capability (30 V maximum; 40 mA maximum). Dual-rank registers permit the simultaneous updating of all outputs.

All outputs are open-collector gates with pull-up resistors to the internal 5 V supply for driving standard TTL or 5 V CMOS loads. Placement of a jumper permits use of an external voltage source up to 28 V. Outputs can then interface to high voltage CMOS logic or be used to drive relay coils, lamps, or other loads not exceeding 40 mA.

Output polarity of each group of eight outputs is determined by jumper placement. This allows the user to arrange logic polarity to any desired power-up/reset condition required by the application.

Specifications

Open Circuit Voltage:	+30 V max
Sink Current:	-40 mA max

Eight-Point Form-C Relay Output--472031

The Eight-Point Form-C Relay Output card provides eight three-wire form-C outputs (normally open, normally closed, and common) to drive various control devices. Each relay has a "set" and "reset" coil and is magnetically latches in its current state at power down. Eight control bits are used to address and control the relays individually. Dual-rank registers permit simultaneous updating of all relay states.

Specifications

Initial Contact Resistance:	30 milliOhm, max
Maximum Contact Switching Power:	2000 VA, 150 W (resistive)
Maximum Switching Voltage:	250 VAC
Maximum Switching Current:	8 Amperes
Breakdown Voltage:	1000 V between open contacts 1000 V between contacts andground
Set/Reset Time:	8 ms (approximately)

System 472 Specifications – Analog Input Cards

16-Channel Analog Signal Input Cards 472060, 472064 and 472059

System 472 offers three differential multiplexer card; A 16-channel programmable gain preamplifier card with 10 Hz filters, another with 100 Hz filters and a third with no amplifiers and no filtering.

The 16-channel Programmable Preamp/Multiplexer, 472060, is a high accuracy, low bandwidth card capable of accepting full scale signal inputs ranging from ± 5 mV to ± 10.24 V in 12 binary steps. The 472064 is similar in all respects except the filter cutoff frequency is fixed at 100 Hz instead of 10 Hz. The 472059 card accepts up to 16 analog inputs but has no gain and no filtering making it low cost solution for measuring high level signals between ± 2.56V and ± 10.24 V full scale while taking advantage of the 50 KHz throughput rate.

System 472 with 472060/064 Card Installed

Number of Channels: 16 guarded differential input channels. Input sources may be floating or grounded.

Ranges: ± 5 mV to ± 10.24 V in 12 binary steps: fully programmable for each channel.

Input Filter: Passive RC filter on each channel 3-pole, low-pass with terminal slope approaching 18 dB/octave; -3 dB at 10 Hz: -3dB at 100 Hz in the 472064 card.

Input Impedance: 10 MegOhms at dc.

Maximum Input Voltage: ± 30 V differential or common mode without damage.

Common Mode Voltage: ±10 V operating.

Common Mode Rejection: 120 dB (80 dB + gain in dB to 120 dB Max); dc to 60 Hz with 350 Ohm source imbalance.

Full Scale Accuracy: ±(0.02% FS + 2 uV) for 120 hours at calibration temperature ± 5°C. Includes errors contributed by gain instability, of set instability and non-linearity.

ADC Resolution: 16-bits, including sign

System 472 Specifications – Analog Input Cards (Continued)

System 472 with 472059 Card Installed

Number of Channels:	16 guarded differential input channels. Input sources may be floating or grounded.
Ranges:	± 2.56 V to ± 10.24 V in 3 binary steps: fully programmable for each channel.
Input Filter:	The 472059 has no filtering on the input.
Input Impedance:	10 MegOhms at dc.
Maximum Input Voltage:	± 30 V differential or common mode without damage.
Common Mode Voltage:	±10 V operating.
Common Mode Rejection:	80 dB dc to 60 Hz with 350 Ohm source imbalance.
Accuracy After Cal:	± 0.05% FS at constant temperature: ±0.003% FS/°C after postamplifier calibration.
ADC Resolution:	16-bits, including sign
Dynamic Crosstalk:	74 dB worst case on adjacent channel inscan.
Zero Stability and Noise:	± 1.25 mV RTO, ± 0.1 mV/°C.

System 472 Analog Output Cards

Two Channel 16-Bit DAC
472070

The Two Channel DAC Output card provides two channels of analog output from System 470. Each channel consists of a 16-bit digital-to-analog converter (DAC) scaled to deliver ±10.24 V output. Each output can deliver 20 mA of load current with remote sense leads provided to cancel line drops. Dual-rank registers permit simultaneous updating of both channels.

Specifications

Output Voltage: ±10.24 V full scale.

Output Current: ±20 mA.

Accuracy: ±0.02% of full scale.

Stability: ±0.005% of FS at constant temperature; 0.001%/°C over 0 to 50°C.

Resolution: 0.00305% FS/count (1 part in 32,768).

Noise: Less than 500 uV in 10 KHz bandwidth

Sixteen Channel 12-Bit DAC
472071

The 16 Channel DAC Output card provides 16 channels of analog output from System 470. Each channel consists of a 12-bit digital-to-analog converter (DAC) scaled to deliver ±10.24 V output. Each output can deliver 20 mA of load current with remote sense leads provided to cancel line drops.

Specifications

Output Voltage: ±10.24 V full scale.

Output Current: ±20 mA.

Accuracy: ±0.02% of full scale.

Stability: ±0.005% of FS at constant temperature; 0.001%/°C over 0 to 50°C.

Resolution: 0.05% FS/count (1 part in 2,048).

Noise: Less than 500 uV in 10 KHz bandwidth.

System 472 Miscellaneous Components

16-Channel Isothermal Connector 472081

The Isothermal Connector provides the means of terminating thermocouple input cables at the rear panel of the System 472. It can be used with any of the following analog input cards.

472060	16-Channel Programmable Gain Amplifier/10 Hz filters.
472064	16-Channel Programmable Gain Amplifier/100 Hz filters.

The Isothermal Connector plugs directly into the input (edge) connector of the analog input card. Thermocouple cables are brought into 15 sets of screw terminals on the connector, corresponding to multiplexer input channels 1 through 15. A temperature transducer in the connector supplies a reference voltage to channel 0 that is proportional to the termination temperature.

The termination temperature and the type of thermocouple on each channel is the information the host computer requires to convert the thermocouple voltage to temperature. Since the conversion is under control of the computer, thermocouple types can be mixed.

Specifications:

Reference Temperature:	1 mV/°C (Channel 00).
Reference Temperature Accuracy:	±0.25°C over the range of 10°C to 45°C.
Thermocouple Inputs:	Channels 01 through 15.
Temperature Gradient:	0.1°C across terminations

Extender Cards 470103

This set of two extender cards is used for calibration and servicing of the printed circuit cards in the system. It allows access to card components and test points under operating conditions.

System 472 Data General Specifications

Power Requirements:	105 V to 130 V (220 V to 250 V), 50 to 400 Hz, 250 W.
Environmental Requirements:	0°C to 50°C, 90% relative humidity, non-condensing. Will withstand shock and vibration of normal shipping and handling of laboratory equipment.
Cooling Requirements:	To be mounted in cabinet with unobstructed airflow and equipped with a 300 cfm blower.
Size:	7-inch panel height in 19" rack; 23-inch depth be hind front panel. Neff recommends that assemblies be mounted in a 19-inch rack with 30 inch depth to accommodate connector build-up.
Weight:	32 pounds, without function cards installed.

System 472 Ordering Information

Part Number	Description
472100	Input/Control Assembly with IEEE-488 I/O Interface. Includes 16 I/O slots, 16-bit ADC, power supply, Logic Control, and Analog Subassembly cards.
472101	Expansion Input Assembly. Provides 16 additional I/O slots for 472100 and 472200.
470108	Small Computer System Interface, SCSI, Host Adapter for PCI bus.
470110	IEEE-488 Interface, PCI bus
472200	Input/Control Assembly with SCSI I/O Interface. Includes 16 I/O slots, 16-bit ADC, power supply, Logic Control, and Analog Subassembly cards.
472300	Input/Control Assembly with Ethernet I/O Interface. In cludes 16 I/O slots, 16-bit ADC, power supply, Logic Con trol, and Analog Subassembly cards.

Function Cards

Part Number	Description
472010	32-Bit TTL Input.
472011	16-Bit Isolated Digital Input.
472012	Two-Channel Frequency or Period Input.
472013	32-Bit TTL Input/Output.
472015	2-Channel Frequency or Period Input Card
472030	32-Bit TTL Output.
472031	Eight-Point Form-C Relay Output.
472059	16-Channel Differential Mux (Direct Input) w/o Filter
472060	16-Channel Programmable Gain Amplifier w/10 Hz filters.
472064	16-Channel Programmable Gain Amplifier w/100 Hz filters.
472070	Two Channel, 16-Bit DAC Output
472071	16-Channel 12-Bit DAC

System 472 Ordering Information (Accessories)

Accessories

470080	Screw Terminal Input Connector
472081	15-Channel Isothermal Connector
470103	Extender Card Set.
472900	Instruction Manual (extra copy, two supplied with system at no charge)

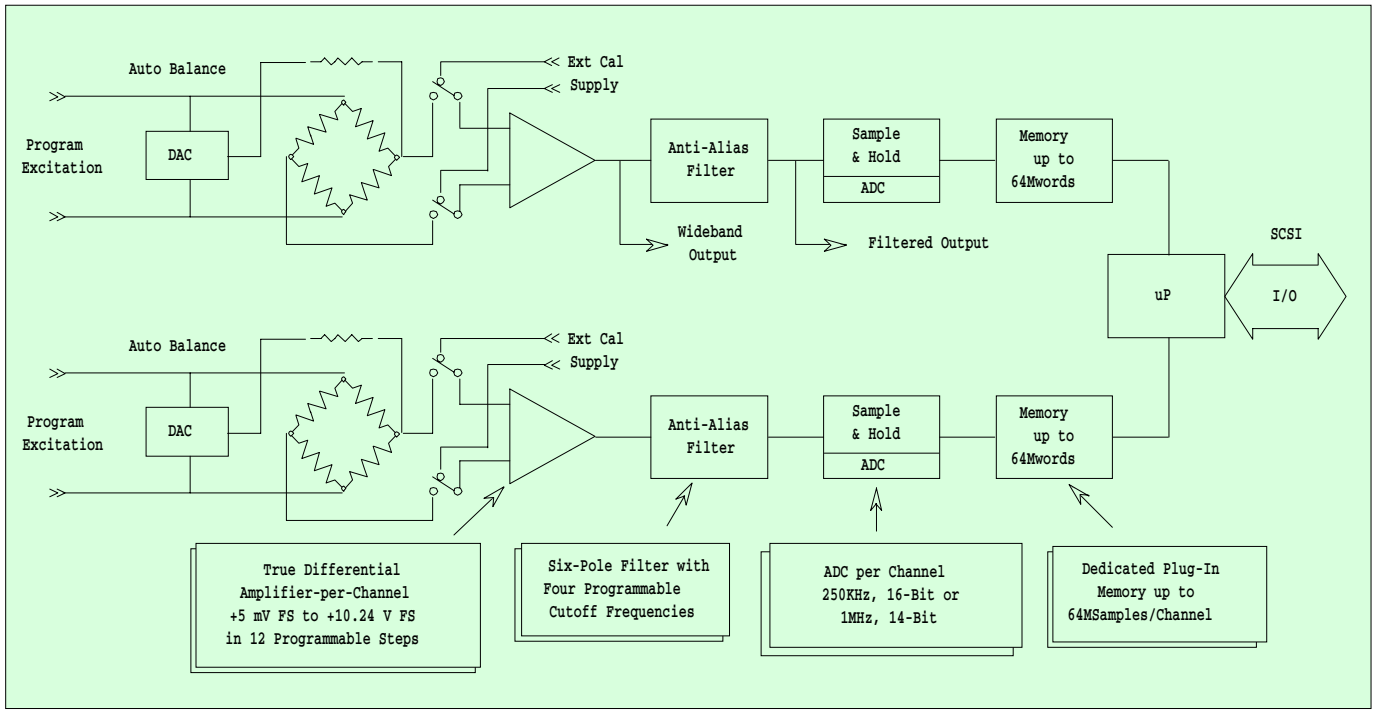
Section V

System 495

Data Acquisition
&
Recording System

System 495 Data Acquisition & Recording System

- o Differential Amplifier and ADC per Channel.
- o 12 Programmable Full-scale Gain Steps.
- o 4 Programmable Filter Steps.
- o Simultaneous Sample & Hold.
- o 1 MHz Channel Sample Rate at 14-bits
- o 256 KHz Channel Sample Rate at 16-bits.
- o 1 MHz Aggregate Real-Time Throughput
- o Dual Speed Clock
- o Programmable Bridge Excitation Voltage.
- o Program-initiated Bridge Auto-Balance.
- o Shunt-R Cal.
- o Voltage Substitution Calibration



Introduction

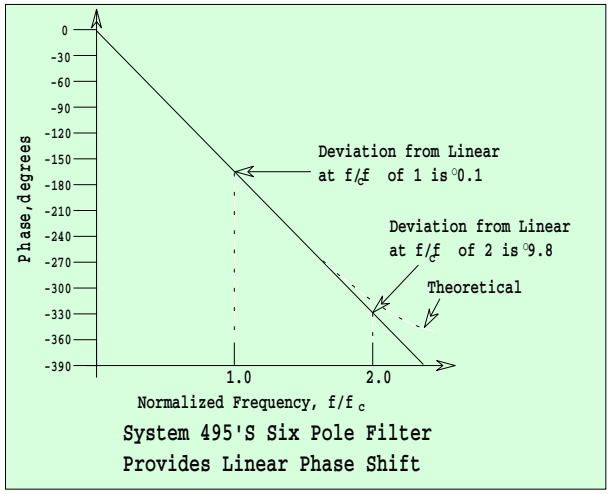
Traditionally, high-speed digital systems employ multiplexed systems in which multiple-sensors share one or more high-speed analog-to-digital converters. The disadvantages of the multiplexed approach include channel-to-channel interference caused by the multiplexer, channel sampling rate limitations less than the analog-to-digital converter sampling rate, and the need for complex and unique high-speed communications interfaces. Also, such systems typically require external signal conditioning to amplify low-level sensor inputs. To overcome these problems, Neff's System 495 uses a proven wide range, guarded differential amplifier-per-channel technique with a dedicated high-speed analog-to-digital converter for each channel. In addition to storing data locally in memory, a subset of each chan-

System 495 Data Acquisition & Recording System Continued)

nel's data can selectively be transmitted to the host for monitoring or recording at an aggregate rate of 1MHz. After the test, each channel data can be returned over a standard SCSI interface.

System Overview

The System 495 Data Acquisition and Recording System samples and records very high speed analog transient phenomena at sampling rates up to 1 MHz. Input signals can range from ±5 mV to ±10.24 V full scale and can occur at frequencies from dc to 200 KHz. Data samples are temporarily stored in DRAM memory, with a separate plug-in memory module provided for each channel in a choice of sizes--1MSample to 64MSample. Each channel includes a differential input amplifier with 12 programmable gain steps, a 6th order low-pass Bessel filter with four program selectable cutoff frequencies, and a sampling A/D converter. Both 14-bit and 16-bit A/D converters are available.



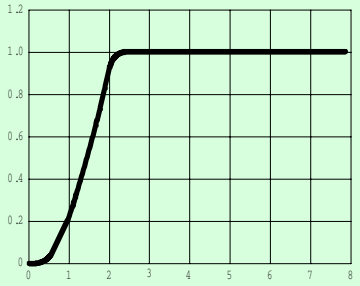
System 495'S Six Pole Filter
Provides Linear Phase Shift

Common memory and sample rate management circuitry is provided to control all channels. This circuitry includes a programmable sample rate clock, 24-bit memory address register and 24-bit sample counter. Sample rate can be synchronized by either the internal programmable clock or by an external
TTL clock (or 5 volt CMOS clock).

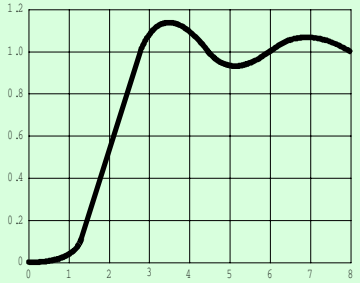
A control register bit selects the clock to be used. The external clock mode is useful to sync sampling with external events. The internal clock is programmable over a range of 0.298 Hz to 2.5 MHz. Multiple-enclosure 495 systems can be interconnected in a master/slave array with the master providing a common clock to all enclosures. A trigger signal starts recording data into the channels) memory. Three methods of initiating the trigger signal are provided.

1. Program control
2. External logic signal
3. Analog level detection on one channel

Step Response Characteristics
for Bessel and Butterworth Filters



6-Pole Bessel



Since The System 495's Bessel Filter Provides No Overshoot For Step Inputs, It Is Ideal For Transient Measurements.

System 495 Data Acquisition & Recording System (Continued)

Total Static Accuracy at Zero Frequency

The composite static accuracy at zero frequency is a function of the fixed systematic error (accuracy, full-scale stability, non-linearity, and zero stability) and random error attributable to noise at a stated bandwidth. The total static error at any full-scale range can be computed as follows:

Total Accuracy, %FS = ±(Fixed Error + Random Error)
where:

Fixed Error, %FS = $[(\text{FS Accuracy})^2 + (\text{FS Stability})^2 + (\text{Linearity})^2 + (\text{Zero Stability})^2]^{1/2}$
and:

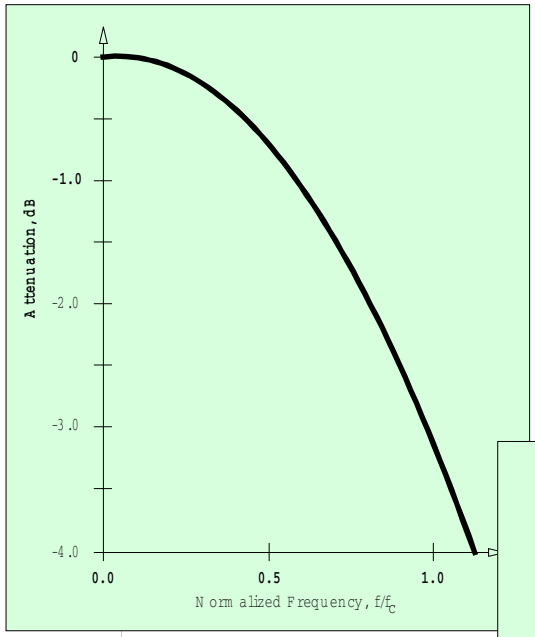
Random Error, %FS =

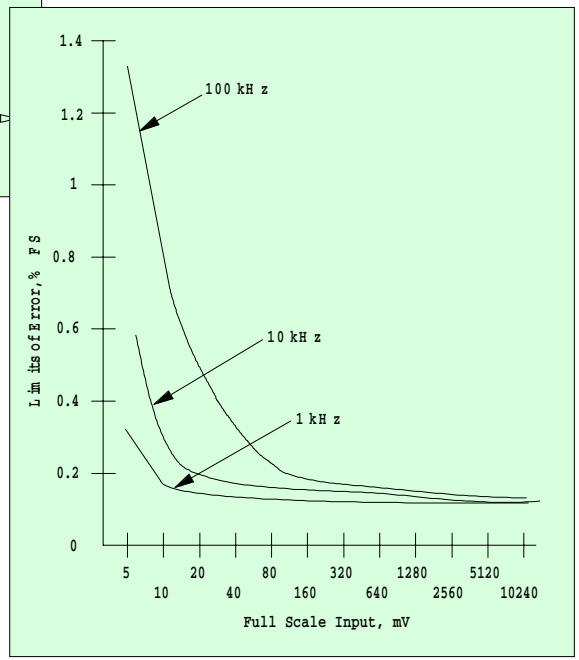
$$\frac{[(\text{RTI Noise} \times \text{Gain})^2 + (\text{RTO Noise})^2]^{1/2} \times 100}{10.24}$$

Since noise is specified as ±3-sigma , the total accuracy can be interpreted as a 99.7% confidence level.

Frequency Response Considerations

For non-zero frequencies, the total error consists of the static error and the dynamic error. The amplitude frequency response characteristics of the Bessel filter can be used as an estimator of dynamic error. For applications such as shock and blast, the overshoot characteristics should be considered as well as phase non-linearity.



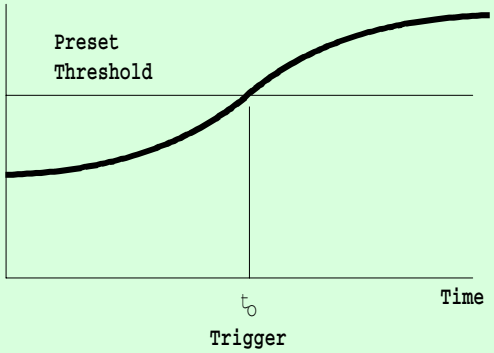


System 495 Data Acquisition & Recording System Continued)

Operating Modes

The System 495 can operate in two different modes; the pre/post trigger mode and the record block mode.

Event Trigger Mode. When operated in the Event Trigger Mode, prior to receipt of a trigger signal, A/D data is written continuously to memory. New data overwrites old data in a circular manner. When the trigger is received, the sample counter is enabled and **N** more samples are written to memory (where **N** is the initial sample count value specified). Recording stops when the sample counter runs down. The memory then contains **N** samples taken after receipt of the trigger signal and "Available Memory - **N**" samples taken before the trigger.



Any one of the system's channels can be used to define either an upper or lower threshold level. Once the level has been exceeded for this key parameter, all channels are triggered at time t_0 to capture N additional samples

The Host program polls the System 495 status register to determine when recording has stopped. Next, the host reads the current memory address pointer location and subtracts the sample count value to determine when the trigger signal occurred. The host then reads the channel's memory data into a file. The various parameters used for recording can be appended to the front of the file for use in future data reduction and display.

Block Record Mode. The Block Record Mode is used to record separate blocks of data, each started by receipt of a trigger signal. The host sets the System 495 memory address pointer and specifies a sample count value. When a trigger signal is received, "N" samples are recorded starting at the specified memory address location. The host polls the System 495 to determine when recording has stopped, then reloads the new address pointer and sample count values. The next trigger signal initiates the next record block. However, a disarm command must be sent before a subsequent arm command is effective, even if a trigger has occurred and a block recorded. After the required number of record blocks have been recorded, the host reads the channel's) memory data into a file with numbered record blocks.

Record Trigger

A trigger signal is used to start recording of acquired data into channel memory. Three methods of initiating record trigger are provided.

1. Program control;
2. External logic signal;
3. Analog level detection on one channel.

System 495 Data Acquisition & Recording System Continued)

Program Control. is primarily used for calibration and check-out before a test is performed. The host computer can position the memory address pointer, define a sample count value and start recording. With a known input signal, system accuracy tests can be performed. The address and sample count registers can also be checked.

External Logic Signal.
Control register bits are provided to enable external TTL and analog level detection trigger modes. External TTL signals may be either pulses or level transitions of either polarity.

Analog Level Detection on One Channel.
The analog level detector is used to initiate a trigger signal when a channel's output signal level exceeds a preset threshold level. The threshold level is defined by an 8-bit value (7-bits plus sign) ranging from -10.24 to +10.24 volts. Resolution is 80 millivolts. Polarity (direction) is programmable so that a trigger can occur when the signal goes either more positive or more negative than the threshold level. When the polarity bit is set (high level), trigger occurs when the channel signal level goes more positive than the threshold level. An enable bit is also included and must be set to enable the level detector. Recording continues if the signal level falls back below the trip point.

The signaling channel output must be wired to the level detector input. This is accomplished by connecting a wire from the desired channel output to the level detector input on the memory controller card. Either the wideband or the filtered output can be used.

Monitor Mode
The host computer can read the current A/D data values of all channels in the system. This is a "real time" monitor function accomplished by executing an input scan list. Typically, the host computer will not be able to keep up with the 495 sample rate, so it will not read all A/D samples. Each channel will return the current A/D register contents at the time it is read. This data may be used to drive a display--e.g., at a 1-second refresh rate to test setup and system calibration.

Trigger Module, 90023536

This trigger module plugs onto the I/O card and provides for connection of up to eight isolated trigger input signals. Each input may be configured for either 5 Volt logic levels or high voltage AC or DC levels. The analog level detector and TTL input trigger may be included in the 8.

Each trigger may be configured with a programmed memory block size and the triggers may be combined in AND and OR functions.

System 495 Specifications

Full Scale Input: 12 programmable steps provide bipolar input ranges of 5 mV, 10 mV, 20 mV, 40 mV, 80 mV, 160 mV, 320 mV, 640 mV, 1.28 V, 2.56 V, 5.12 V, and 10.24 V.

Full-Scale Accuracy: ±0.1% of FS at zero frequency.

Full-Scale Stability: ±0.02% of FS at constant temperature; ±0.005% per °C.

Input Impedance: 10 MegOhms shunted by 500 pF.

Source Current: Less than 1.0 nA at 25 °C , ±0.1 nA/°C.

Zero Stability: ±5 uV RTI ±1.0 mV RTO at constant temperature; ±1.0 uV/°C RT1, ±100 mV/°C RTO.

Noise:

100.00 KHz57 uV RTI + 2 mV RTO
10.00 KHz 18 uV RTI + 2 mV RTO
1.00 KHz 6 uV RTI + 1 mV RTO

Common Mode Voltage: ±10 Vdc peak AC operating, ±30 V without damage.

Common Mode Rejection: 66 dB + gain in dB to 120 dB max, dc to 60 Hz with 350-ohm source imbalance.

Filter: 6-pole Bessel filter with four programmable cutoff frequencies. Each frequency is determined by a plug-in resistor network over the range of 100 Hz to 200 KHz. Standard frequencies are 10 KHz, 20KHz, 50 KHz, and 100 KHz.

Phase Coherency: Phase shift matched channel-to-channel within 5 degrees with amplifiers on same gain and filter step, dc to cutoff.

Voltage Substitution Calibration: Solid state relay provided to switch amplifier input terminals to common CAL bus under program control.

Excitation Supply Feedback: Solid state relay provided to switch amplifier input terminals to excitation supply sense lines under program control.

Shunt R Calibration: Solid state switch to apply shunt resistor across bridge arm under program control. Switch ON resistance less than 30 ohms.

System 495 Specifications (Continued)

Auto-Balance: Auto-balance DAC outputs a voltage between 0V and the excitation supply voltage level. This voltage drives the balance limit resistor that is connected to one corner of the bridge. A DAC output voltage is selected to balance the bridge output voltage to zero.

Bridge Conditioner Mode Board: Plug on circuit board provided to mount bridge completion, shunt R cal and balance limit resistors. 1, 2, and 4 arm circuits may be used with either local or remote supply sensing.

Excitation Supply

Output Voltage: Programmable over the range of 0V to 10 V with a 12-bit DAC.

Output Current: 100 mA maximum operating current; short-circuit protected.

Output Noise: Less than 100 uV pk-pk in 1 KHz bandwidth.

Line Regulation: Less than 0.1% change for 10% line variation.

Load Regulation: Less than 0.1% change from no load to full load.

Remote Sensing: Positive and ground sense leads are provided for remote sensing.

Analog-to-Digital Converter

14-Bit Option

Sample Rate: 1 MHz maximum.
Resolution: 14-bits including sign.
Linearity: ±0.02% of FS + 1-count.

16-Bit Option

Sample Rate: 250 KHz maximum.
Resolution: 16-bits including sign.
Linearity: ±0.02% of FS + 1 count.

System 495 Specifications (Continued)

General Specifications

Power Requirements:	105 to 130 VAC or 200 to 250 VAC, 50/60 or 400 Hz; 100W.
Environmental:	0°C to 50°C (32°F to 122°F); 90% relative humidity, non-condensing. Will withstand shock and vibration of normal shipping and handling of laboratory equipment.
Cooling Requirements:	To be mounted in a 19-inch rack with unobstructed airflow and equipped with a 300 cfm blower.
Physical:	7-inch panel height in 19-inch rack; 23-inch depth behind front panel. Neff recommends that assemblies be mounted in a 19-inch rack with 30-inch depth to accommodate connector buildup. Weight without amplifier/ADC cards is 30 pounds.

System 495 Ordering Information

Part Number	Description
495101	Expansion Input Assembly (16 slots)
495200	Input/Control Assembly with SCSI Interface (16 slots).
495070	250 KHz Programmable Amplifier/Filter with 16-bit ADC and 1 MSample RAM Memory.
495071	250 KHz Programmable Amplifier/Filter with 16-bit ADC and 16 MSample RAM Memory.
495072	250 KHz Programmable Amplifier/Filter with 16-bit ADC and 32 MSample RAM Memory.
495073	250 KHz Programmable Amplifier/Filter with 16-bit ADC and 64 MSample RAM Memory.
495080	1 MHz Programmable Amplifier/Filter with 14-bit ADC and 1 MSample RAM Memory.
495081	1 MHz Programmable Amplifier/Filter with 14-bit ADC and 16 MSample RAM Memory.
495082	1 MHz Programmable Amplifier/Filter with 14-bit ADC and 32 MSample RAM Memory.
495085	8-Input Trigger Module
495083	1 MHz Programmable Amplifier/Filter with 14-bit ADC and 64 MSample RAM Memory.

Software

495803	LabWindows/CVI Instrument Driver
495804	WIN495
495103	Card Extender Set.

Memory Modules

900235393	1 MSample Memory, 16-Bit
900235009	16 MSample Memory, 16-Bit
900235008	32 MSample Memory, 16-Bit
900235007	64 MSample Memory, 16-Bit
900235392	1 MSample Memory, 14-Bit
900235005	16 MSample Memory, 14-Bit
900235003	32 MSample Memory, 14-Bit
900235001	64 MSample Memory, 14-Bit

Accessories

495900	Extra Operation and Maintenance Manual

System 495 Ordering Information (Continued)

Filter Modules

43318-100	6-pole Filter, 100 Hz
43318-200	6-pole Filter, 200 Hz
43318-500	6-pole Filter, 500 Hz
43318-1k	6-pole Filter, 1 KHz
43318-2k	6-pole Filter, 2 KHz
43318-5k	6-pole Filter, 5 KHz
43318-10k	6-pole Filter, 10 KHz
43318-20k	6-pole Filter, 20 KHz
43318-50k	6-pole Filter, 50 KHz
43318-100k	6-pole Filter, 100 KHz
43318-200k	6-pole Filter, 200 KHz
43318-X	6-pole Filter, Special Value

Note

There is a one-time set-up charge of $500 for each special value filter module.

Note

Four user-specified filter modules are included with each Amplifier/ADC/Filter card. If no filter frequencies are specified, filters for 10 KHz, 20 KHz, 50 KHz, and 100 KHz are supplied as standard.

Section VI

System 620

Family of Data Acquisition Products

Introduction to the System 620 Family

The System 620 Family

System 620 is a family of computer-based data acquisition products that can be configured for the user as a completely integrated, high performance analog front-end subsystem installed in cabinets and including computer interface and software drivers. The System 620 family consists of the following principal subsystems:

Series	Function
300	Signal Conditioning
600	Amplifier-per-Channel Multiplexed System
500	Measurement and Control I/O System

Flexible Signal Conditioning

The System 620/Series 300 Signal Conditioner is a data acquisition subsystem that conditions signal transducers for measurement by analog subsystems. Each channel can be configured for a particular transducer type including strain gage, thermocouple, RTD, etc. The subsystem provides constant voltage or constant current excitation, bridge completion, and programmable calibration.

Analog Input Systems

The key component in any data acquisition system is the amplifier/ADC between the low-level analog inputs and the computer. Neff offers a full line of such systems including the Series 600. With 16-bit resolution the Series 600 offers programmable gain *and* programmable filter frequency per channel and built-in automatic calibration.

Analog System Control

The System 620 family of analog subsystems is interfaced to the host computer using the Series 500.

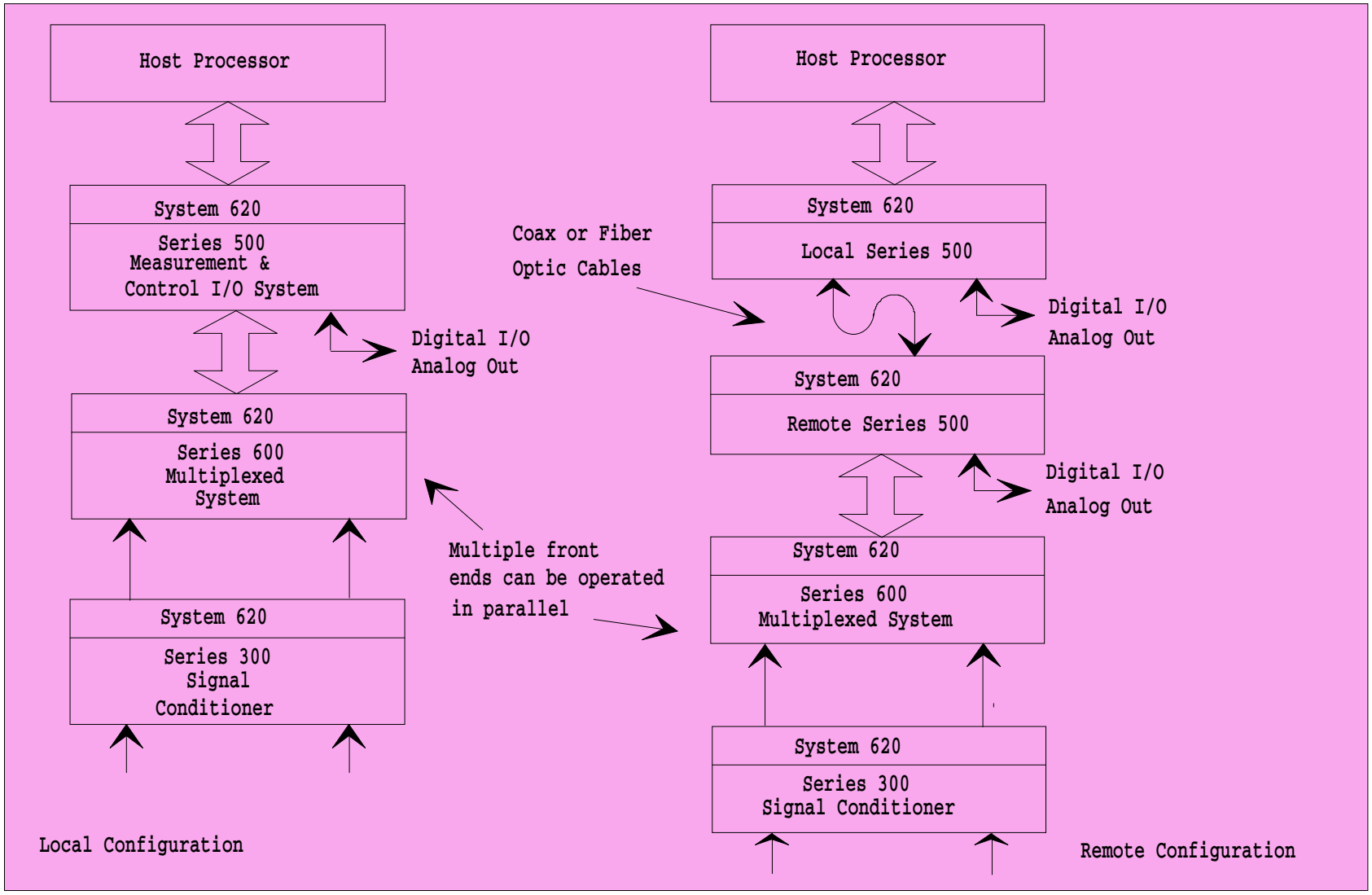
Dual Buffered Controller.

With this technique, A/D data are stored in a data buffer until the buffer is filled, at which time an interrupt request to the host computer is generated. Dual ping-pong data buffers are used, which ensure continuous gapless data.

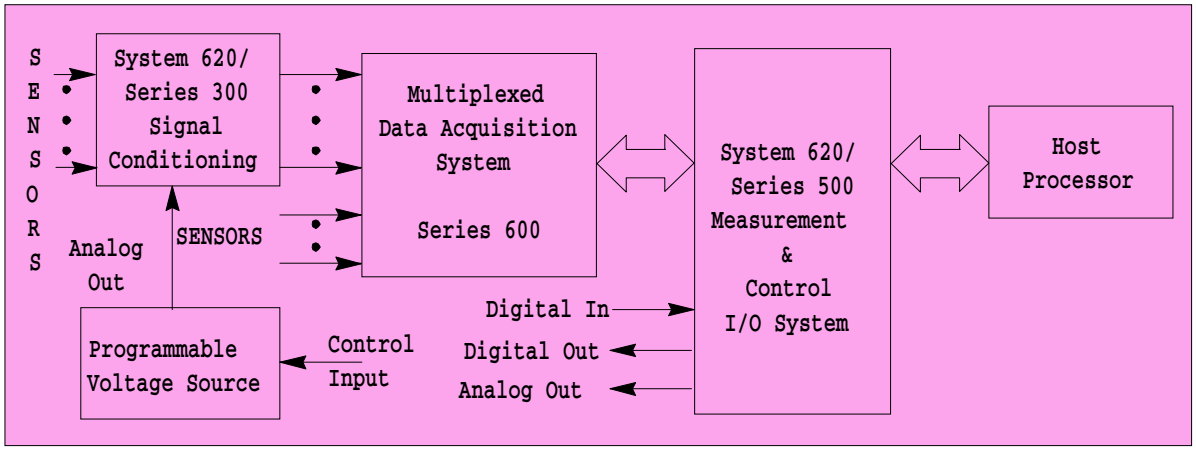
Flexible System Configuration

The System 620 family includes the Series 500, a bus-structured digital subsystem that ties the other System 620 subsystems together and allows unlimited flexibility in system configuration. The user can configure, both in an electrical and in a physical sense, a data acquisition system to the exact requirements. For example, Series 500 provides a digital interface for System 620 multiplexers and offers a serial link hardware set for operating one or more remote multiplexers. It supports all digital I/O functions normally encountered in measurement and control applications: TTL input, TTL output, interrupt-supported DC Sense, DAC output, and others.
System 620 is structured for easy expansion, both in capacity and capability, and for simple reconfiguration. Today's System 620 data acquisition system will not be obsolete tomorrow.

Introduction to the System 620 Family (Continued)



Series 300 Signal Conditioner



- o Constant Voltage Excitation for Bridge Transducers
- o Constant Current Excitation for RTDs and Potentiometers
- o Accommodates One, Two, and Four-Arm Bridges
- o Bridge, RTD, and Thermocouple Calibration

Introduction

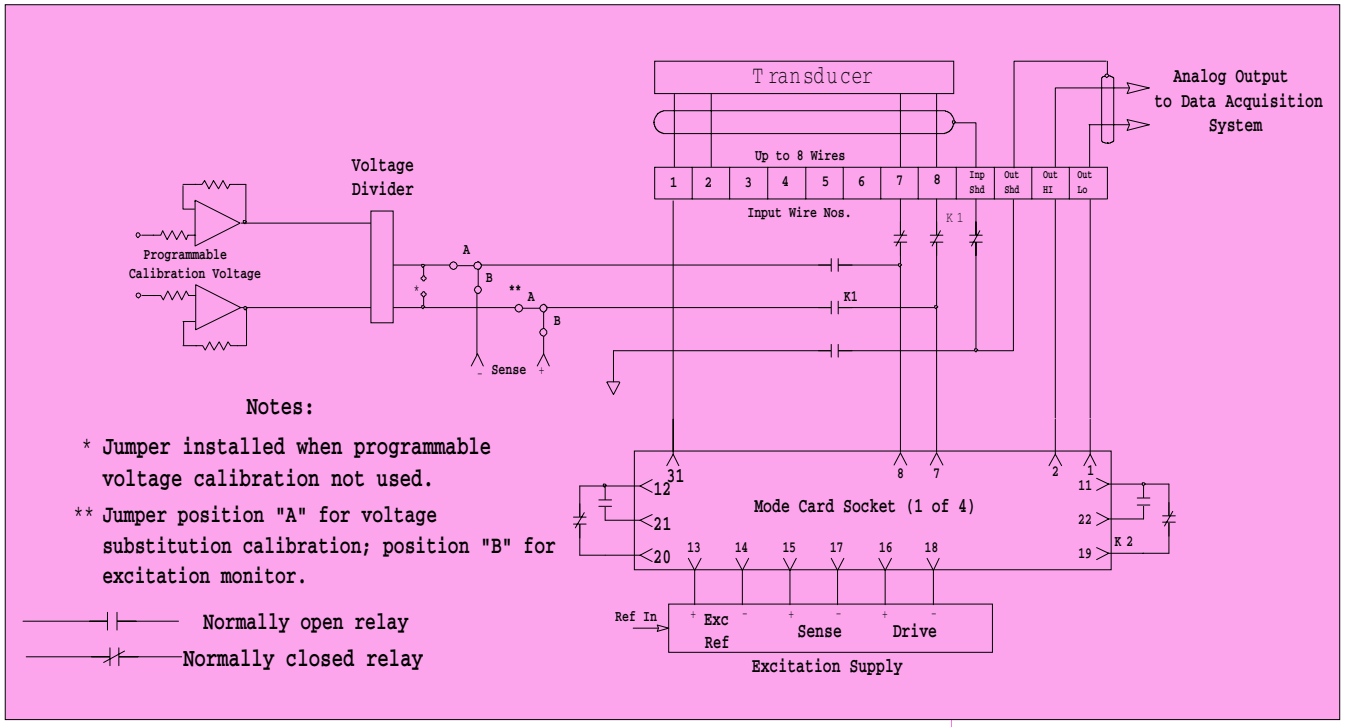
The Neff Series 300 Signal Conditioner is a data acquisition subsystem that helps convert transducer changes into electrical signals for measurement by analog systems. Each channel can be individually configured for a particular transducer type. The subsystem provides constant voltage or constant current excitation, bridge completion, and programmable calibration.

The Series 300 Signal Conditioner features an individual excitation regulator for each input channel. Advantages of individual excitation are: (1) excitation voltage or current is individually selectable; and (b) a short on the excitation supply of one channel will not affect other channels. The excitation regulator for each channel is mounted on the four-channel Input Conditioning card and is configured by a plug-in mode card for either constant voltage or constant current operation. Remote sensing is achieved by the removal of jumper links. Pre-regulated dc power is obtained from a power supply in the 64-Channel Input Assembly.

Basic Signal Conditioning

Many transducers, particularly bridge types, require auxiliary circuits for operation. These are provided by the Input Conditioning circuits. A mode card configures the Input Conditioning and calibration circuits for operation with a particular type of transducer. The excitation supply, one per channel, provides constant voltage or constant current excitation as appropriate for the transducer type. While each channel has its own regulator, all regulators within a 64-channel assembly are driven by a common supply.

Series 300 Signal Conditioner (Continued)



Voltage substitution from a programmable source is a calibration mode that can be applied to all channels, regardless of transducer type. Voltage substitution is useful for determining system gain, linearity, and accuracy. By programming "zero input", system noise and zero stability can be checked.

Transducer calibration is a function of transducer type. Bridge transducers require shunt calibration; a calibration resistor of known value is switched in parallel with one arm of the bridge. RTD (resistance-temperature device) transducers are usually calibrated using an R-Substitution method in which the RTD is removed from the system input and replaced by a precision calibration resistor. Thermocouple measurement channels are calibrated by substituting a precision voltage for the thermocouple input.

Input Conditioning Card (620350)

A four channel Input Conditioning plug-in printed circuit card is the basic component of the Series 300 Signal Conditioner. The Input Conditioning card provides excitation power, relays, and calibration circuits for each of four channels. Up to 16 of these cards can be installed in a 19-inch by 7-inch mounting assembly that provides primary power, computer decoding logic, and connector terminations for 64 channels.

Each Input Conditioning card accepts four "piggyback" Mode cards, one for each channel, that configure the input conditioning and calibration circuits for operation with a particular type of transducer. Standard Mode cards are available for use with most commonly used transducers while special Mode cards are available to accommodate virtually any type of transducer. Specifications of the standard mode cards are given on the following pages.

Series 300 Signal Conditioner (Continued)

Mode card calibration circuits provide precision voltage or resistance substitution for standard fixed calibration points appropriate for the transducer type. As an option, programmable calibration, for use with all types of transducers, is available.

Placement of a jumper permits excitation voltage readback.

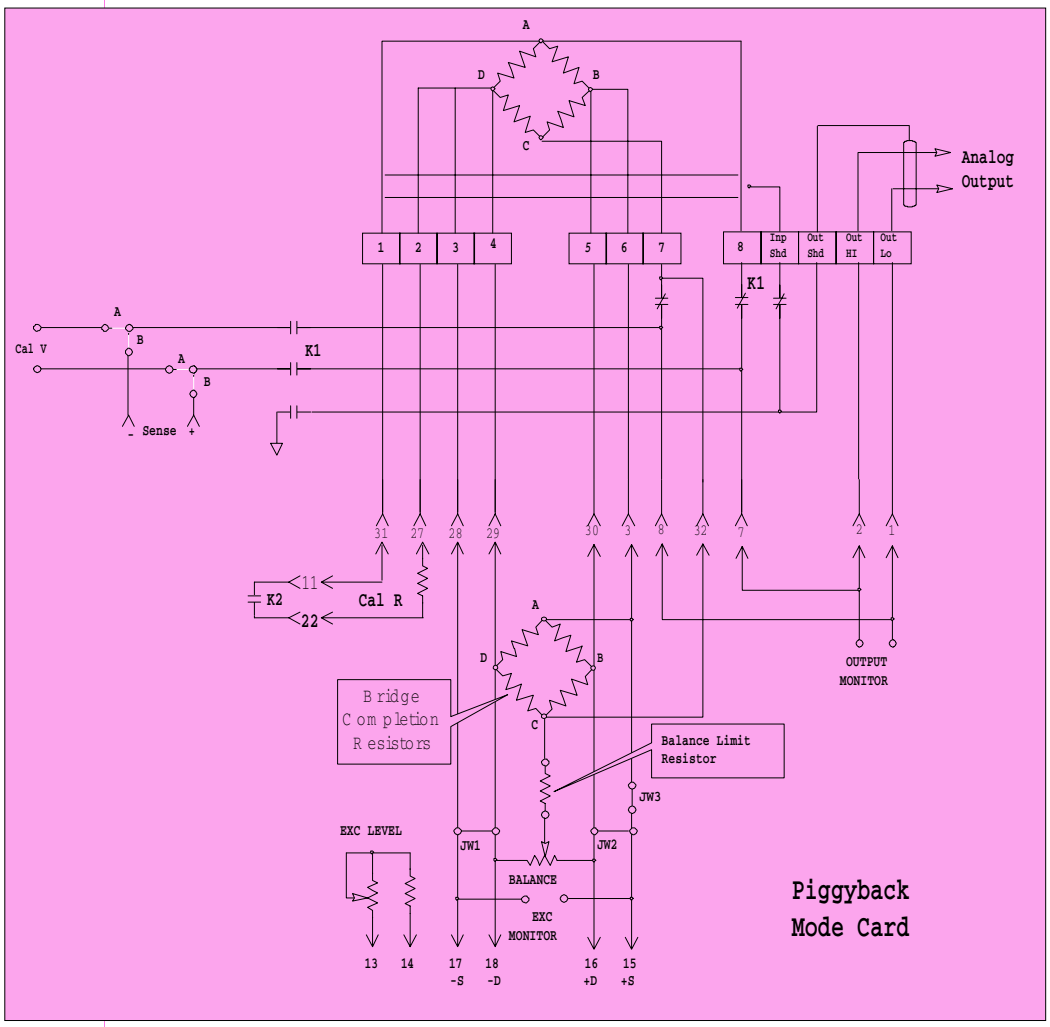
Standard input connections, up to eight conductors plus shield, are made to solder-type printed circuit card edge connectors. Optionally, an input card with screw terminals is available (620380). These terminals accept standard crimp-style wire lugs. Additionally, Barrier Strip/ Cable Assemblies are available as an option.

By adding 64-Channel Input Assemblies equipped with the required complement of four-channel Input Conditioning and Mode cards, channel capacity can be expanded to 2048. All necessary inter-assembly and interface cabling and solder-type input connectors are supplied

Strain Gauge Mode Card 620360

o Constant Voltage Excitation
o Remote Sensing
o Conditions 1, 2, or 4-Arm Bridges

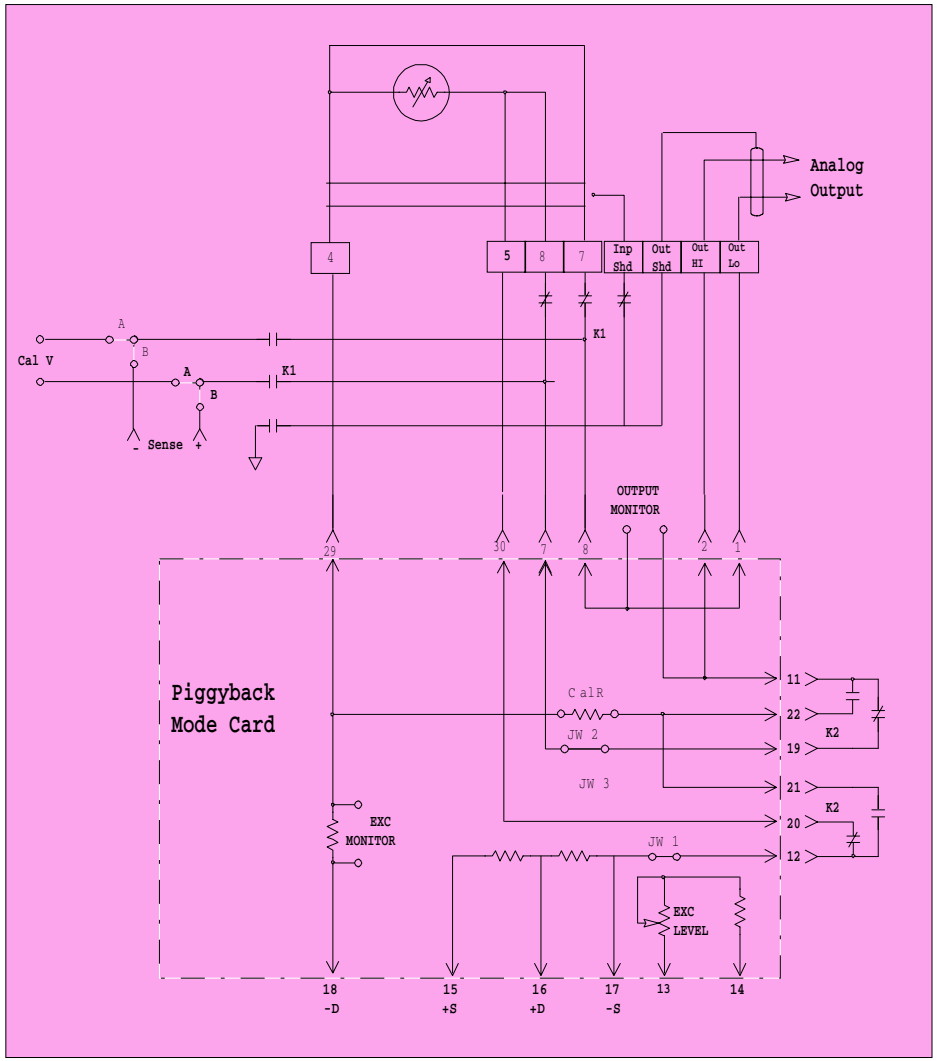
The Strain Gage Mode Card configures one channel of the four-channel Input Conditioning card to accommodate strain gages with one, two, or four active arms. It provides constant voltage excitation with remote sensing selected by jumper placement. Terminals are provided for mounting resistors for excitation scaling, bridge completion, balance limit, and calibration.



RTD / Potentiometer Mode Card 620361

- 0 Constant Current Excitation
- 0 Two, Three, or Four-Wire Configurations
- 0 Resistance Substitution Calibration

The RTD/Potentiometer Mode Card configures one channel of the four-channel Input Conditioning card for use with resistance-temperature devices or potentiometers in a two, three, or four-wire configuration. The excitation supply is set for constant current output.

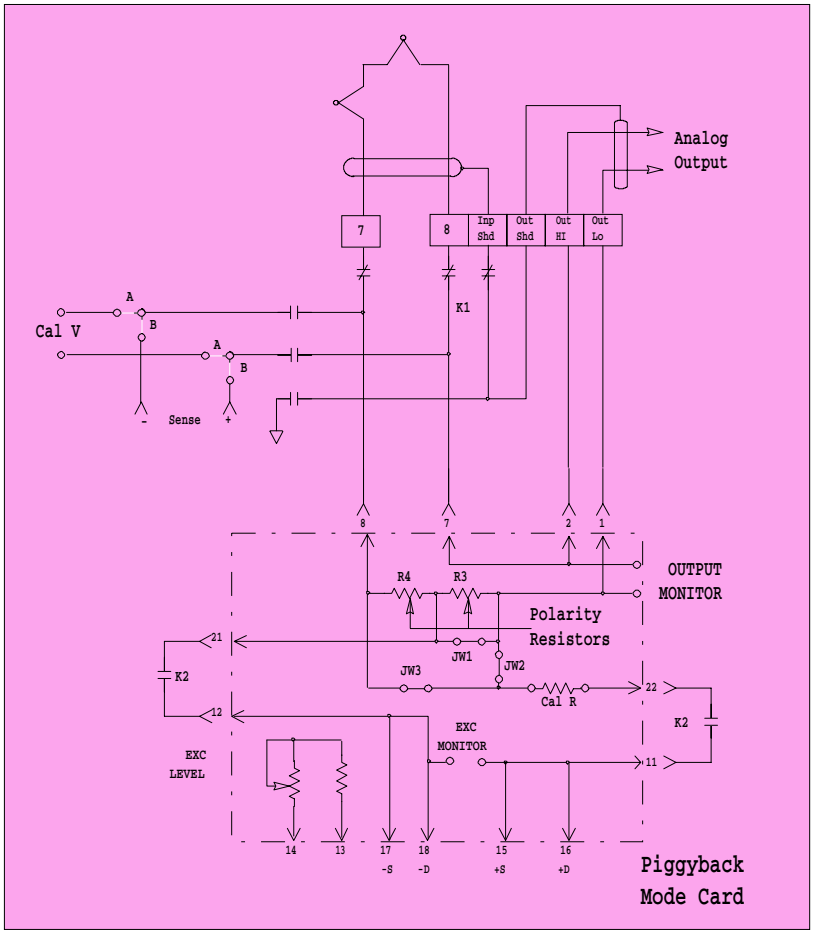


Thermocouple Mode Card 620362

0 5 Volt Calibration Voltage
0 Voltage Substitution T/C Calibration

Note: The user must provide an external reference junction.

The Thermocouple Mode card configures one channel of the four-channel Input Conditioning card to accommodate thermocouple or other low-level inputs. The excitation voltage is set to 5 V for use as a calibration source. Terminals for a resistive divider are provided to adjust the excitation-derived voltage for compatibility with channel sensitivity. Selecting the transducer Cal Mode causes the thermocouple input to be replaced by voltage appearing on the lower leg of the divider.



Series 300 Specifications

Excitation Power Supply

Constant Voltage Mode

Output Voltage: Continuously adjustable from2-10V by resistor adjustment on Mode Card.

Output Current: 100 mA maximum per channel, 3.8 A maximum per 64 channels. Each channel unconditionally short-circuit protected.

Response Time: Excitation supply output will settle to within 1%of setting in less than 20 uS from a no-load to full-load change. Turn-on overshoot less than 10% of setting.

Line Regulation: Less than 0.01% or 200 uV, whichever is greater, for a ±10% input line voltage variation.

Load Regulation: Less than 0.01% or 200 uV, whichever is greater, for a no-load to full-load change.

Ripple: Less than 100 uV peak-to-peak in a dc to 1KHz bandwidth.

Stability: ±0.01% at constant temperature: ±0.005%/°C.

Remote Sensing: Positive and ground sense leads are provided for remote sensing. Sense lead current less than 100uA.

Constant Current Mode

Output Current: Adjustable from 2-50 mA by resistor adjustment on Mode Card.

Compliance Voltage: 0 to 7 volts.

Response Time: Output settles to within 1% of setting in less than 50 uS from a no-load to full-load change. Output terminals unconditionally short-circuit protected. Turn-on overshoot less than 10%.

Line Regulation: ±0.01% or 0.1 uA, whichever is greater, for a ±10% input line voltage variation.

Output Impedance: $R_o = 5 \times 10^3 / I_o$ to 1 MOhm, maximum.

Ripple: Less than 2 uA peak-to-peak over the bandwidth dc to 1 KHz.

Output Stability: ±0.01% at constant temperature: ±0.005%/°C.

Series 300 Specifications (Continued)

Mode Cards

Strain Gage

Excitation Voltage: Adjustable from 4-10 V with 10 mV resolution by potentiometer with screwdriver adjustment.

Balance Control: 25,000 ohm, 15-turn cermet potentiometer with screwdriver adjustment. Temperature coefficient is ±100 ppm/°C. Terminals provide for mounting Balance Limiting resistor.

Bridge Completion: Terminals provide for four completion resistors.

Input Wiring: Up to 8 conductors with shield.

Test Points: Front mounted jacks for monitoring excitation voltage and channel output.

Calibration: Shunt resistive calibration, optional voltage substitution calibration, or normal operation selected by TTL logic.

Shunt Resistor: Terminals for mounting calibration resistor for single-point shunt calibration.

RTD/Potentiometer

Excitation Current: Continuously adjustable from 5-15 mA with 30 uA resolution by means of a front-mounted, screwdriver adjustable, potentiometer. A scaling resistor may be changed to achieve output currents above the range of 1-50 mA.

Compliance Voltage: 7 Volts maximum

Input Wiring: Up to 4 conductors with shield.

Test Points: Front mounted jacks for monitoring excitation current and channel output.

Calibration: Resistance substitution calibration, optional voltage substitution calibration, or normal operation selected by TTL logic.

Transducer: RTD or potentiometer is replaced by precision calibration resistor mounted on Mode Card terminals to accomplish single-point upscale calibration. Terminals for mounting calibration resistor are provided.

Series 300 Specifications (Continued)

Mode Cards

Thermocouple

Excitation Voltage: Used for calibration. Adjustable to 5 V ± 0.01% by screwdriver adjustable potentiometer.

Input Wiring: Two conductors with shield.

Test Points: Front mounted jacks for monitoring excitation voltage and channel output.

Calibration: Voltage substitution using excitation source; optional voltage substitution using external programmable source, or normal operation selected by TTL logic.

Transducer Calibration: Provides single-point voltage substitution calibration. Mode card includes provisions for mounting a divider network to achieve a millivolt level calibration voltage from the excitation supply.

System Specification

Power Requirements: 105-130 VAC or 200-250 VAC. 50 to 400 Hz; 150 W (max).

Physical Dimensions: 7-inch panel height in 19-inch rack; 23 inch depth behind front panel. Neff recommends mounting in 19-inch rack with 30-inch depth to accommodate connector build-up.

Weight: 28 pounds, without Four-Channel Conditioning cards.

Cooling Requirements: To be mounted in cabinet with unobstructed airflow and equipped with 300 cfm blower.

Environment: 0 C to 50C, 90% humidity, non-condensing. Will withstand shock and vibration of normal shipping and handling of laboratory equipment.

Series 300 Ordering Information

Configuring the Series 300

1. Determine the quantity of 64-Channel Input Assemblies necessary to mount the required number of channels. Each assembly includes the primary power supply, logic, cables, and solder-type input connectors.

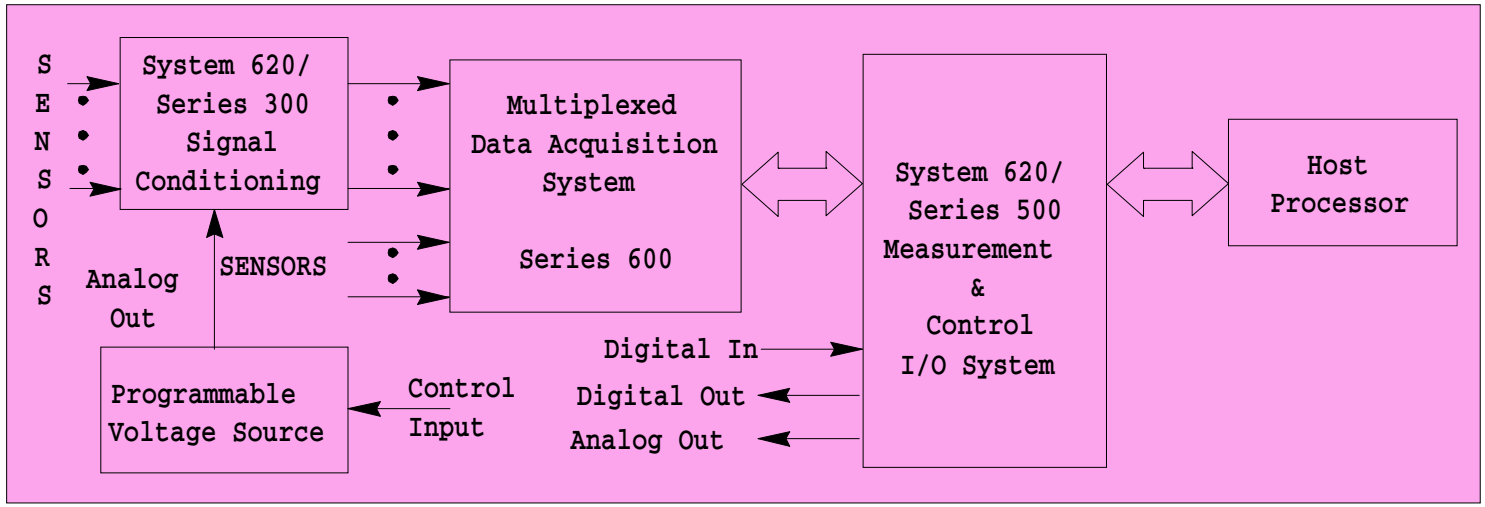
2. Determine the quantity of Four-Channel Input Conditioning cards necessary for the required number of channels. Solder type input connectors are provided for each card.

3. Determine the quantity of each type of Mode Card required according to the types of input transducers employed.

4. If screw terminals are desired in place of the standard solder-type printed-circuit card edge connectors, order the appropriate number of Four-Channel Screw Terminal cards.

620300	64 Channel Input Assembly	N/64
620350	4-Channel Input Conditioning Card	N/4
Mode Cards		
620360	Strain Gauge	N//1
620361	RTD/Potentiometer	N/1
620362	Thermocouple	N/1
620380	Four-Channel Screw Terminal Card	N/4
620313	Extender Cards	
620953	Instruction Manual	

Series 500 Measurement and Control System



- o Links I/O Functions to Host Computer
- o Versatile Computer I/O
- o Plug-in Function Cards

- o Easy Expansion
- o Local or Remote Data Acquisition

Introduction

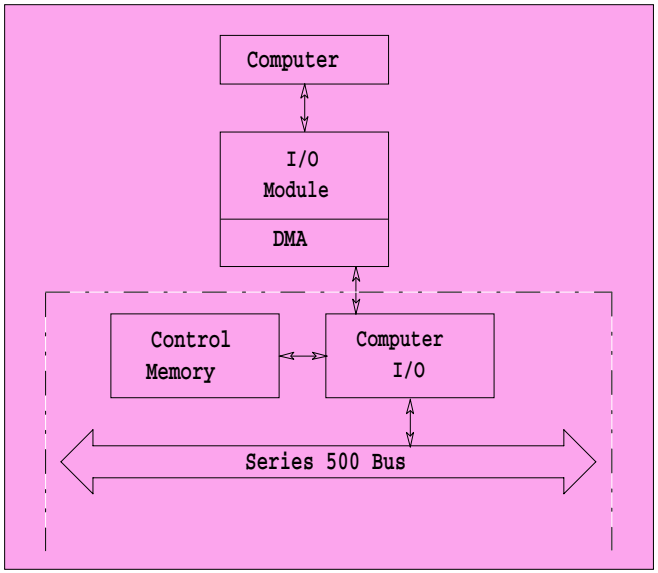
The Series 500 is one member of the Neff System 620 family of computer controlled measurement and control subsystems. Its purpose is to provide communication between the controlling computer and other members of the System 620 family, including analog systems and analog or digital I/O function cards.
A major feature of the Series 500 is a serial data link that controls the operation of up to eight remote systems located to 1000 meters from the computer.

Expansion modules provide easy expansion of function card capacity -- up to 256 function cards per local or remote site.

Basic functional areas within the Series 500 are:

1. Local Series 500 Bus
2. Computer I/O Card and Memory Control
3. Function I/O (includes analog "front ends" and Series 500 analog and digital function cards.)

Series 500 Measurement and Control System (Continued)



Series 500 Bus

The Series 500 is based on a proprietary 18-bit input bus and a 16-bit data bus. The input bus is used to communicate function addresses, instructions or data from the computer to the various functions. The data bus is used to transmit output data from the selected function to the computer. Bus transfers are accomplished through an interlocked handshake arrangement. Bus control signals include four request lines that may be used by an I/O function to interrupt the program.

Computer I/O

The interface between the Series 500 bus and the computer is a SCSI interface.

Analog Subsystem Control

1. Dual Buffered Controller. A/D data are stored in a data buffer until the buffer is filled. New data are diverted to the alternate buffer and an interrupt request is sent to the host computer to initiate a transfer of data from the first buffer. Dual ping-pong data buffers ensure continuous, gapless data.

Series 500 Measurement and Control System (Continued)

Function Card I/O

Various I/O functions are interfaced to the Series bus by function cards that plug into the Series 500 assembly. Standard function cards are listed below. These are described individually in the following pages..

32-Bit TTL Output (620530). Transfers TTL data from the Series 500 bus to peripheral device.

16-Point Relay Output (620531). Drives various functions with signals derived from the Series 500 bus.

Eight-Channel DAC Output (620540). Outputs eight individual analog signals derived from digital data on the bus.

Four-Channel Isolated DAC (620541). Outputs four individual analog signals, each of which is galvanically isolated. Ideal for control application

Fiber-Optic Serial Link (620552). Enables the use of fiber-optic cables as the serial link between the Eight-Point Serial Controller at the local site and a remote system. Consists of fiber-optic paddleboards to replace the cable termination boards used for driving coax cables.

32-Bit TTL Input (620560). Transfers TTL data from the peripheral device to the Series 500 bus.

32-Bit Isolated DC Sense (620561). Monitors contact closures or other types of event lines and generates interrupt requests to the computer.

Four-Channel Counter/Stepper (620562). Allows frequency measurement, period measurement, and event counting. It also delivers pulse outputs.

Isolated 32-Bit TTL Input (620564). Transfers 32 bits of TTL data from the peripheral device to the Series 500 bus; includes a "data hold" output.

Eight-Port Serial Controller (620576). Permits the operation of up to eight remote systems located at distances up to 20,000 feet from the computer.

Series 500 Measurement and Control System (Continued)

Series 500 Assemblies

Each Series 500 assembly is 14-inches high, 19-inches wide, and 22-inches deep. Each is equipped with a power supply and can accommodate multiple function cards

Local Input Assembly (620500). The Local Input Assembly is designed to service I/O functions at the local (computer) site. A Computer I/O card links the Series 500 bus to the computer interface. Up to 16 function cards can be installed in any combination. The Display/Control Panel is standard on this assembly.

Remote Input Control Assembly (620502). The Remote Input Control Assembly is designed to service I/O functions at a remote site (up to 20,000 feet from the computer). A Transmitter/Receiver (T/R) card transmits and receives data to and from an Eight-Port Serial Controller function card installed in the system at the local site. All transmissions are carried over coax or fiber-optic cables to the local site. Up to 16 function cards can be installed in this assembly in any combination. The Display/Control Panel is standard on this assembly.

Expansion Input Assembly (620501). The Expansion Input Assembly is used at either a local or remote site (or both) to increase function card capacity at the site. Up to 15 Expansion Input Assemblies (multiple function cards each) can be "daisy-chained" to the first Input control or Remote Input control Assembly for a total function card capacity of 256 per site. The assembly is equipped with a Decode/Buffer card to regenerate the Series 500 bus and to provide address decoding for the additional data points or channels. The Display/Control Panel is not used on this assembly.

Synchronized Digital Input Assembly (620503). This assembly is used to expand the HSRO (High Speed Read Only) capacity of the Dual-Bus Buffered Controller type of Analog System Controller, which allows intermixing of analog and digital inputs. Series 500 dual-bus controller configurations are described in the following pages. The Display/Control Panel is not used on this assembly.

Local Dual-Bus Buffered Controller Assembly (620520)
This dual bus assembly is designed to service I/O functions at the local (computer) site while supporting continuous, gap-free data with synchronous discrete signal inputs. A Computer I/O card links the Series 500 bus to the computer interface. Up to 7 function cards can be installed in both the HSRO bus and the Standard bus. The Display/Control Panel is standard on this assembly.

Remote Dual-Bus Buffered Controller Assembly (620519) This dual bus assembly is designed to service I/O functions at the remote (computer) site while supporting continuous, gap-free data with synchronous discrete signal inputs. A Computer I/O card links the Series 500 bus to the computer interface. Up to 7 function cards can be installed in both the HSRO bus and the Standard bus. The Display/Control Panel is standard on this assembly.

Series 500 Local Configurations

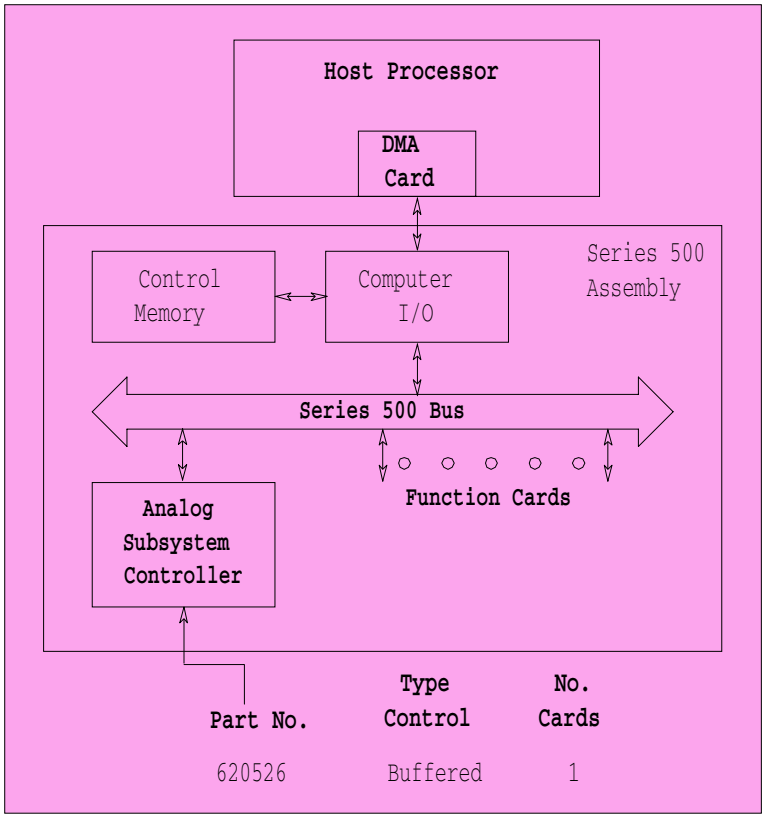
Local Configurations

The Series 500 provides the interface between the host processor and the System 620 product family.

One of the principle functions of the Series 500 is analog subsystem control. Multiple analog subsystems can be controlled using a single Series 500 assembly.

The table below indicates the available Series 500 assemblies that can be used for local configurations and the number of available card slots. Note that the Local Dual-Bus Buffered Controller Assembly, 620520, uses a split bus arrangement -- Series 500 I/O bus and High-Speed Read Only (HSRO) bus, which enables discrete inputs to be read as part of the analog input scan.

Expansion Assemblies (620501) can be added to increase function card capacity. The HSRO bus can be expanded using 620503



Part Number	Assembly	Available Slots	Remarks
620500	Local Input Assembly	16	Does not include Analog
620520	Local Dual-Bus Buffered Controller Assembly	S500 I/O:7 HSRO:7	Includes Buffered Controller and integral HSRO

Local Dual-Bus Buffered Controller Assembly 620520

Description

The dual-bus configuration of the Local Buffered Controller provides the user with programmable control over a local analog system's scan and sample rate and permits analog and digital addresses to be intermixed in a single scan list. In addition, the use of two data buffers allows data to be acquired continuously (no data gaps) and a 1000-hour elapsed time clock can be used to time stamp all acquired data.

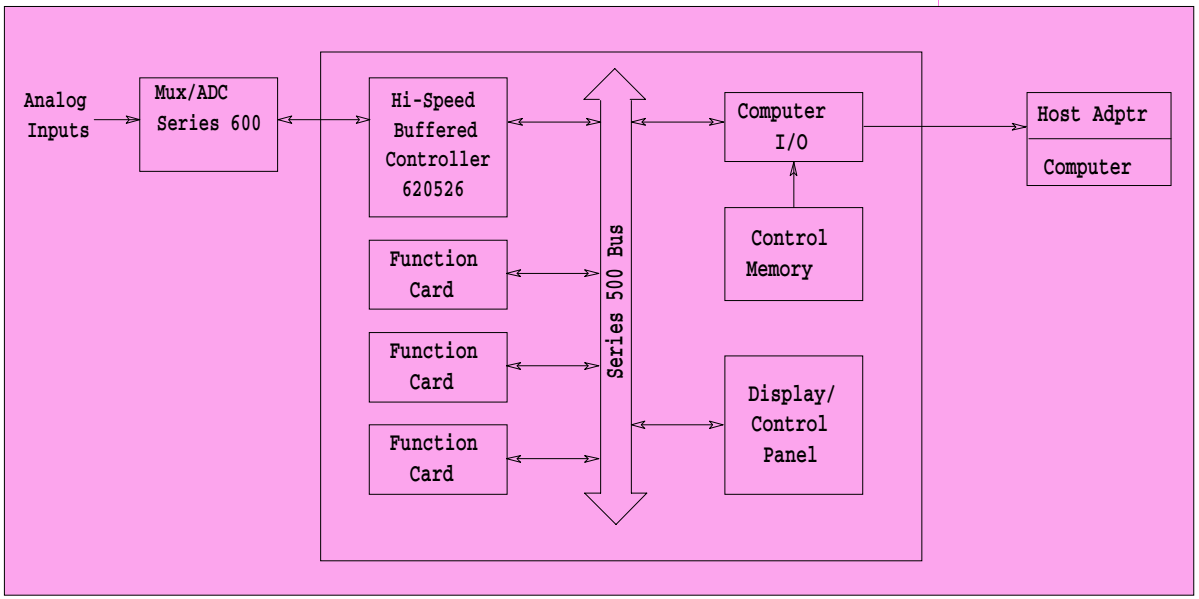
Intermixed sampling of analog and digital inputs preserves exact time correlation between digital events and analog readings. External time signals, for example, can be read into the analog scan.

Local Dual-Bus Adapter Assemblies consist of a Series 500 dual-bus rack with front-panel controller and are equipped with a scan control memory, quartz-based clock, digital bus adapter, 1000-hour clock, and dual RAM buffers.

The Digital Bus Adapter holds the 1000-hour elapsed time clock and controls the High-Speed, Read-Only (HSRO) bus, which is used exclusively for digital input functions (TTL, DC Sense, Isolated Latch, etc.). The Series 500 standard I/O bus is used for digital output functions and analog I/O.

The scan list, stored in the scan control memory on the High Speed Buffered Controller, includes both analog channel addresses and digital input addresses. Digital input cards on the HSRO bus are addressed via the Bus Adapter, as if they were analog signals. As the scan list is executed, A/D data and digital input data are returned to the Dual RAM Buffer. Data are written, alternately, to the two data buffers. As one buffer is filled, an interrupt request is posted to the host computer. That initiates a read operation from that buffer while A/D data, uninterrupted, is written into the second buffer. This technique overcomes the timing limitations of software operating systems and supports continuous data acquisition.

The programmable quartz-based clock precisely controls samples and scan rates and provides a time base for the 1000-hour clock.



Local Dual-Bus Buffered Controller Assembly (Continued) 620520

Specifications

Scan Memory: 8K Words.

Data Buffers: 28K Words each.

Programmable Sample Period: 10 us to 255 us; resolution 1.0uS

Programmable Scan Period: 10 us to 1.023 sec; resolution 10 us, 100 us, 1 ms.

Rate (Data Buffer to Computer, DMA): 300KWords/Sec

Function Card Capacity:

Std Bus:
7 function cards.

HSRO Bus:
7 function cards, accepts the following
620560:32-Point TTL Input.
620561:32-Point DC Sense.
620562:4-Channel Counter/Stepper (counter functions only).
620563:Isolated Latch.
620564:Isolated Latch w/Data Hold

1000-Hour Clock

Format: BCD; read as six words: hours, minutes, seconds, milliseconds, and microseconds, plus two overhead words; freeze time and resume time.

Elapsed Time: 1000 hours, maximum.

Resolution: 1 uS.

Reset: Under program control.

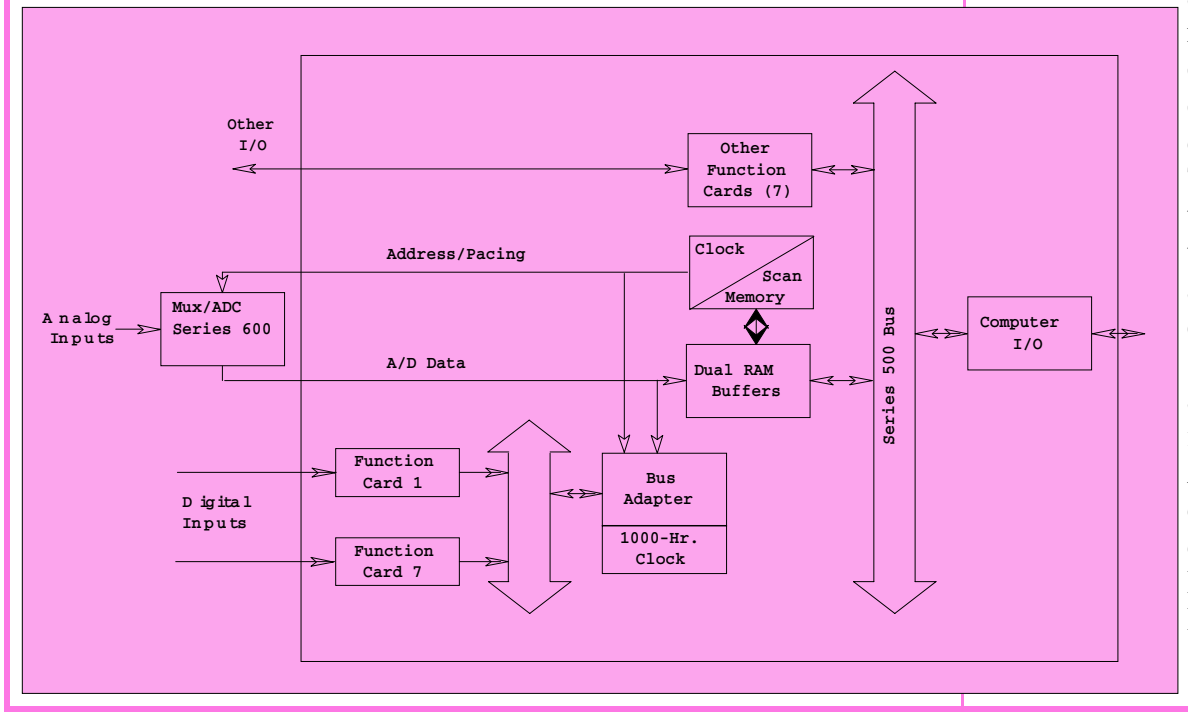
Expansion: **Series 500 Bus:** Assembly 620501 (16 additional card slots).
HSRO Bus: Assembly 620503 (16 additional card slots).

Local Dual-Bus Buffered Controller Assembly (Continued) 620520

Power Requirements:	105 to 130/200 to 250 VAC, 50 to 400 Hz; 720 W, maximum.
Operating Temperature:	0°C to 50°C; 90% relative humidity, non-condensing. Will withstand shock and vibration of normal shipping and handling of laboratory equipment.
Cooling Requirements:	To be mounted in cabinet with unobstructed airflow and equipped with 300 cfm blower.
Physical Dimensions:	14-inches high, 19-inches wide, and 22-inches deep. Neff recommends that assemblies be mounted in a 19-inch rack having 30-inch depth to accommodate connector build-up.
Weight:	50 pounds
Cables:	Interconnecting cables between Local Dual Bus Buffered Controller Assemblies and the analog system are supplied when the controller Assembly is purchased with the analog system. If purchased later for field installation, it is necessary to purchase a Shipping Kit that includes the appropriate cables. Shipping Kit part numbers are listed below.
Series 600:	9010100

Local Buffered Controller Card 620526

- o Dual Data Buffers for Continuous Data Acquisition.
- o Precise Programmable Control over Scan and Sample Rate.
- o Enhanced Data Handling Capability of Computer Interface.
- o Allows Operation of Multiple Analog Systems to Increase Total Data Input Rate.



Description

Local Buffered Controller Card Sets provide the user with precise timing control over channel sampling rate and scan repetition rate of a Neff analog system operated at or near the computer site. The use of dual data buffers allows continuous acquisition of analog data and enhances the data handling capability of the Series 500 computer interface.

Card 620526 consists of one card performing combined functions. Basic functions include a programmable clock, scan control memory, and dual RAM buffers. A card set is installed in a Series 500 Input Control Assembly (620500), which includes Computer I/O circuitry. The assembly has the capacity for 15 additional function cards to accommodate other I/O functions.

The RAM scan control memory is initially loaded with the desired scan list (channel number and gain) to control the scanning sequence of the analog system. Scan and sample rates are controlled by a programmable quartz-based clock. The clock pulses are applied to the sample & hold amplifier (preceding the ADC) in the analog system. This technique provides precise timing in the analog domain.

A/D data are returned from the analog system to the dual data buffers. As the scan list is executed, A/D data and digital input data are returned to the Dual RAM
Buffer.

Local Buffered Controller Card (Continued) 620526

Data are written, alternately, to the two data buffers. As one buffer is filled, an interrupt request is posted to the host computer. That initiates a read operation from that buffer while A/D data, uninterrupted, is written into the second buffer. This technique overcomes the timing limitations of software operating systems and supports continuous, gap-free data acquisition.

Once the scan list is entered into control memory and execution initiated, the only activity on the Series 500 bus and computer interface is the reading of the data buffers. Since the buffer read operation is a high-speed data transfer, time is available between transfers to read and write other functions on the bus or to service an additional analog system/buffered controller, which doubles the analog input rate. For example, two Series 600 systems (100 KHz) results in an analog input rate of 200 KHz.

Specifications

Cards:	620526:	(1) High Speed Buffered Controller.
Scan Memory:	620526:	8K Words.
Data Buffers:	620523:	4K Words each.
	620526:	28K Words each.
Programmable Sample Period	620526:	10 uS to 255 uS; Resolution = 1.0 uS.
Programmable Scan Period	620526:	10 uS to 1.023 S; Resolution = 10 µS, 100 µS, 1.0 mS.
Maximum Read Rate (Data Buffer to Computer, DMA):	620526:	300K Words/Sec.
Maximum Average Continuous Acquisition Rate:	620526:	100 KHz.
Hardware Requirements:		Card sets are installed in the Input/Control Assembly (620500).
Cables:		Interconnection cables between Local Buffered Controller Card Sets and the analog system are supplied when the Card Set is purchased with the analog system. If purchased later for field installation, it is necessary to purchase a Shipping Kit that includes the appropriate cables. Shipping Kitpart numbers are listed below.
Series 600:		9010100

Series 500 Remote Configurations

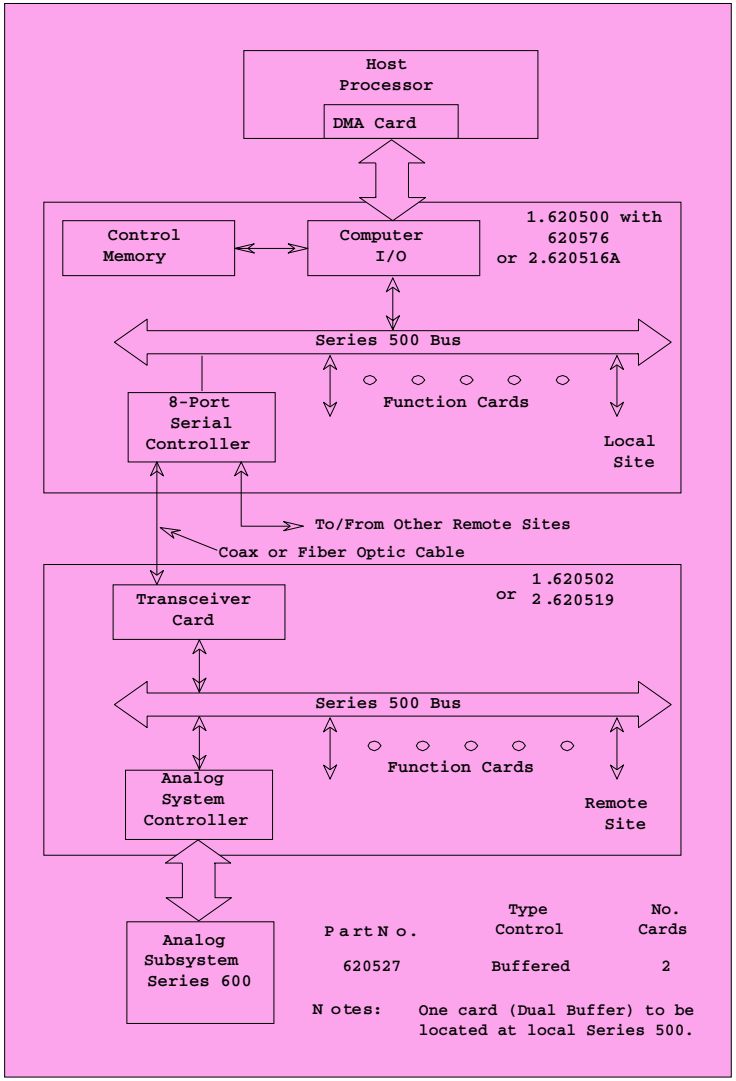
Remote Configurations

The Series 500 supports various remote configurations. Each remote configuration requires that a Series 500 assembly be installed local to the host computer and a Series 500 assembly be installed at the remote site. An Eight-Port Serial Controller (620576) is installed at the local Series 500 providing control of up to eight remote systems which can be located up to 1500 meters from the computer site. The serial links between the local and remote sites can be implemented with either coax or fiber optics.

One of the principal functions of the Series 500 is analog subsystem control. Multiple analog systems can be controlled using a single Series 500 assembly.

The table on the following page indicates the available Series 500 assemblies that can be used for remote configurations and the available number of function card slots. Note that the Remote Dual-Bus Buffered Controller Assembly, 620519 , utilizes a split-bus arrangement: Series 500 I/O bus and a High-Speed Read-Only (HSRO) bus. This technique enables discrete inputs to be read as part of the analog input scan.

Expansion Assemblies (620501) can be added to increase function card capacity. The HSRO bus can be expanded using 620503.



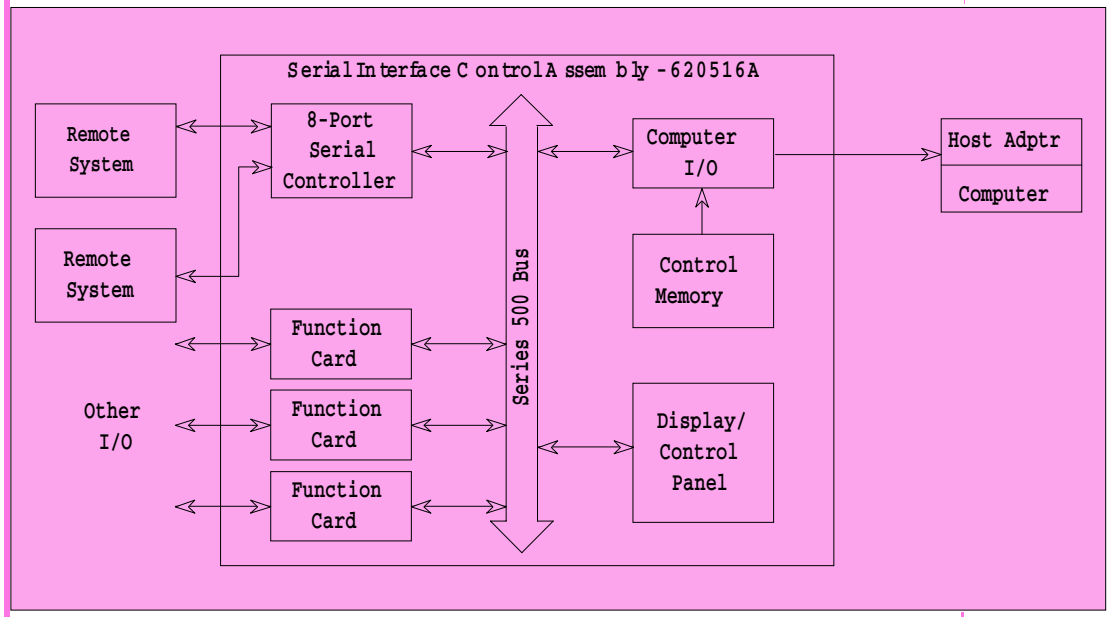
Series 500 Remote Configurations (Continued)

Part Number	Assembly	Available Slots	Remarks
620500	Local Input Control Assembly	16	Located at Host. Requires 8-Port Serial Controller (620576) for Remote Configuration
620502	Remote Input Control Assembly	16	Located at Remote Site. For remote configurations, requires Buffered Controller (620527) for Series 600.
620516A	Serial Interface Control Assembly	3	Located at Host. Includes 8-Port Serial Controller (620576)
620519	Remote Dual-Bus Buffered Controller Assembly	S500 I/O:7 HSRO:7	Includes Buffered Controller (620527) and separate HSRO Bus

Available Series 500 Assemblies for Remote Configurations

Serial Interface Control Assembly 620516A

- Primary Interface Between the Computer and up to Eight Remote Subsystems.
- Discrete I/O Capability.
- Error Check for All Serial Transmissions.
- Coax or Fiber-Optic Serial Links.



Description

The Serial Interface Control Assembly is the primary interface between computer and up to eight remote subsystems located up to 1500 meters from the computer. Installed at the local (computer) site, the Serial Interface Control Assembly is equipped with an Eight-Port Serial Controller function card that transmits and receives serial data to and from the remote subsystems over coax or fiber-optic cables.

Full Remote Analog and Digital Capability

Remote subsystems, interfaced to a Remote Site Control Assembly, can be fully expanded and used with the Series 300 Signal Conditioner. Maximum sampling rates are determined by the type and length of cable installed. The maximum rate of 100 KHz is maintained at distances up to 1500 meters using fiber-optic cable. The rate decreases when coax cables are used.

Discrete I/O

Three additional function cards can be installed in the Serial Interface Control Assembly to accommodate other I/O functions (contact closures, frequency, TTL, analog output, etc.) at the local site.

Serial Interface Control Assembly (Continued) 620516A

Specifications

Transmission Mode: Half or full duplex, depending on operating mode and I/O function.

Transmission Accuracy: Less than 1 error/10^9 transmissions.

Card Complement: Computer I/O (includes 4096-word RAM):
Display/Control Panel (optional);
Function Cards:
1. Eight-Port Serial Controller;
2. Any (optional);
3. Any (optional);
4. Any (optional).

Compatible Systems (at remote site): 620502 - Series 500 Remote Input Control Assembly;
620519 - Remote Dual-Bus Buffered Controller Assemblies.

Maximum Distance: 1000 feet using RG-8 coaxial cable
1500 meters using fiber optic cable.

Power Requirements: 105 to 130/200-250 VAC, 50 to 400 Hz;
720 W, maximum.

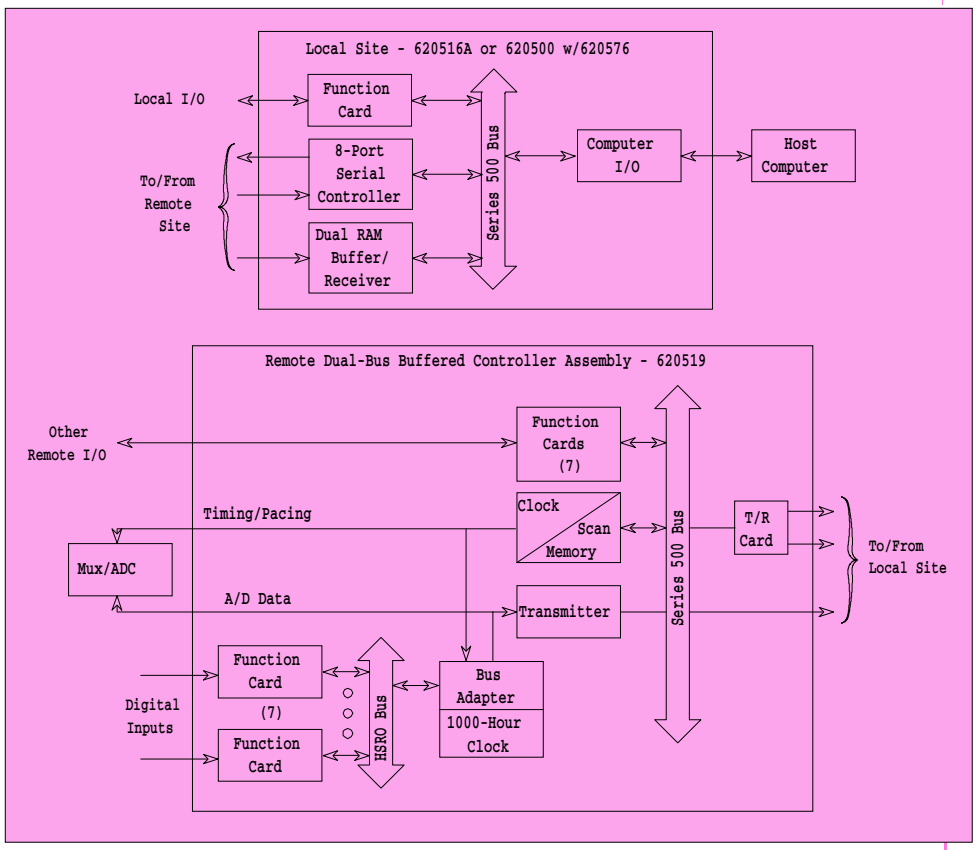
Operating Environment: 0° to 50°C; 90% relative humidity, non-condensing. Will withstand shock and vibration of normal shipping and handling of laboratory equipment.

Cooling Requirements: To be mounted in cabinet with unobstructed airflow and equipped with a 300 cfm blower.

Physical Dimensions: 14-inches high, 19-inches wide, and 22-inches deep. Neff recommends that assemblies be mounted in a 19-inch rack having 30-inch depth to accommodate connector build-up. Weight without function cards is 50 pounds.

Remote Dual-Bus Controller Assembly 620519

- o Precise Programmable Control Over Scan and Sample Rates.
- o 1000-Hour Clock Time-Stamps Incoming Data.
- o Dual Bus Allows Intermixed Analog/Digital Inputs.
- o Dual Data Buffers for Continuous Data Acquisition.
- o Enhanced Data Handling Capability of Computer Interface.
- o Time Correlation Between Digital Events and Analog Data Samples.



Description

The dual-bus configuration of the Remote Buffered Controller provides the user with programmable control over a remote analog system's scan and sample rate and permits analog and digital addresses to be intermixed in a single scan list. In addition, the use of two data buffers allows data to be acquired continuously (no data gaps) and a 1000-hour clock can be used to time-stamp all incoming data.

Intermixed sampling of analog and digital inputs preserves exact time correlation between digital events and analog readings. External time signals, for example, can be read into the analog scan.

Remote Dual-Bus Buffered Controller Assemblies consist of a Series 500 dual-bus rack with front panel controller and equipped with a Transceiver (T/R) Card, quartz-based clock, scan control memory, digital bus adapter, 1000-Hour Clock, and Data Transmitter. They also include a Dual RAM Buffer/Receiver to be installed at the local assembly (computer site). See “Specifications” for local site hardware requirements.

Remote Dual-Bus Controller Assembly (Continued) 620519

The remote system communicates with the host computer over a serial data link implemented by an Eight-Port Serial Controller function card in the local assembly and the T/R card in the Remote Buffered Controller. The local and remote sites communicate over coax or fiber-optic cables.

The Digital Bus Adapter holds the 1000-hour elapsed time clock and controls a separate High Speed Read-Only (HSRO) bus used exclusively for digital input functions (TTL, DC Sense, Isolated Latch, etc.). The Series 500 standard I/O bus is used for digital output functions and analog I/O.

The scan list, stored in the Buffered Controller's scan control memory, includes both analog channel addresses and digital addresses. Digital input points on the HSRO bus are addressed as if they were analog channels. As the scan list is executed,
A/D data and digital input data are applied to a Transmitter, which returns the data serially to the Dual RAM Buffer/Receiver in the local assembly. Data is written, alternately, to the two data buffers. As one buffer is filled, an interrupt request is posted to the computer, which initiates a DMA read operation from that buffer while acquired data, uninterrupted, is loaded into the second buffer. This technique overcomes the timing limitations of software operating systems and results in continuous data acquisition.

The programmable quartz-based clock precisely controls sample and scan rate and provides a time base for the 1000-hour clock.

Specifications:

Scan Memory: 8K Words each.

Data Buffers (2): 16K Words each.

Programmable Sample Period 10 uS to 255 uS; Resolution; 1 uS.

Maximum Transfer Rate (Data Buffer to Computer, DMA): 300K Words/Sec;

Maximum Continuous Acquisition Rate: 100 KHz;

Function Card Series 500 I/O Bus Capacity:

Std bus: 7 function cards;

HSRO Bus: 7 function cards; accepts the following:

620560 -32-Point TTL Input;
620561 -32-Point DC Sense;
620562 -4-Channel Counter/Stepper
620563 -Isolated Latch;
620564 -Isolated Latch with Data Hold.

Remote Dual-Bus Controller Assembly (Continued) 620519

1000-Hour Clock

Format: Read as six words: hours, minutes-seconds, milliseconds, and microseconds, plus two overhead words; freeze time and resume time.

Elapsed Time: 1000 hours, max.

Resolution: 1 uS.

Reset: Under program control.

Expansion: Series 500 I/O Bus: Assembly 620501 (16 additional slots);
HSRO Bus: Assembly 620503

Hardware Requirements at Local Site: 620516A Serial Interface Control Assembly or 620500 Input Control Assembly with 620576 Eight-Port Serial Controller function card.

Maximum Cable Length (Computer to Remote System): 1000 feet using RG-8 coaxial cable.
1500 meters using fiber optic cable.

Power Requirements: 105 to 130/200 to 250 VAC, 50 to 400 Hz; 720 W, maximum.

Operating Environment: 0°C to 50°C, 90% relative humidity, non-condensing

Environment: Will withstand shock and vibration of normal shipping and handling of laboratory equipment.

Cooling Requirements: To be mounted in cabinet with unobstructed airflow and equipped with a 300 cfm blower.

Physical Dimensions: 14-inches high, 19-inches wide, and 22-inches deep. Neff recommends that assemblies be mounted in a 19-inch rack having 30-inch depth to accommodate connector build-up.
Assembly 620519 weighs 52 pounds.

Cables: Interconnecting cables between Remote Dual-Bus Buffered Controller Assembly and the analog system are supplied when the Controller Assembly is purchased with the analog system. If purchased later for field installation, it is necessary to purchase a Shipping Kit that includes the appropriate cables. Shipping Kit part numbers are listed below.

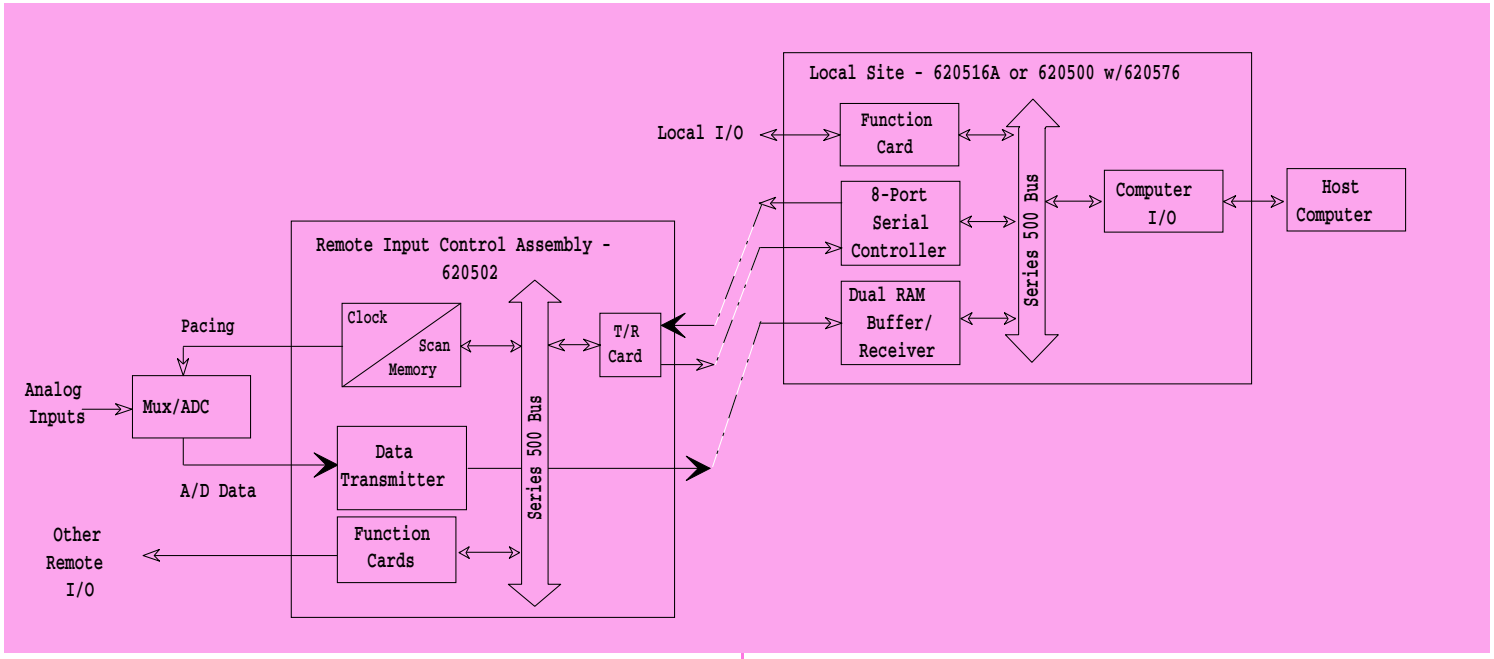
Series 600 9010104

Remote Buffered Controller Card 620527

- o Dual Data Buffers for Continuous Data Acquisition.
- o Precise Programmable Control Over Scan and Sample Rates of Remote Analog Systems.
- o Enhanced Data Handling Capability of Computer Interface.
- o Allows Operation of Multiple Remote Analog Systems to Increase Total Data Input Rate.

Description

Remote Buffered Controller Card Sets provide the user with precise timing control over channel sampling rate and scan repetition rate of Neff analog systems operating at remote sites. The use of dual data buffers allows continuous acquisition of analog data and enhances the data handling capability of the Series 500 computer interface. Remote systems communicate with the host computer over a serial data link implemented by an Eight-Port Serial Controller function card at the local (computer) site and a Transmitter/Receiver (T/R) in each remote system.



Remote Buffered Controller Card(Continued) 620527 620527

Card Set 620527 consists of two cards, one of which includes combined functions. Basic functions include a Programmable Clock, Scan Control Memory, Data Transmitter, and (at the local site) dual RAM Buffer/Receiver. The Dual RAM Buffer/Receiver is installed in the assembly at the local site (see "Hardware Requirements" under "Specifications"). The other cards are installed in a 620502 Remote Input Control Assembly, which includes a Transmitter/Receiver to terminate the serial data link and has provision for 15 function cards to accommodate other I/O functions.

The RAM scan control memory is initially loaded with the desired scan list (channel number and gain) to control the scanning sequence of the analog system. Scan and sample rates are controlled by the programmable quartz-based clock. The clock pulses are applied to the sample & hold amplifier (preceding the ADC) in the analog system. This technique provides precise timing in the analog domain.

As the scan list is executed, A/D data is returned to the data transmitter, which converts the data to serial form and transmits it back to the dual RAM buffers/receivers at the local site. When one buffer is filled, an interrupt request is posted to the host computer, which begins a DMA read operation from the buffer while A/D data, uninterrupted, is written to the second buffer. This results in continuous, gapless data.

Once the scan list is entered into control memory and execution initiated, the only activity on the Series 500 bus and computer interface is the reading of the data buffers. Since the buffer read operation is a high-speed data transfer, time is available between transfers to read and write other functions on the bus or to service an additional analog system/buffered controller, which doubles the analog data rate. For example, two Series 600 systems (100 KHz) results in an analog input rate of 200 KHz.

Specifications

Cards:	High Speed Buffered Controller. Dual RAM Buffer/Receiver
Scan Memory:	8K Words.
Data Buffers:	28K Words each.
Programmable Sample Period	10 uS to 255 uS; Resolution = 1.0 µS.
Programmable Scan Period	10 uS to 1.023 S; Resolution = 10uS, 100 uS, 1.0 mS.
Maximum Read Rate (Data Buffer to Computer):	300K Words/Sec.

Display/Control Panel 620511

- Permits Manual Operation of the Series 500 Bus.
- Maintenance and Troubleshooting Aid.
- Simplifies Program Debugging.

The Display/Control Panel permits manual operation of the Series 500 bus. Designed as a troubleshooting aid, it is useful for program debugging and for initial system installation. It consists of a circuit card that plugs into a card slot (J104) of the Series 500 and a switch/indicator assembly that mounts on a hinged front panel.

The switch/indicator assembly is an 18-bit switch register with a corresponding 18-bit LED display. The computer can read data entered via the switches and write data to the LED display. This allows the operator to monitor programs as they are performed and to verify hardware operation.

To select computer operation, the operator depresses the Remote switch on the front panel. The Remote indicator illuminates and the system is placed under computer control. When the switch is again depressed, local operation is selected and the Remote indicator turns off. The system is now off-line in terms of input data bus transfers. The computer, however, retains its ability to perform all other functions. It can read the I/O card status register and other functions not involving input bus transfers.

To manually initiate an input bus cycle, the operator can select an address on the front panel switch register and apply the address to the input bus by depressing a switch. The LEDs display the address on the input bus. When the switch is released, the LEDs display the word on the data bus. Improper bus operation, for any reason, can easily be detected by this procedure.

The Display/Control Panel is standard on the following Series 500 assemblies:

620500: Local Input Assembly.
620502: Remote Input Control Assembly
620519: Remote Dual-Bus Buffered Controller Assembly.
620520: Local Dual-Bus Buffered Controller Assembly.

It is optional on the 620516A, Serial Interface Control Assembly.

The Display/Control Panel is not used on Expansion Assemblies.

32-Bit TTL Output Card 620530

- o 32 Outputs from Series 500 Bus for Driving External Devices (30 V, max).
- o Variable Word Length.
- o Selectable Logic Polarity.

The TTL Output function card provides 32 outputs for driving TTL-compatible loads or other loads not exceeding output capability (30 V, max; 40 mA max). Pull-up resistors are connected to the internal 5 V supply. Repositioning a jumper wire allows operation on external power of up to 30 V.

Variable Word Length

A matrix of jumpers allows the selection of output formats of four eight-bit words, two 16-bit words, or one 32-bit word.

Selectable Polarity

Another jumper wire can be positioned to obtain either positive or negative true output logic relative to the corresponding point on the data bus.

Specifications

Output Characteristics

Open Circuit Voltage:	+30 V, maximum.
Sink Current:	40 mA, maximum.

Bus Characteristics

Operating Mode:	Half Duplex.
Bus Loading:	One TTL Load.
Data Rate:	100 KHz.

16-Point Relay Output Card 620531

- o Delivers Form-C Outputs from the Series 500 bus.
- o Three-Wire Outputs (Normally Open and Normally Closed).
- o Internally Supplied Relay Power.

The Relay Output function card provides 16 points of form-C outputs to drive various control functions. Data from the input bus is buffered into the card's 16-bit data register and simultaneously echoed back to the data bus. Data is loaded into the card's register in two bytes requiring two separate write instructions.

The 16 relay coils are normally energized by internal 22 Vdc power from the bus. Repositioning of a jumper wire allows external power to be used where system requirements so dictate.

Specifications

Format: Form-C relay output (3-wire) providing normally open and normally closed contacts. Addressed in two groups of eight relays each.

Relay Characteristics

Contact Rating: 20 Watts @ 1.5 A or 500 V.

Coil Power: 24 V @ 10 mA (relays are non-latching; data is lost on power removal).

Bus Characteristics

Operating Mode: Half Duplex.

Data Rate: 100 KHz.

Operate Time: 0.5 mS.

Release Time: 0.5 mS.

Bus Loading: One Bus Load.

Eight-Channel Output Card 620540

- o Delivers Eight Individual Analog Outputs from the Series 500 Bus.
- o Current or Voltage Outputs.
- o Remote Sense Capability in Voltage Mode.
- o 12-Bit Resolution.

The Eight-Channel DAC function card delivers eight individual analog outputs from the Series 500 bus. Each channel consists of a 12-bit register, DAC, and buffer amplifiers. Plug-in jumper modules are installed in either of two sockets for each channel to obtain current mode (socket 1) or voltage mode (socket 2). In voltage mode, the user has remote sensing capability, a feature recommended for maximum accuracy.

Analog Output Levels

Voltage mode format is bi-polar with standard full scale range of ±10.24 V. A jumper wire can be removed to obtain full scale of ±10 V. Current mode output ranges from 4 mA to 20 mA (see chart).

Specifications

Accuracy:	12-bit resolution; ±0.02% FS + 1/2 LSB.
Output Level:	Three ranges selected by jumpers: ±10.24 V, ±10.00 V, or 4-20 mA in current mode.
Response Time:	Output settles to within 0.05% of final value in less than 1 mS.
Stability:	±1/2 LSB for 200 hours.
Compliance Voltage (Current Mode):	12 Vdc.
Drive Capability (Voltage Mode):	±20 mA; output will drive capacitive load of 10 uF and is short-circuit protected.

Twelve-Bit Isolated DAC Output Card 620541

Description

This version of the Series 500 DAC Output function card provides four channels of isolated analog output. Each channel is implemented with a selectable voltage or current mode, 12-bit DAC, and buffer amplifier.

The Isolated DAC was designed for use in control applications. Twelve opto-couplers provide isolation between channels and from ground. A single-pole RC filter is included to limit response time.

For maximum accuracy, remote sensing is available when the card is configured for voltage mode.

Specifications

Full Scale Output

Voltage Mode: ±10V (or 10.24 V) at ±20 mA.

Current Mode: 4 to 20 mA with 12 V compliance.

Isolation: Outputs galvanically isolated from each other and ground.

Common Mode: ±300 Vdc or peak ac, channel-to-channel-to-ground.

Output Loading: Stable with up to 10 mA load; unconditionally short-circuit protected.

Resolution: 1 part in 4096 (12-bits).

Accuracy: ±0.02% of FS + 1/2 LSB.

Stability: ±1/2 LSB for 200 hours.

Response Time: 1-second single-pole filter determines response time (user alterable). Shipped with 1 MegOhms resistor and 1 uF capacitor installed.

Fiber Optic Serial Link 620552

- o High Noise Immunity/Lightning Protection.
- o Protection from Inductive Tapping for Data Security.
- o Increased Transmission Lengths at Maximum Data Rates (100 KHz at distances to 1500 meters).

Description

Series 500 Controllers support remote site operations using a Serial Controller Card (620576). This card supports transmission via coax cables. The introduction of fiber optic cable provides an alternate mode of transmission. Using special adapters in conjunction with the Serial Controller, transmission between a local Series 500 and remote Series 500 can be implemented with fiber optic cable.

Existing coax cable systems using the Neff Serial Controller can be upgraded by replacing cable termination paddleboards with fiber optic boards.

The 620552 supports one remote site and requires a cable with six optic fibers.

Specifications:

Recommended Light Guide Cable:	AT&T 62.5/125 micron (Part Number LGBC-004A-LRX or equivalent).
Connector Type:	ST Twist Lock.
Wavelength:	820 nanometers.
Maximum Fiber Length:	1500 meters using 62.5/125 Micro M cable.
Maximum Data Rate:	100 KHz.
Temperature Range:	0°C to 50°C, operating.

32-Bit TTL Input Card 620560

- Transfers 32 Points of TTL Data from Input Device to the Series 500 Bus.
- Continuous Input or Input Only When Requested by External Device.
- Data Read as Two 16-Bit Words.

The TTL Input function card transfers TTL data from a peripheral device to the Series 500 bus. The 32 points of data are read as two 16-bit words designated Group 00 and Group 01 as indicated by the least-significant bit of the address word. Input data is read as the function card is addressed.

Removal of a jumper on the card activates a Load input line that permits data to be transferred into the function card's input register only when a signal from the device is present on the line. Simultaneously, an Interrupt Request is generated to the computer (if card is mounted in a local Series 500 system). If the card is mounted in a remote Series 500 system, the interrupt appears in the status register. Contact the factory regarding handling of the interrupt generated at a remote site.

Specifications

Data Inputs:	Two 16-bit words; each line represents one TTL load with a 3300 ohm pull-up to +5 Vdc.
LOAD and LOAD:	One TTL load with 3900 ohm pull-up to +5 Vdc.
Data Format:	Positive true; complemented by jumper placement.

32-Bit Isolated DC Sense Input Card 620561

- o Transfers 32 DC Inputs (Relay Contacts, Control Signals, etc.) to the Series 500 Bus.
- o Optical Coupling to Bus.
- o Voltage Level Selection.
- o Interrupt Request Capability.

The 32-Point Isolated DC Sense function card provides 32 optically coupled dc inputs from monitoring status or control signals generated by relay contacts or similar devices. The 32 data points are read as two 16-bit words designated Group 00 and Group 01 and indicated by the least-significant bit of the address word.

Voltage Level Selection

JW1	0 State	1 State
In	1 to 12 V	0 to 1.5 V
Out	12 to 48 V	0 to 60 V

Each of the 32 input points is configured as shown. A jumper (JW1) is installed or removed to accommodate various input levels. The jumper "out" configuration is used for general purpose applications. The jumper is installed for lower voltage applications including TTL levels. For voltages higher than 48 V, the zener diode voltage and series resistance can be increased accordingly.

Interrupt Request Generation

Each input point can generate an Interrupt Request when a change of state of input data occurs. A switch is provided for each point (32 manual switches) to either defeat to enable interrupt capability for that point. The Interrupt Request can be jumpered to any one of the Series 500's Interrupt Request lines.

A data point must change and remain in the changed state for at least 10 mS for an Interrupt Request to be generated. The interrupt request remains in effect until the block of addresses is read.

Specifications

Data Format: 32 data points read as two 16-bitwords; Data points 00-15 become data bus bits DB00 - DB15.

Input Levels: Contact closures or two voltage levels selected by jumper JW1.

Common Mode: 1000 V can be applied between each input and ground.

Interrupt Capability: Activated by switch for each input point; interrupt occurs after 10 mS window

Four-Channel Counter/Stepper Card 620562

- Frequency Measurement.
- Period Measurement.
- Event Counting.
- Stepper Pulse Output.
- Self Test Mode.
- Variable Time Rate.

The Four-Channel Counter/Stepper function card can be installed in any Series 500 assembly at either a local or remote site. It is equipped with a 32K binary counter on each of its four channels and a crystal-controlled time base generator that is common to all channels. By means of miniature switches on the card, each channel is configured to operate in one of four operating modes:

1. Frequency Measurement.
2. Period Measurement.
3. Totalize.
4. Stepper Pulse Output.

An additional self-test mode is selected by software. In this mode, an internal 100 KHz oscillator tests the operation of the counters and of the interrupt request feature in all operating modes.

Frequency Measurement

In the Frequency Measurement Mode, input pulses are counted over one of five time periods. At the end of the period, the contents of the counter are loaded into a data register, the counter is reset to zero, and counting is resumed.

Period Measurement

In the Period Measurement Mode, an internal frequency divider and the reference frequency are used to make time measurements over a selected number of periods. At the end of the selected number of periods, contents of the counter are loaded into a data register, the counter is reset, and the measurement is repeated.

Totalize Mode

Totalize mode permits either a simple count of events or the generation of an Interrupt Request to the computer after a selected number of events.

Event counting consists simply of setting the counter to zero and issuing a Start instruction. Input pulses are counted over the range of zero to 32,767 decimal. Overflow occurs on the sixteenth bit (32,768) and further counts are inhibited. Current count value can be read at any time with a Read Count instruction.

For an Interrupt Request to be generated after a prescribed number of counts, the counter is preset to the two's complement of the desired count. At overflow, further counting is inhibited and the Interrupt Request is generated on the selected Interrupt Request line.

Stepper Pulse Output

In this mode, a prescribed number of pulses and a direction control bit are output to drive a stepper motor or similar device. Pulse rate is selected by switches on the card.

The counter is initially preset to the desired number of pulses to be generated over the range of zero to 32,768. A Start instruction begins the output pulse train that continues until counter overflow. Current count value can be read at any time by a Read Count instruction.

Input/Output Configurations

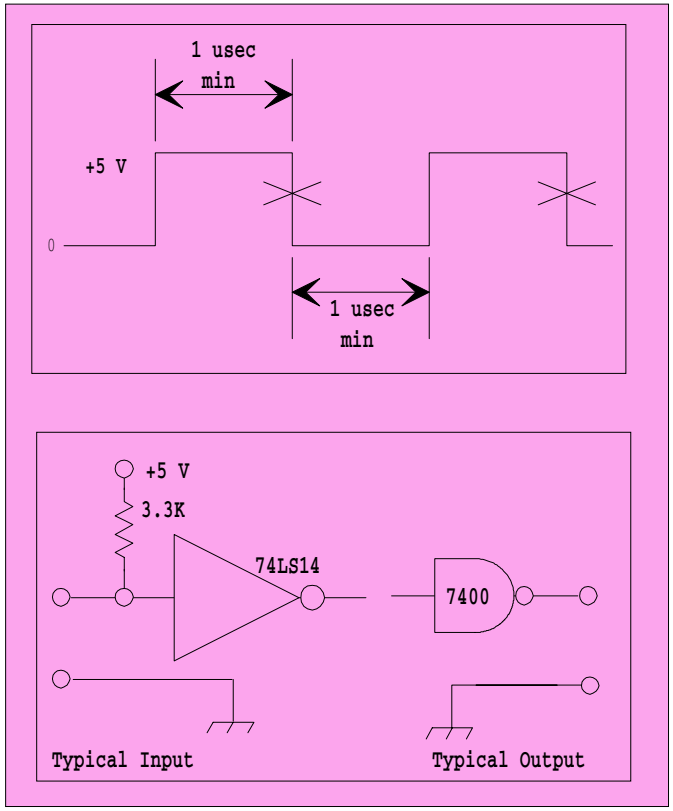
Input terminals are single-ended non-isolated TTL as shown. An internal pull-up to +5 V is included to permit either current or voltage sense. Maximum input frequency is 500 KHz with a minimum pulse width and space of 1mS. All count operations are clocked on the 1 to 0 transition pulse edge.

Specifications

Frequency Mode

Accuracy: ±0.01% of reading ±1 count.

Test Mode 10 KHz ±1 count.
Data Format: Frequency = Count Value/Gate Time.



Four-Channel Counter/Stepper Card (Continued) 620562

Minimum Pulse Width: 1 microsecond.

Frequency Range and Resolution:

Gate Time	1 mS	10 mS	100 mS	1 Sec	10 Sec
Range	500 KHz	500 KHz	327 KHz	32 KHz	3.2 KHz
Resolution	1 KHz	100 Hz	10 Hz	1 Hz	0.1 Hz

Period Mode

Accuracy: ±0.01% of reading ± input rise time (.6 to 4 V transition time).

Time Base: 100 KHz ±0.01%.

Test Mode: 100 mS test signal.

Data Format: Period = 10^{-5} x Count Value/N (Periods)

Period Range and Resolution:

No. of Periods Measured	1	10	100	1000	10000
Range	327 mS	32 mS	3.2 mS	327µS	32 µS
Resolution	10 uS	1 uS	100 nS	10 nS	1 nS

Totalize Mode

Input Frequency: 500 KHz, maximum.

Range: Sample count:0 to 32,767; Preset mode:0 to 32,768.

Accuracy: ± Input rise time (.6 to 5 V transition time).

Stepper Mode

Range: 1 to 32,768 output pulses.

REF	REF/2	REF/4	REF/8	REF/16
10 KHz	5 KHz	2.5 KHz	1.25 KHz	625 Hz
1 KHz	500 KHz	250 KHz	125 KHz	62.5 KHz

Pulse Rates:

Duty Cycle: 50%.

Direction Control: One TTL line.

Isolated Latch 620563

- o Flip-flop Type Latches for 32 Input Points.
- o Optical Coupling.
- o Voltage Level Selection.
- o Interrupt Request Capability.

The Isolated Latch function card provides 32 points of D flip-flop latches for monitoring momentary change-of-state input levels. Optical coupling on all inputs provides ground isolation at levels to 1000 volts. The 32 data points are read as two 16-bit words designated Group 00 and Group 01 and indicated by the least-significant bit of the address word.

Voltage Level Selection

Each of the 32 input points is configured as shown below. A jumper (JW1) is installed or removed to accommodate various input levels.

The jumper is "out" for general purpose applications. The jumper is "in" for lower voltage applications, including TTL levels. For voltages higher than 48 V, the zener diode voltage and series resistance can be increased accordingly.

JW1	0 State	1 State
In	1 to 12 V	0 to 1.5 V
Out	12 to 48 V	0 to 60 V

Interrupt Request Generation

Each input point can generate an Interrupt Request when a change of state of input data occurs. A switch is provided for each point (32 manual switches) to either defeat or enable interrupt capability for that input. The Interrupt Request can be jumpered to any one of the Series 500's four Interrupt Request lines.

Specifications

Format: 32 data points read as two 16-bit words. Data points 0-15 become data bus bits DB00 – DB15.

Input Levels: Voltage level selected by jumper.

Common Mode: 1000 V can be applied between input and ground.

Interrupt Capability: Activated by switch for each input point.

Isolated TTL Input With Data Hold 620564

- Transfers 32 Points of TTL Data from Input Device to Series 500 Bus.
- Data Hold Line to Stabilize Input Data.
- Optical Coupling for Maximum Isolation.
- Data Read as Two 16-Bit Words.

The Isolated TTL Input with Data Hold function card is used to input digitally-coded TTL levels from a counting device (counter, DVM, clock, etc.) which, if read while its output code is in a transitional state, would result in ambiguous code status.

With this card, the TTL levels are "frozen" by a Data Hold signal from the card. After a 5-microsecond settling time, the inputs are gated into latches on the card. The 32 data points are read as two 16-bit words, each gated by a separate Data Hold line.

All lines including the Data Hold line are optically coupled. When using the Data Hold feature, the user must supply +5 V and ground to operate the opto-couplers for this line.

An Interrupt Request can be generated by closing an appropriate IR switch on the card. When the I/O card receives the IR signal, it reads the contents of the card's register.

Specifications

Data Input:	Two 16-bit words; data points 00-15 become data bus bits DB00-DB15.
Data Hold:	10 uS duration; input latched 5 uS after leading edge.
Interrupt Capability:	Interrupt request activated by external device.
Common Mode:	1000 V can be applied between each input point and ground.

Eight-Port Serial Controller 620576

- o Controls Operation of up to Eight Remote Systems Located up to 1500 Meters From the Computer.
- o Error Check of All Transmissions.
- o Coax or Fiber-Optic Cable to Remote Sites.
- o Supports Remote Analog Systems at Full Rated Specifications (including expanded systems and the Series 300 Signal Conditioner).

The Eight-Port Serial Controller is a special purpose function card used only at a local (computer) site to establish a serial link with up to eight remote systems. It is a standard card for the Serial Interface Control Assembly (620516A). It contains a data transmitter and receiver. The transmitter converts parallel data from the local Series 500 bus to serial format and transmits the data to one or more remote systems. The receiver accepts serial data from the addressed remote system, converts the data to parallel format, and outputs the data to the local bus.

A similar function is performed at each remote site by transceiver (T/R) cards installed in the remote Series 500 systems. Serial data are transferred between the Serial Controller and each remote system over two coax cables (three required when a Buffered Controller interface is used). Optionally, fiber-optic cable can be used.

Error Detection

Serial data are transmitted in ±5 V, return-to- zero format with all transmissions to and from the remote system checked for errors. Serial parity and pulse count tests are performed to detect reversed polarity bits and missing or added pulses that could be received as valid bits. Errors are flagged by bits in the Serial Controller's status register.

Data Rates

Data rate is dependent on the Computer I/O card operating mode, response time of the I/O function, and the type and length of the interconnecting cables.

The Series 600 is limited to 1,000 feet using coaxial cable and 1500 meters using fiber optic cable.

Maximum System Rate	Maximum Cable Length		
	RG-8	RG58/U	Fiber-Optic
50 KHz	4,500	1.000	4,500
22 KHz	7,000	1,500	4,500
12.5 KHz	10,000	2,000	4,500
6.25 KHz	20,000	3,000	4,500

Eight-Port Serial Controller 620576 (Continued)

Remote Site Configurations

The remote end of the serial data link can be terminated by one of two Neff systems:

1. Series 500 Remote Input Control Assembly - (620502). This remote system contains a T/R card, a Display/Control Panel, and space for 16 function cards.

2. Remote Dual-Bus Buffered Controller Assembly - (620519). This assembly contains Buffered Controller circuitry that includes scan memory, quartz-based clock, data transmitter, and a separate High-Speed Read-Only (HSRO) bus. Seven function card slots are available in 620519 for the Series 500 I/O bus and seven are available in the HSRO bus (digital input cards only).

Specifications:

Transmission Mode:	Half or full duplex, depending on operating mode and I/O function.
Transmission Accuracy:	Less than 1 error/10^9 transmissions.
Bus Loading:	1 bus load.

(Note: Cables and BNC connectors are supplied by the user.)

Series 500 Ordering Information

620500	**Input Control Assembly.** Includes wired enclosure, power supply, Computer I/O Card, Display/Control Panel and space for 16 function cards.
620501	**Expansion Input Assembly.** Includes wired enclosure, power supply, Decode/Buffer Card, Expansion Cable and space for 16 function cards.
620502	**Remote Input Control Assembly.** Includes wired enclosure, power supply, Transceiver Card, Display/Control Panel and space for 16 function cards.
620503	**Synchronized Digital Input Assembly. (HSRO Bus Expansion).** Includes wired enclosure, power supply, Mux/500 Adapter Card, expansion cable and space for 16 digital input function cards.
620511	**Display/Control Panel for 620516A.**
620516A	**8-Port Serial Controller Assembly.** Includes wired enclosure, power supply, Computer I/O Card, 8-Port Serial Controller and space for 3 additional function cards.
620519	**Remote Buffered Controller Assembly.** Includes dual-bus rack, power supply, Display/Control Panel, Transceiver, High-Speed Buffered Controller Card, Bus Adapter and Dual RAM Buffer.
620520	**Local Buffered Controller Assembly.** Includes dual-bus rack, power supply, Display/Control Panel, Computer I/O, High-Speed Buffered Controller Card and Bus Adapter.
620526	**Local Buffered Controller Card Set (Included in 620520).** Includes High-Speed Buffered Controller Card.
620527	**Remote Buffered Controller Card Set (for Series 600).** Includes High-Speed Buffered Controller card (to be installed in 620502 and is part of the 620519) and Dual RAM Buffer/Receiver (to be installed 620500 or 620516A at the computer site).

Series 500 Ordering Information (Continued)

Function Cards

620530	32-Bit TTL Output
620531	16-Point Relay Output
620540	Eight-Channel DAC Output
620541	Isolated DAC (12-bit)
620560	32-Bit TTL Input
620561	32-Bit Isolated DC Sense
620562	Four– Channel Counter/Stepper
620563	32-Bit Isolated Latch
620564	32-Bit Isolated TTL Input with Data Hold
620576	Eight-Port Serial Controller

Accessories

620513	Extender Cards – Series 500.
620965	Instruction Manual, extra copy (two supplied with system at no charge).

Software

620599	SCSI Demo Software

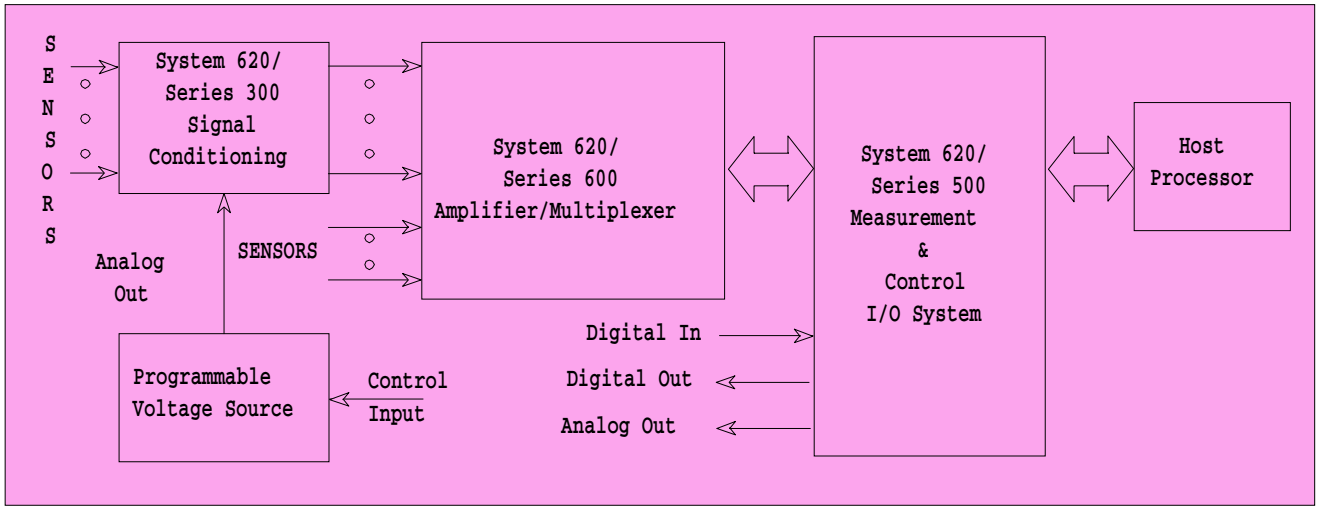
Series 500 Ordering Information (Continued)

Shipping Kit **

9010100	Shipping Kit: Local Buffered Controller Card Set (620526) used with Series 600
9010101	Shipping Kit: Remote Buffered Controller Card Set (620527) used with Series 600.
9010104	Shipping Kit: Remote Dual-Bus Buffered Controller Assembly (620519) used with Series 600.

**These are for reference. Normally supplied, they may be required when modifying or updating a configuration.

Series 600 Amplifier/Multiplexer



- o Automatic Zero and Full-Scale Calibration.
- o Precision Internal Calibration Voltage Source.
- o High Resolution (16-Bits, Including Sign).
- o 100 KHz Throughput Rate.
- o Direct Analog Output from all Channels
- o Alpha-Numeric Display.
- o Wide Range Zero Offset Capability.
- o Autoranging
- o Accuracy: ±(0.02% + 2 uV)

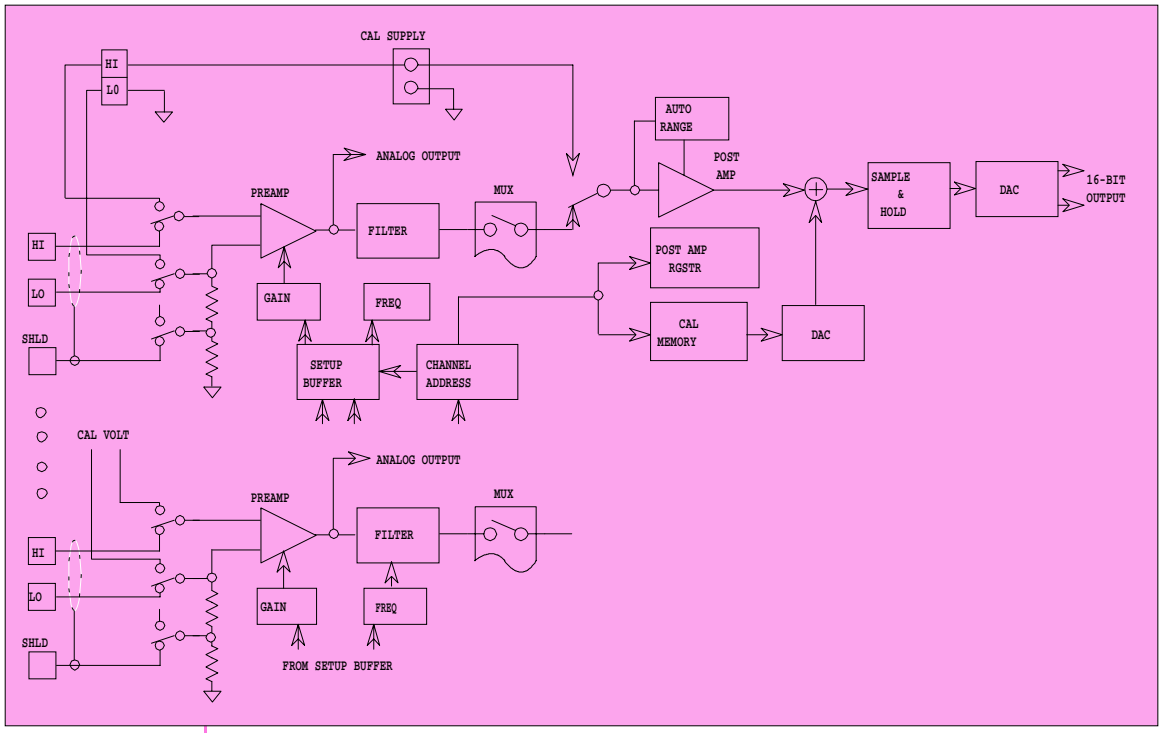
Introduction

The Series 600 is a top-of-the-line multiplexing data acquisition system providing the utmost is performance, accuracy and convenience. Featuring leading-edge technology and innovative design, Series 600 brings extensive automation and complete programmability to the testing laboratory.
The key to Series 600's high performance is the effective combination of fully programmable preamp/filters, programmable post amplifier, sophisticated microprocessor-controlled calibration circuits, and the amplifier-per-channel data acquisition technique that realizes the lowest noise level and highest common mode rejection obtainable in a data acquisition system.

Series 600 Amplifier/Multiplexer

Programmable Gain Over the Full Dynamic Range

With programmable gain, test setup time is greatly reduced as is the bother and confusion of manual switch settings. In Series 600, the gain of each channel is programmable from ±5 mV full scale to ±10.24 V full scale in 12 binary steps. Preamp gain for each channel is selected and stored as part of the initialization process. Then, during operation, post amplifier gain is set for each channel according to gain codes entered in the scan list. With autorange selected, the post amplifier gain code is supplied by automatic ranging circuits.



Pre-amps Include Programmable Filter

Two input pre-amps are available in Series 600 to allow both static and dynamic measurements. Both have programmable filter cutoff frequencies of 1 Hz, 10 Hz, 100 Hz and 1 KHz. The Low-level differential pre-amp, 620650 has 2-pole Butterworth filters. The 620654 is supplied with a 6-pole Butterworth filter. The sample and hold preamp, 620654, permits simultaneous sampling of multiple low-level input channels and is used where channel-to-channel time correlation is desired. Both preamps have fully guarded inputs and operate from grounded or floating signal sources.

Series 600 Amplifier/Multiplexer (Continued)

Calibration is Automatic

Periodic calibration is an important aspect of data system accuracy, but manual calibration procedures can be time consuming and costly. With Series 600, manual calibration tasks are eliminated.
On command, the internal microprocessor takes over control of the Series 600 and begins a sequence of steps to derive and store calibration factors for each channel. The calibration data is stored in on-board memories and, during run mode, are summed with the post amplifier output voltage to obtain fully calibrated signals for conversion by the ADC.

First, the calibration bus is connected to the input of the post amplifier. Each of the post amplifier's six gain steps are calibrated at zero and upscale points. Next, the pre-amps are calibrated—a process that involves zero and upscale readings at 16 points per channel. Then, preamp linearity is adjusted by application of a bipolar calibration voltage.

Calibration is conducted without removing cards or even opening the enclosure so the system is calibrated at its actual operating temperature. This eliminates drift due to differences in calibrating and operating environment.

The automatic calibration procedure results in static accuracy of ± 0.02 full-scale + 2 μV) including the effects of gain error, offset, nonlinearity and crosstalk for 30 days.

Calibration memories and registers holding the initial preamp conditions (gain and filter per channel) can be read by the host computer and stored in its non-volatile memory for backup in case of power failure. In addition, the host computer has access to the Series 600's calibration relays. If the user desires to verify system calibration, the computer can operate the relays to permit application of internal or external test voltages.

Diagnostics Without Software

The automatic calibration procedure serves as a systematic test of system operation without the use of software diagnostic routines or costly manual maintenance procedures. With calibration conducted prior to test, the user is assured that the system is fully operational as well as completely calibrated.

If any calibration point cannot be successfully calibrated, an error flag is issued. Any error detected during calibration of the post amplifier is a gross error, since it affects all channels. In this case, the calibration process is aborted and the computer is notified that immediate attention is required. During preamp calibration, any channel drawing excessive current from the calibration bus is automatically disconnected for the remainder of the CAL procedure and flagged as a faulty channel.

If an error is detected during zero and upscale preamp calibration or during the bipolar linearity check, the faulty channel is identified as well as the gain or filter step at which the error was detected. In this case, the user can decide whether or not to proceed with the text, depending on the effect the error would have on his test objectives.

Series 600 Amplifier/Multiplexer (Continued)

Continuous Analog Output on All Channels

A unique feature of the Series 600 is continuous analog outputs from each channel. A result of the amplifier-per-channel approach, these outputs are available at the rear panel of the Series 600 assembly. The outputs, at 5 mA, are unaffected by the filters, multiplexer, or post amplifier.

Wide-Range Zero Offset Capability

Zero offset capability allows the user to correct measurements to compensate for initial or "tare" offset, typical of transducers. This feature is also useful for zero referencing a non-zero signal or for entering arbitrary offsets onto any channel.
After calibration, a scan is made of all channels and readings of tare offset are obtained. This data is written to the Series 600 CAL memory, overwriting zero correction data. During a test scan, Series 600 automatically subtracts these values from the readings on each channel. The system compensates for up to 5.12 Vdc offset at the input to the post amplifier. With system gain selected for 40 mV full scale (preamp gain of 64; postamp gain of 4), an offset of twice full scale (80 mV) at the input can be suppressed to zero. For other desired offsets, the user can replace offset data with appropriate values.

Autoranging (50 KHz only)

Series 600 can be operated in autorange as well as in programmable gain mode. In autorange, optimum system gain is selected automatically according to the magnitude of the input. Using the NEFF supplied 16-bit interface, the three least significant bits of the A/D word are replaced by the appropriate post amplifier gain code. Four autorange steps are available: each preamp gain step times the post amplifier gains of 1 through 32.

Real-Time Display

A trap mode allows observation of any channel in the system during a test run. The display is updated each time the channel is sampled. To select a channel for display, the user touches the keypad switches. The display indicates the channel number, filter frequency, full scale range, and input signal amplitude. Filter frequency is indicated by BW (0, 1, 2 or 3) where 0 = 1 Hz, 1 = 10 Hz, 2 = 100 Hz and 3 = 1 KHz.. Range (FS) is indicated by the full scale value in millivolts. At full scale ranges of 1 V or less, the measured input voltage is expressed in millivolts. At higher ranges, it is expressed in volts.

Front Panel Operation

The user can take the system off-line by pressing the Remote switch. As a precaution against accidental selection, the question ... **Put Mux Off-line?** ...is displayed. Touching the Enter switch indicates "yes". The Remote indicator turns off, the host computer is locked out and control of the Series 600 is transferred to the front panel keypad.

Series 600 Amplifier/Multiplexer (Continued)

Local operation is useful for installation, test and maintenance. The user can select any channel, choose range and filter frequency, and read the input voltage on the selected channel. The input voltage can be taken from a single sample or an averaged reading taken over a selectable number of scans. The user can manually step through the channels at slow rates to closely observe system operation, monitor the internal calibration voltages, and even perform system calibration.

Local Autocal

Calibration of the Series 600 from the front panel starts with a selection of the CAL switch. After entering the starting and ending channels the system automatically starts a series of six calibration routines. The name of each routine is displayed as it is performed. At the conclusion of a successful calibration, the system displays the numbers of any channels which did not complete calibration successfully. Additionally, the gain and filter step which failed calibration is displayed. This aids in diagnostic efforts.

Series 600 Specifications

Specifications:

Speed: 100KHz maximum.

Ranges: Program selected; 12 binary steps;
100KHz; ± 5 mV FS to ± 10.24 V FS
50 KHz; ± .625 mV FS to ± 10.24V FS

Filter: F_0 = 1 Hz, 10 Hz, 100 Hz, and 1 KHz
620650; 2-Pole Butterworth
620654; 6-Pole Butterworth

Resolution: 16-bits (15 + sign bit)

Basic Accuracy: ± (0.02% FS + 2 uV) for 30 days at constant temperature after automatic calibration; includes effects of gain error, offset, non-linearity and non-overloading crosstalk.

Gain Stability w/Temp Change: ± 0.002%FS/°C change from automatic calibration temperature.

Zero Stability w/Temp Change: ± 1.0 uV/°C change from automatic calibration temperature.

Input Guarded differential input on each channel;

Configuration: floating or grounded signal sources measured without degradation.

Common Mode Voltage,operating: ± 10 Vdc or peak ac.

Common Mode Rejection Ratio: 120 dB Max (66 dB + gain in dB + filter attenuation) dc to 60 Hz with 350 Ohm source imbalance.

Source Current: ± (1 nA @ 23°C + 0.1 nA/°C).

Input Overload Without Damage: ± 100 Vdc or peak ac, common mode or normal mode.

Sample & Hold (620654 preamp)

- **Acquisition Time:** 30 uS
- **Droop (Hold Mode):** 0.5 mV/mS
- **Aperture Uncertainty:** 100 nS, max.

Series 600 Specifications (Continued)

Noise: Total Noise RTI = $\frac{[(N_1)^2 + (N_2)^2]^{1/2}}{A}$

Where N_1 = RTI noise;
N_2 = RTO noise:
A = System gain = $\frac{10.24\ V}{FS\ Range}$

f_0	N_1	N_2
1 Hz	1 uV	
10 Hz	1 uV	
100 Hz	2 uV	2500 uV
1 KHz	6 uV	

Offset: Included in the basic accuracy specification.

Static Crosstalk: Included in the basic accuracy specification.

Crosstalk (Adjacent Channel Overload: ± 0.02% FS (only affects channel following overloaded channel in scan list).

Non-Linearity: Included in the basic accuracy specification.

Automatic Calibration: On command, uP adjusts zero and gain of each channel to within basic accuracy specifications and verifies calibration.

Analog Output: Unfiltered (wideband) output at ± 5 mA from each preamp; available at rear panel.

Control/Display Panel: 32-character alphanumeric display and key-pad for entering instructions.

Autorange (50 KHz Only): Post amplifier provides autorange over a 1 to 32 gain range in six steps. Combined with preamp gain, following ranges are available;

Preamp Gain	Autoranges
512	± 0.625 mV to ± 20 mV
64	± 5 mV to ± 160 mV
8	± 40 mV to ± 1.28 V
1	± 320 mV to ± 10.24 V

Series 600 Specifications (Continued)

Environmental Specifications:

Power Requirements:	105 to 130/200 to 250 VAC, 50 to 400 Hz 150 W.
Operating Environment:	0°C to 50°C, 90% relative humidity, non-condensing; will withstand shock and vibration of normal shipping and handling of laboratory equipment.
Cooling Requirements:	To be mounted in a cabinet with unobstructed airflow and equipped with a 300 cfm blower.
Physical Dimensions:	7-inch panel height in 19-inch rack; 23-inch depth behind front panel. Neff recommends mounting in a 19-inch rack having 30-inch depth to accommodate connector build-up. Weight without Preamp/Filter cards is 40 pounds.

Series 600 Ordering Information

Part Number	Description
620600	**Input Control Assembly**. The first assembly in a Series 600 system; includes control logic, post amplifier, ADC, calibration computer and control/display panel. Supports up to seven Input Assemblies (620601). Includes interconnecting cable to Controller.
620601	**Input Assembly.** For up to 64-channel expansion. Accepts up to 16 four-channel pre-amp cards and is supported by the Input Control Assembly (620600). Includes connecting cables.
620650	**Four-Channel Preamp/Filter.** Programmable gain on each channel of 1, 8, 64 and 512. Two-pole Butterworth filter on each channel programmable for f_0 = 1 Hz, 10 Hz, 100 Hz and 1 KHz. Analog output (unfiltered) from each channel available at rear panel of the Series 600 assembly.
620654	**Preamp/Filter with Sample & Hold.** Preamp has same features as 620650 except that each channel is equipped with sample and hold circuits and the programmable filters are six-pole Butterworth.

Accessories

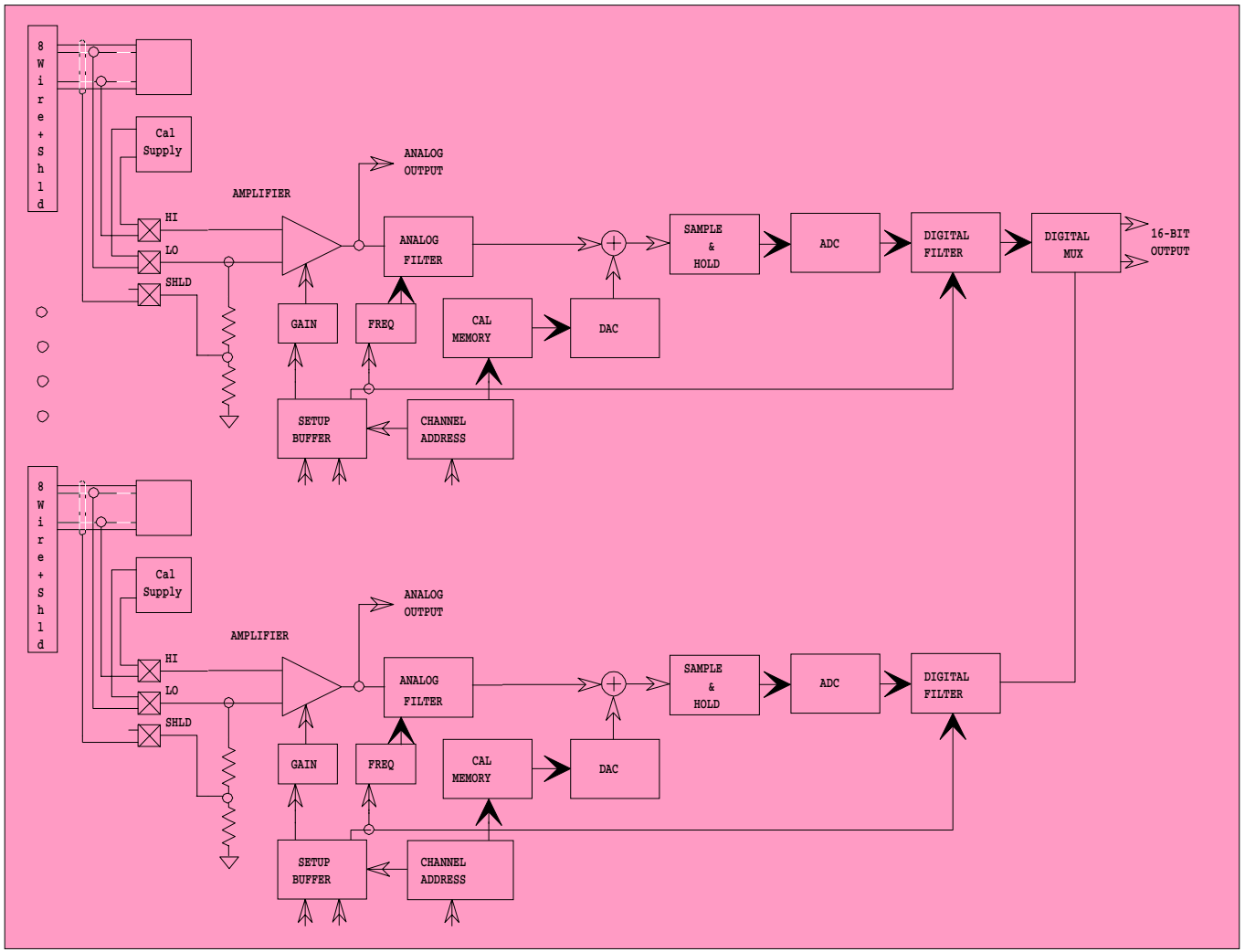
620603	**Series 600 Service Kit.** Includes extender cards for maintenance of the Series 600.
620997	**Instruction Manual.** Extra copy. (two are supplied with each system at no charge)

Section VII

System 730

Dynamic Signal Acquisition System

System 730 Data Acquisition System



System 730 Data Acquisition System

- o One degree phase match between channels
- o Programmable digital filter per channel
- o 96 KHz per channel sampling rate
- o 12 KHz analog signal bandwidth
- o 2 MSample per second throughput rate
- o Automatic built-in calibration
- o Built-in signal conditioning
- o Programmable gain

High Performance Dynamic Signal Capture

System 730 is a high performance data acquisition system front end optimized for acquisition of dynamic signals with 1° channel-to-channel phase match, greater that 290 dB/octave filter roll-off rate and accuracy of ± (0.02% FS + 2 uV).

Analysis of dynamic signals requires attention to phase shift in addition to signal amplitudes. Skew and phase shift contribute errors that cannot be tolerated in many applications.

Functional Description

System 730 is a high performance ADC per channel system featuring automatic calibration, a 2 MHz throughput rate and programmable gain amplifier/filters on each channel. Amplified signals pass through an analog anti-aliasing filter before being digitized and filtered further by a digital filter. The result is an extremely quiet output signal represented by a very low ratio of sample rate to filter cutoff frequency. Full scale ranges of ± 5 mV to ± 10.24 V are accomplished in 12 binary steps.

Filter Comparisons

An 8-pole Bessel, linear phase, filter attenuates signals by 90 dB at approximately 7 times the cutoff frequency while a Butterworth filter reaches the same level at 4 times the cutoff frequency. Digital filtering in the System 730 provides 120 dB attenuation at 1.33 times the cutoff frequency. Theuresult is a much wider bandwidth supported by a given output sampling rate.

Other filter related issues include phase shift matching and ripple, or error in the passband. An 8-pole Butterworth exhibits a phase shift of –360° at the –3 dB point. The use of 5% components could result in a channel-to-channel variation of ± 36°. If this does exist on two channels whose data is to be used in a complex analysis, the apparent ratio of the two signals at that frequency is more than 2:1 even with an identical input. The Bessel characteristic is less of a problem at –182° at the –3 dB point, but attenuation of signal begins at dc and at only 10% of that frequency it is already at –3%. Not only is there a phase problem, but a magnitude error as well. The Butterworth characteristic has attenuation of –0.4% at 75% of the bandpass so the bandpass error is much less.

System 730 Data Acquisition System (Continued)

Compare these performance numbers with those of the System 730. Ripple in the passband is 0.005 dB and phase matching between channels is less than 1° throughout the passband in the low and medium ranges. The passband extends to 90.0% of the –3 dB frequency. Additionally, the stopband, at –120 dB, begins at 1.33 times the passband and the decimation that occurs with the digital filter results in an output sampling rate only 2.67 times the passband frequency. The benefit is that the sampling rate can be minimized for a particlar signal bandwdth while providing superior accuracy and noise reduction. This reduces the load on interface bandwidth and on the data storage medium.

Sampling Rate vs. Passband

A total of 88 sample rate/filter cutoff frequencies are fixed with an additonal 21 reserved for customer definition. One of the 8 groups of these combinations contains 25 selections. In this group called 'Global Filter Steps', all channels operate at the same rate and at the same filter cutoff frequency. These combinations are suitable for testing that requires frequency domain analysis. The other groups with 9 different filter cutoff frequencies are intended for applications that require time domain analysis; that is the sampling rate can be selected to be much higher than the filter cutoff frequency. In all cases, all channels are sampled simultaneously and at the same programmable rate.

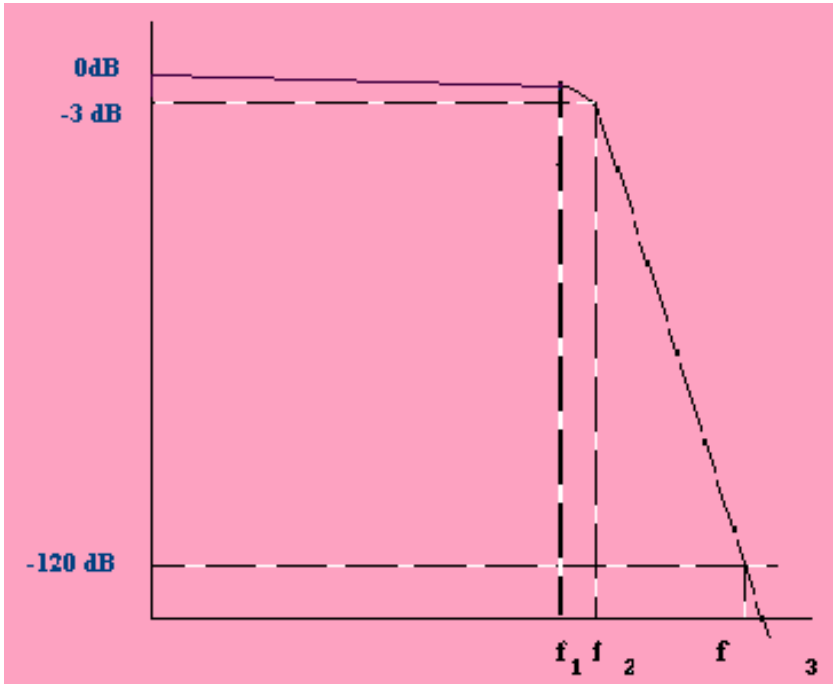
Global Steps

Filter	A/D SR	Decima-	Sample	Pass-	Transition	Antialias
24	96000	3	32000	12000.00	4000.00	Fast
23	96000	4	24000	9000.00	3000.00	Fast
22	96000	5	19200	7200.00	2400.00	Fast
21	96000	6	16000	6000.00	2000.00	Fast
20	96000	8	12000	4500.00	1500.00	Fast
19	96000	10	9600	3600.00	1200.00	Fast
18	96000	12	8000	3000.00	1000.00	Fast
17	96000	16	6000	2250.00	750.00	Medium
16	96000	24	4000	1500.00	500.00	Medium
15	96000	32	3000	1125.00	375.00	Medium
14	96000	40	2400	900.00	300.00	Medium
13	96000	48	2000	750.00	250.00	Medium
12	96000	64	1500	562.50	187.50	Medium
11	96000	80	1200	450.00	150.00	Medium
10	96000	96	1000	375.00	125.00	Medium
9	96000	128	750	281.25	93.75	Medium
8	9600	16	600	225.00	75.00	Slow
7	9600	24	400	150.00	50.00	Slow
6	9600	32	300	112.50	37.50	Slow
5	9600	40	240	90.00	30.00	Slow
4	9600	48	200	75.00	25.00	Slow
3	9600	64	150	56.25	18.75	Slow
2	9600	80	120	45.00	15.00	Slow
1	9600	96	100	37.50	12.50	Slow
0	9600	128	75	28.125	9.3750	Slow

System 730 Data Acquisition System (Continued)

Filter Groups A Through G

In these 7 groups all channels are again sampled simultaneously at the same rate but any channel can operate at any filter cutoff frequency in the group.



Filter Points of Interest
f_1 = bandwidth
f_2 = -3 dB point
f_3 = stopband

System 730 Data Acquisition System (Continued)

Group A Filter Steps

Filter Step	A/D SR Hz	Decima-tion	Sample Rate	Passband f1	Transition Band	Antialias Filter
A36	9600	48	200	Reserved	12.5	Slow
A35	9600	48	200	Reserved	12.5	Slow
A34	9600	48	200	Reserved	12.5	Slow
A33	9600	48	200	85	12.5	Slow
A32	9600	48	200	67.5	12.5	Slow
A31	9600	48	200	45	12.5	Slow
A30	9600	48	200	30	12.5	Slow
A29	**9600**	**48**	**200**	**20**	**12.5**	**Slow**
A28	9600	48	200	15	12.5	Slow
A27	9600	48	200	11.25	12.5	Slow
A26	9600	48	200	8.4375	12.5	Slow
A25	9600	48	200	6.3275	12.5	Slow

Group B Filter Steps

Filter Step	A/D SR Hz	Decima-tion	Sample Rate	Passband f1	Transition Band	Antialias Filter
B48	9600	24	400	Re-served	25	Slow
B47	9600	24	400	Reserved	25	Slow
B46	9600	24	400	Reserved	25	Slow
B45	9600	24	400	175	25	Slow
B44	9600	24	400	135	25	Slow
B43	9600	24	400	90	25	Slow
B42	9600	24	400	60	25	Slow
B41	**9600**	**24**	**400**	**40**	**25**	**Slow**
B40	9600	24	400	30	25	Slow
B39 9	600	24	400	22.5	25	Slow
B38	9600	24	400 1	6.875	25	Slow
B37	9600	24	400 1	2.655	25	Slow

System 730 Data Acquisition System (Continued)

Group C Filter Steps

Filter Step	A/D SR Hz	Decima-tion	Sample Rate	Passband f1	Transition Band	Antialias Filter
C60	9600	12	800	Reserved	50	Slow
C59	9600	12	800	Reserved	50	Slow
C58	9600	12	800	Reserved	50	Slow
C57	9600	12	800	225	50	Slow
C56	9600	12	800	200	50	Slow
C55	9600	12	800	180	50	Slow
C54	9600	12	800	120	50	Slow
C53	**9600**	**12**	**800**	**80**	**50**	**Slow**
C52	9600	12	800	60	50	Slow
C51	9600	12	800	45	50	Slow
C50	9600	12	800	30	50	Slow
C49	9600	12	800	25.31	50	Slow

Group D Filter Steps

Filter Step	A/D SR Hz	Decima-tion Rate	Sample Rate	Passband f1	Transition Band	Antialias Filter
D72	96000	64	1500	Reserved	61	Medium
D71	96000	64	1500	Reserved	61	Medium
D70	96000	64	1500	Reserved	61	Medium
D69	96000	64	1500	688	61	Medium
D68	96000	64	1500	506.25	61	Medium
D67	96000	64	1500	337.5	61	Medium
D66	96000	64	1500	225	61	Medium
D65	**96000**	**64**	**1500**	**150**	**61**	**Medium**
D64	96000	64	1500	112.5	61	Medium
D63	96000	64	1500	84.375	61	Medium
D62	96000	64	1500	63.28125	61	Medium
D61	96000	64	1500	47.466	61	Medium

System 730 Data Acquisition System (Continued)

Group E Filter Steps.

Filter Step	A/D SR Hz	Decima-tion Rate	Sample Rate	Passband f1	Transition Band	Antialias Filter
E84	96000	20	4800	Reserved	490	Medium
E83	96000	20	4800	Reserved	490	Medium
E82	96000	20	4800	Reserved	490	Medium
E81	96000	20	4800	1900	490	Medium
E80	96000	20	4800	1620	490	Medium
E79	96000	20	4800	1080	490	Medium
E78	96000	20	4800	720	490	Medium
E77	**96000**	**20**	**4800**	**480**	**490**	**Medium**
E76	96000	20	4800	360	490	Medium
E75	96000	20	4800	270	490	Medium
E74	96000	20	4800	202.5	490	Medium
E73	96000	20	4800	151.88	490	Medium

Group F Filter Steps

Filter Step	A/D SR Hz	Decima-tion Rate	Sample Rate	Passband f1	Transition Band	Antialias Filter
F96	96000	10	9600	Reserved	1000	Fast
F95	96000	10	9600	Reserved	1000	Fast
F94	96000	10	9600	Reserved	1000	Fast
F93	96000	10	9600	3800	1000	Fast
F92	96000	10	9600	3240	1000	Fast
F91	96000	10	9600	2160	1000	Fast
F90	96000	10	9600	1440	1000	Fast
F89	**96000**	**10**	**9600**	**960**	**1000**	**Fast**
F88	96000	10	9600	720	1000	Fast
F87	96000	10	9600	540	1000	Fast
F86	96000	10	9600	405	1000	Fast
F85	96000	10	9600	303.75	1000	Fast

System 730 Data Acquisition System (Continued)

Group G Filter Steps

Filter Step	A/D SR Hz	Decima-tion Rate	Sample Rate	Passband f1	Transition Band	Antialias Filter
G108	96000	3	32000	Reserved	2000	Fast
G107	96000	3	32000	Reserved	2000	Fast
G106	96000	3	32000	Reserved	2000	Fast
G105	96000	3	32000	14000	2000	Fast
G104	96000	3	32000	10800	2000	Fast
G103	96000	3	32000	7200	2000	Fast
G102	96000	3	32000	4800	2000	Fast
G101	**96000**	**3**	**32000**	**3200**	**2000**	**Fast**
G100	96000	3	32000	2400	2000	Fast
G99	96000	3	32000	1800	2000	Fast
G98	96000	3	32000	1350	2000	Fast
G97	96000	3	32000	1012.5	2000	Fast

System 730 Data Acquisition System (Continued)

Table 20 Passband ripple and phase tracking vs. Passband.

Passband Hz	Passband ripple (dB)	Ch-ch phase match
14000	+0.1/-0.3	3.0
9000	+0.1/-0.25	2.5
7200	+0.1/-0.2	2.0
6000	+0.1/-0.15	1.5
DC-3000	+0.1/-0.1	1.0

NOISE RTI = $\frac{[(N_1 * A)^2 + (N_2)^2]^{1/2}}{A}$

Where;

N_1 = RTI noise term;

N_2 = RTO noise term

A = 10240 mV /FS mV

RTI is referred to input; RTO is referred to output

Noise vs. Bandwidth.

Passband $f_{1\ Hz}$	Noise RTI	Noise RTO
12000	20 uV	1.75 mV
6000	14 uV	1.5 mV
3000	9.8 uV	1.25 mV
1500	7.0 uV	1.0 mV
750	4.9 uV	1.0 mV
375	3.5 uV	1.0 mV
150	2.2 uV	0.75 mV
90	1.8 uV	0.75 mV
45	1.3 uV	0.75 mV
30	1.0 uV	0.75 mV

2-Channel Amplifier/Filter/ADC 730060

Two Channel Amplifier/Conditioner Card

The two channel card provides transducer excitation, signal conditioning, amplification, filtering and digitizing. An analog filter precedes the digitizer to protect against aliasing.

Each of the channels includes a mode card to interface to a particular type of transducer.

Strain Gauges. A 350Ω strain gauge conditioner card provides all necessary resistors and components to accomplish up to 8 wire bridge configurations. A full bridge configuration with remote sensing of excitation voltage and one-step, R-Shunt Calibration is possible.

Jumper positions generate an 8-bit code which can be sensed by the computer for identification of the channel configuration.

A voltage-mode excitation power supply is programmable over the range of 0 to 10 volts with 12 bit resolution and output currents to 50 mA per channel. Excitation voltage may be read back under program control.

The tare offset correction DAC has 12bit resolution and it may be invoked by the system host computer at any time.

Amplifier. The balanced differential amplifier provides 13 programmable full-scale input steps to cover the range of ± 2.5 mV to ± 10.24 V. It is direct coupled with a ± 10 V common-mode voltage operating range.

AC or DC input coupling and switching between the common analog calibration bus and signal inputs are program selectable.

A buffered wideband direct output is provided for driving other recording or display devices.

Analog Antialiasing Filter. The amplifier output drives an analog antialiasing filter with three ranges. Cutoff frequencies are selected to be compatible with the three ranges of the digital filter.

A/D Converter/Digital Filter. The analot-to-digital converter provides 16-bit, including sign, resolution at a maximum digitizing rate of 96 KHz. Output sampling rates after filtering range from 75 Hz to 32 KHz.

Calibration

The system processor performs voltage substitution calibration of individual channels to correct zero offset and full-scale errors using an internal calibration supply. Calibration voltages are applied to the amplifier inputs via the analog calibration bus using solid state relays controlled by the processor. Correction coefficients are determined for each of the 13 gain steps on each channel included in the calibration routine. Stored in non-volatile RAM on the system I/O board,

coefficients are transferred to individual channels along with specified full-scale values during system set.

Digital Input Card

The Digital Input Card supports up to 24 isolated discrete data inputs plus 2 handshake signals. All inputs are buffered by TTL devices which drive optic couplers to provide ground isolation between the user device and System 730. The two handshake signals provide synchronization with the user device. An external 5 volt source is required to power the isolated input.circuitry. Internal power may be used when isolation is not required.

System 730 Specifications

Specifications

Number Of Channels:	2 channels per card, 32 channels per box, expandable to 256 channels in 8 boxes.
Input Configuration:	Balanced differential. Operates from grounded or floating signal sources.
Full-Scale Input:	Thirteen program selectable steps provide bi-polar input ranges of: 2.5 mV, 5 mV, 10 mV, 20 mV, 40 mV, 80 mV, 160 mV, 320 mV, 640 mV, 1.28 V, 2.56 V, 5.12 V and 10.24 V.
Input Impedance:	100 MegOhms in parallel with 500 pF, DC coupled mode. 1 MegOhm in parallel with 500 pF, AC coupled mode.
Maximum Differential or Common-mode Input :	± 100 volts DC, or peak AC, without damage.
Source Current:	Less than 1.0 nA at 25 ° C. ± 0.1nA/ °C
AC Coupling:	-3dB at 1.0 Hz
Basic Accuracy:	±(0.02% FS plus 2uV) for 30 days at constant temperature after automatic calibration. Includes errors contributed by gain stability, offset stability, non-linearity and crosstalk. Noise and common-mode errors are additive.
Gain Stability:	± 0.002% FS/°C change from automatic calibration temperature.
Zero Stability:	±1.0uV/°C RTI or 100uV/°C RTO, whichever is greater, from automatic calibration temperature.
Common-mode Voltage:	± 10V DC or peak AC operating, ± 100 Volts without damage.
Common- mode Rejection:	66dB + gain in dB to 120dB max, DC to 60Hz with 350 Ohm source imbalance, in DC coupled mode.
Voltage Substitution	Solid state relay provided to switch amplifier

System 730 Specifications

Calibration:	input terminals to common internal DC calibration source, under program control. External CAL INPUT for user supplied DC or AC calibration source, selectable under program control..
Direct Output Level:	Provides continuous analog output, per channel ±10.24V for ± FS input, @ ± 5 mA
Bandwidth:	Wideband 50 KHz or filtered by antialias filter, jumper selectable
Accuracy:	0.05% of FS plus ± 2.0 mV
Power Requirements:	105V to 130V (220V to 250V), 50 to 400 Hz, 550W.
Environmental Requirements:	0°C to 50°C, 90% RH, non-condensing. Will withstand shock and vibration of normal shipping and handling of laboratory equipment.
Cooling Requirements:	To be mounted in cabinet with unobstructed airflow and equipped with a 300 cfm blower.
Size:	7-inch panel height in 19" rack; 23-inch depth behind front panel. Neff recommends that assemblies be mounted in a 19-inch rack with 30-inch depth to accommodate connector build-up.
Weight:	53 pounds without function cards installed.

System 730 Ordering Information

Part Number	Description
730200	Control Assembly configured for SCSI. First assembly in a System 730; includes control logic, calibration computer, power supply and control/display panel. Accepts up to 16 function cards, Supports up to 16 Expansion Assemblies (730101)
730101	Expansion Assembly. Accepts up to 1l6 function cards, Supported by Control Assembly (730200)
730060	2-Channel Amplifier/Filter Card with Signal Conditioning
730011	24-Bit Isolated TTL Input Card
730360	Strain Gauge Mode Card. One required for each strain gauge channel. Supports 1, 2 or 4 arm bridge.
730362	Voltage Mode Card. One required for each voltage input channel.
Software	
730800	WIN730
Accessories	
730900	Operation and Maintenance Manual; System 730

Section IX

Neff Support

Neff System Support

- o 1-Year Warranty.
- o Factory Installation Assistance.
- o Board Exchange Program.
- o Field Service and Training.

Warranty

Most manufacturers of electronic equipment limit their warranties to 90 days, but products manufactured by Neff Instrument Corporation are warranted for a period of one year from delivery. The Neff warranty covers all broken or defective parts, except those damaged by misuse or accident, and all labor involved where defective products are returned to the Neff factory. The customer is responsible for incoming shipping costs. Return shipping cost is paid by Neff.

Since Neff systems are modular, it is easy to isolate any malfunction to a specific printed-circuit board. Once this is done, you will need a replacement board as soon as possible. Neff has a Board Exchange Program to speed up the warranty replacement procedure. The program works like this:

1)The customer calls Neff Sales Department for RMA number.

2)The customer issues a purchase order to Neff for the re- placement board at the price listed in the spare parts price list. Notify (telephone) Neff, giving purchase order number.

3)The customer ships the defective board to Neff (shipment prepaid).

4)Upon receiving the purchase order number, Neff will ship a replacement board (new or remanufactured equivalent)promptly, usually within one day. It will be shipped prepaid by Neff via UPS. Costs of alternate transportation methods (air freight, etc.) will be paid by the customer.

5)When the board under warranty is received, Neff will is-sue a credit for the full price of the replacement board. The replacement board is warranted to the end of the original 1-year warranty period. In cases where the board has been severely damaged by accident or misuse, and Neff determines that a guaranteed repair cannot be made, the customer will be notified before further action is taken.

Field Service

When equipment is repaired by Neff Field Service Engineers at customer facilities within the local service area (50 mile radius of Neff's plant), the basic Field Service hourly rate applies with a four-hour minimum charge.

Neff System Support (Continued)

Outside of the local service area, a daily rate plus actual transportation cost and flight time are charged. Minimum charge is one day. Field Service rates apply during regular business hours.

Factory Installation Assistance

Neff products are carefully and completely checked out at the system level before shipment from the factory. The customer can expect to be "on-line" very soon after receiving his system. Installation normally consists of simply interconnecting the assemblies, attaching input lines, and connecting the system into the host computer. However, installation assistance is available if desired. A Neff Field Service Engineer will install your system hardware and software for you at regular Field Service rates.

Training

A seminar-type training course is held at regular intervals at Neff's plant. Covering system hardware, the 4 day course starts on the first Tuesday of each even month and covers theory of operation, calibration, service and maintenance of System 620, System 470, System 495 or System 730 depending on the customer's hardware,

The course is conducted by Neff Field Service Engineers having extensive experience in servicing, maintaining, and programming Neff multiplexers, signal conditioners and I/O boards.

Section X

Spare Assemblies

Spare Assemblies

Part No.	Item Description
System 470	
90023104	Power Supply
90023149	Display/Control Assembly (470104)
9002335012	I/O Control Logic (GPIB)
9002335013	I/O Control Logic (SCSI)
90023565	I/O Control Logic (Ethernet)
90023185	Expansion Card
90023535	Analog Subassembly Board
9010076	Mating Connector Kit
System 471	
90023104	Power Supply
9002335021	I/O Logic Control (SCSI)
9002335022	I/O Logic Control (GPIB)
90023424	Analog Subassembly
90023423	Expansion I/O
900233524	ADC, 16-Bit; 10 kHz
900 23414	4-Channel Isolated Amplifier (470058) with signal conditioning
9010076	Mating Connector Kit

System 470/471 Function Cards	
900235682	16-Channel Differential Mux with 4-20 mA Input (470052)
90023568	16-Channel Differential Mux (470050)(470 Only)
900235681	16-Channel Differential Mux with Open Input Source Detection (470051)(470 only)
900235683	16-Channel Differential Mux with Direct Input(470059) (470 Only)
90023158	16-Point Isolated Input (470011)
90023160	4-Channel Bridge Conditioner/Mux (470054) (470 only)
90023164	32-Bit TTL Input (470010)
90023172	32-Bit TTL Output (470030)
90023173	8-Point Form-C Relay Output (470031)
90023175	2-Chan, 16-Bit DAC (470070)
90023176	Screw-Terminal Input Connector (470080)
90023186	2-Channel Frequency orPeriod Input (470012)
90023188	4-Channel RTD Conditioner/Mux (470055) (470 only)
90023205	Programmable Calibration Card (470085) (470 only)
90023211	16-Channel Transformer-Coupled Mux (470056) (470 only)
90023237	16-Channel 12-Bit DAC (470071)
90023245	32-Bit TTL Input/Output Card (470013)
90023407	ARINC 429 Controller (470014) (470 only)
90023409	Scanivalve Controller (470032) (470 only)
90023413	2-Channel Frequency Input (470015)
90023414	4-Channel Isolated Amplifier (471058) (471 only)

Spare Assemblies (Continued)

System 472

Part No.	Item Description
90023104	Power Supply
9002335017	I/O Logic Control (SCSI)
9002335016	I/O Logic Control (GPIB)
90023449	Analog Subassembly
90023423	Expansion I/O
900233525	ADC, 16-Bit; 50 KHz
9010076	Mating Connector Kit

System 472 Function Cards

900231302	16-Channel Differential Mux with 4-20 mA Input (472052)
900231303	16-Channel Differential Mux with Direct Input(472059)
90023158-1	16-Point Isolated Input (472011)
90023164-1	32-Bit TTL Input (472010)
90023172-1	32-Bit TTL Output (472030)
90023173-1	8-Point Form-C Relay Output (472031)
90023175-1	2-Chan, 16-Bit DAC (472070)
90023176	Screw-Terminal Input Connector (470080)
90023186-1	2-Channel Frequency orPeriod Input (472012)
90023237-1	16-Channel 12-Bit DAC (472071)
90023245-1	32-Bit TTL Input/Output Card (472013)
90023413-1	2-Channel Frequency Input (472015)

Part No.	Item Description
90023435	16-Channel Programmable Gain Differential Mulplexer, 10Hz (472060)
900234352	16-Channel Programmable Gain Differential Multlexer, 100Hz (472064)

System 470/471/472 Extender Cards

90022998	Extender, 470 Logic Board
90023161	Extender, 470 Function Cards

System 495

900233565	Control Logic, SCSI
90023380	Bus Terminator
90023397	Power Supply
900235131	Expansion I/O
90023536	Trigger Module
9010133	Mating Connector Kit

System 495 Function Cards

900235385	Ampl/Fltr/ADC Card, 16-Bit, 250 KHz, 1 MSample Mem (495070)
900235384	Ampl/Fltr/ADC Card, 16-Bit, 250 KHz, 16 MSample Mem (495071)

Spare Assemblies (Continued)

Part No.	Item Description
900235383	Ampl/Fltr/ADC Card, 16-Bit, 250KHz, 32MSample Mem (495072)
900235382	Ampl/Fltr/ADC Card, 16-Bit, 250 KHz, 64MSample Mem (495073)
900235389	Ampl/Fltr/ADC Card, 14-Bit, 1 MHz, 1 MSample Mem (495080)
900235388	Ampl/Fltr/ADC Card, 14-Bit, 1 MHz, 16 MSample Mem (495081)
900235387	Ampl/Fltr/ADC Card, 14-Bit, 1 MHz, 32 MSample Mem (495082)
900235386	Ampl/Fltr/ADC Card, 14-Bit, 1 MHz 64 MSample Mem (495083).

System 495 Memory Modules

900235393	1 MSample Memory, 16-Bit
900235009	16 MSample Memory, 16-Bit
900235008	32 MSample Memory, 16-Bit
900235007	64 MSample Memory, 16-Bit
900235392	1 MSample Memory, 14-Bit
900235005	16 MSample Memory, 14-Bit
900235003	32 MSample Memory, 14-Bit
900235001	64 MSample Memory, 14-Bit

Part No.	Item Description

System 495 Filter Modules

43318-100	100 Hz, 6-Pole Filter Module
43318-200	200 Hz, 6-Pole Filter Module
43318-500	500 Hz, 6-Pole Filter Module
43318-1k	1 KHz, 6-Pole Filter Module
43318-2k	2 KHz, 6-Pole Filter Module
43318-5k	5 KHz, 6-Pole Filter Module
43318-10k	10 KHz, 6-Pole Filter Module
43318-20k	20 KHz, 6-Pole Filter Module
43318-50k	50 KHz, 6-Pole Filter Module
43318-100k	100 KHz, 6-Pole Filter Module
43318-200k	200 KHz, 6-Pole Filter Module

System 495 Extender Cards

90022998	Extender Card, Logic Board
90023235	Extender Card, Function Cards

Spare Assemblies (Continued)

Part Number	Item Description
System 620/Series 300	
90022339	4-Channel Input Conditioning Card
90022340	Ref Supply/Relay Driver
90022345	Power Supply
9010076	Mating Connector Kit
System 620/Series 300 Extender Cards	
900220842	Extender, Chan Addr Board
900220843	Extender, 4-Chan Input Board
System 620/Series 500	
90022615	Extender Card Set
90022621	Front Panel Controller (620511)
90022622	32-Point Isolated DC Sense (620561)
90022623	8-Channel DAC Output (620540)
90022626	8-Port Serial Controller (620576)
90022627	Transceiver Card
90022628	32-Bit TTL Input (620560)
90022629	32-Bit TTL Output (620530)
90022630	16-Point Form-C Relay Output (620531)
90022660	4-Channel Counter/Stepper (620562)

Part Number	Item Description
System 620/Series 500 (Continued)	
90022678	Expansion Decode Logic
90022721	32-Bit Isolated Latch (620563)
90022830	32-Bit Iso TTL Input (620564)
90022981	Power Supply, 14-Inch Box
90023123	High-Speed Buffered Controller (620526, 620527)
90023153	Mux Adapter Card (use with 620519 and 620520)
90023198	Dual 16K RAM w/Receiver (620527)
90023354	General Purpose I/O w/SCSI Interface
9010019	Mating Connector Kit

Spare Assemblies (Continued)

System 620/Series 600

Part Number	Item Description
90023017	Control Logic Assembly
90023023	Analog Subassembly w/ADC
90023035	Expansion Box/Control Assy
90023037	Cal Memory and DAC Assy
90023047	Power Supply
90023060	Control Panel/Cal Computer
90023300	4-Chan Preamp/Filter with 2-Pole Butterworth (620650)
90023332	4-Chan Preamp/Filter with 6-Pole Butterworth (620654)
90023301	Cal Supply Assembly
9010099	Mating Connector Kit

System 620/Series 600 - Extender Cards

90022998	Extender, PC Board
90023106	Extender, Function Cards

System 730

Part Number	Item Description
90023486	Control Panel
900234883	I/O Control Logic Card
90023511	Power Supply
900235132	Expansion Logic Assembly

System 730 Function Cards

90023479	2-Channel Amplifier/Conditioner
90023496	24-Bit Isolated TTL Input Card
90023501	Strain Gauge Mode Card
90023508	Voltage Mode Card

Appendix I

Miscellaneous Notes

Regarding

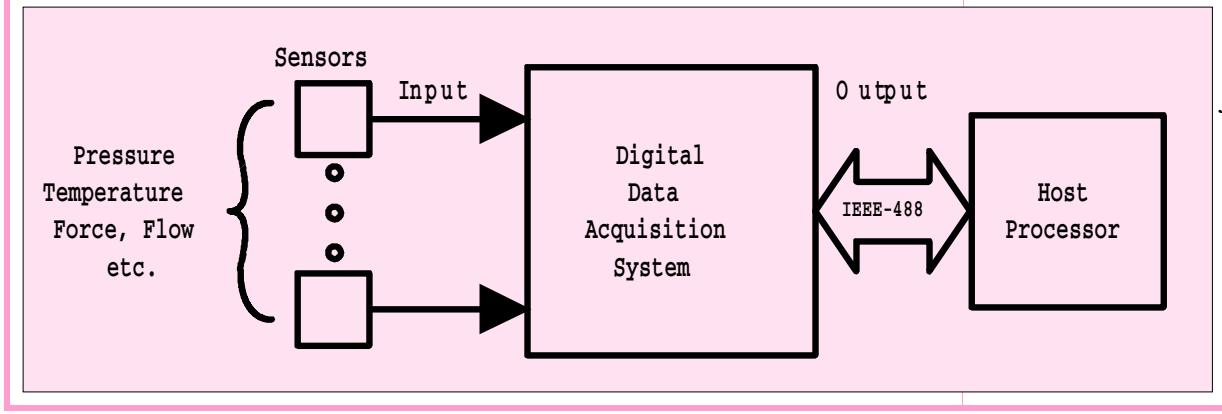
Data Acquisition Systems

Types of Data Acquisition Systems

Introduction

Computer-based digital data acquisition systems (DAS) are used to measure physical variables such as pressure, temperature, force, and flow. With such systems, the input measurand is first converted to an electrical parameter such as resistance, voltage, or current using a sensor which is external to the data acquisition system. The sensor's output is input to the data acquisition system where it is conditioned and converted to a digital word that is equivalent to the analog signal. The digital word is then transmitted to a computer where conversion to engineering units and analysis/display functions are performed.

Digital DAS used today are primarily multi-channel systems. That is, up to N sensors are connected to a single DAS where they time share common equipment. These measurement systems are referred to as multiplexed data acquisition systems. Depending on the extent of shared equipment, multiplexed DAS are categorized as amplifier-per-channel systems or low-level multiplexed systems



Amplifier-Per-Channel Multiplexed Systems

As the term suggests, amplifier-per-channel systems have a dedicated pre-amplifier for every channel. The amplified signals are filtered and then input to a multiplexer. With this arrangement, an analog-to-digital converter (ADC) is timeshared between all N channels. The significant benefits of amplifier-per-channel systems are:

o **Higher throughput rates**. Since the inputs to the multiplexer have been amplified, less gain is required of the post-amplifier. This enables the multiplexer to operate at higher rates.

o **Improved filtering**. Active multi-pole filters (Bessel, Butterworth, etc.) with programmable cutoff frequencies can be implemented with the amplifier-per-channel systems.

o **Higher per channel sampling rate.** Channel revisit limitations associated with low-level multiplexed systems (typically specified as 100 revisits/second) are removed with the amplifier-per-channel systems.

o **Sensor Isolation**. With low-level multiplexed systems, sensor impedance works in conjunction with the resistance of the input passive filter to alter cutoff frequency. With the amplifier-per-channel systems, this effect is eliminated.

Types of Data Acquisition Systems (Continued)

o Improved channel-to-channel isolation. All multiplexer inputs are buffered from each other by the pre-amplifiers thus eliminating the possibility of a defective channel affecting other channels.

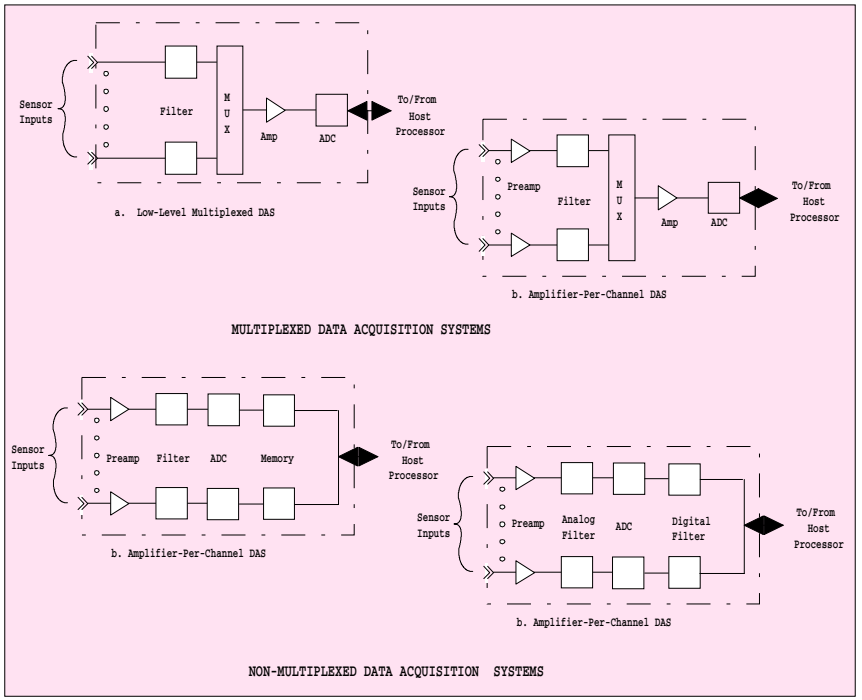
Low-Level Multiplexed Systems

In contrast to amplifier-per-channel systems, low-level multiplexed systems have all gain past the multiplexer. There are variations to this which use more than one level of multiplexing. For such systems, the output of the first level of multiplexing is amplified as well as the output of the second level. To accommodate low-level signals such as those from strain gages or thermocouples, the throughput rate must be decreased to enable the high bandwidth amplifier to settle to the correct value after switching. This results in a lower aggregate throughput compared to the amplifier-per-channel systems.

Non-Multiplexed Systems

High speed transient systems.

Identified by its ADC per channel and on-board memory it typically operates at per channel sampling rates which in aggregate would overwhelm any communication system. Data is stored on board during a test
and transmitted to a host computer following completion. Characteristics of a transient recorder include:



o Very high channel sampling rates. In a transient recorder these rates are only dependent upon the ADC.

o No crosstalk. Each channel is independent with no multiplexing or shared circuits except for power supplies.

o Negligible skew. All channels are sampled simultaneously and controlled by a precision clock.

Types of Data Acquisition Systems (Continued)

o **Independent of computer latency.** On-board clocks control sampling rate, triggers initiate recording and data is store on-board elimination errors caused by failure of the computer to respond in a timely manner.

High Speed Continuous Acquisition Systems

This type of system can be designed with benefits of both the multiplexed amplifier-per-channel and transient recorder systems. Benefits of the non-multiplexed amplifier-per-channel system include:

o **High sampling rates.** With an ADC per channel, the sampling rate is not encumbered with considerations such as multiplexing and post-amplifier settling time.

o **Superior filtering.** With an ADC per channel, digital filtering can be used to augment analog filtering to achieve better anti-aliasing performance with much lower effective sampling rates.

o **Superior phase matching.** Digital filtering provides much steeper, more predictable rolloff rates and phase characteristics than analog filtering with greater stability with time and temperature changes and at lower cost.

Neff Products

Neff manufactures a complete line of instrumentation products which include low-level multiplexed systems, amplifier-per-channel multiplexed systems, signal conditioners, and high-speed transient measurement systems .

The table on the following page lists Neff products by category and summarizes some of the important features of each. Detailed specifications for all products listed are described in the catalog sections of this handbook.

Neff Advantages

Shielding

Twisted, shielded leads are recommended for all low level analog signal applications. Twisted leads minimize the loop area through which magnetic fields pass, thereby minimizing the amount of noise induced from this source while shielding minimizes the amount of noise coupled into the signal leads capacitively.

Neff equipment, unlike that produced by other manufacturers, has no restrictions on shield terminations as long as common mode voltage limitations are observed. The shields may be grounded or ungrounded.

Some manufacturers require termination based upon the type of transducer attached to a particular channel. At Neff, shield termination is independent of the type of transducer used on a channel.

While on the subject of grounding, there are no "good" ground loops!

RF Noise Rejection

All dc amplifiers are susceptible to errors caused by RF energy at their input even if the frequency of that energy is beyond the bandwidth of the amplifier. The RF signal exceeds the slew rate capability of the amplifier resulting in a dc offset which is indistinguishable from a dc signal. Since the RF signal is not constant over time, this offset cannot be zeroed out for a permanent fix.

All Neff products are designed with protection against errors caused by RF signals.

Calibration

As important as the ability to make accurate measurements is the ability to prove and document it. All instrumentation requires periodic calibration even if no adjustments are necessary to bring the unit into specification. Calibration periods vary all the way from 5 minutes in one competitor's equipment to 6 months or longer. Most Neff equipment should be calibrated at 60 day to 6 month intervals.

Summary of Neff Products

Low-Level Multiplexed Systems

Model	Max. Channels	Aggregate Throughput	Computer Interface
System 470	512 analog	10KHz	SCSI, GPIB or Ethernet

Amplifier-Per-Channel Multiplexed Systems

Model	Max. Channels	Aggregate Throughput	Computer Interface
System 620 / Series 600*	512	100KHz	SCSI
System 471 w /470058	1024	10KHz	SCSI, GPIB
System 472 w /472060	2048	50KHz	SCSI, GPIB

* Requires System 620 /Series 500 Measurement and Control System

Summary of Neff Products (Continued)

Amplifier-Per-Channel Non-Multiplexed Systems (continuous recording)

Model	Max. Channels	Aggregate Throughput	Computer Interface
System 730	512	2MHz	SCSI

Transient (high speed) Systems

Model	Max. Channels	Max. Channel Sample Rate	Max. On-Board Storage	Computer Interface
System 495	256	1MHz	64MSamples per channel	SCSI, GPIB

Transducer Conditioning (Stand alone)

Model	Comments
System 620 /Series 300	General purpose conditioning with constant voltage, constant current exci. tation, bridge completion, shunt and R-Cal
System 470, 471, 495 and 730	These systems include transducer conditioning without additional hard- ware.

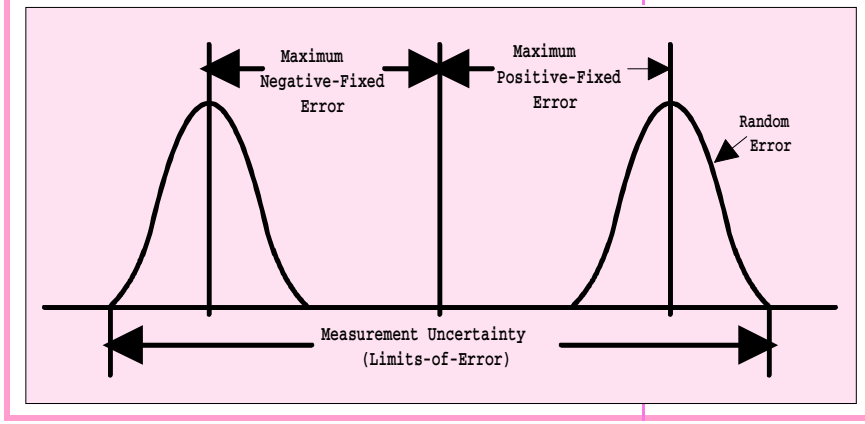
Static Accuracy

Measurement error associated with the DAS at zero frequency (static error) is a function of various fixed errors and random errors. As a consequence of the probabilistic nature of random error, static accuracy is termed measurement uncertainty. Although infrequently used, the term limits-of-error is more descriptive of the fixed and random error.

Bias Error at Constant Temperature. Assuming that temperature is constant, the elemental errors which contribute to the fixed error component of the DAS measurement uncertainty and the units normally reported are:

Elemental Error	Manufacturer's Unit
Gain Accuracy	±%FS
Gain Stability	± %FS
Linearity	± %FS
Hysteresis	±%FS
Resolution	±1/2 LSB
Source Current	± ηA
CMRR	dB
Static Crosstalk	dB
Zero Offset	RTI
Zero Stability	RTI, RTO

At a given input, each of these contributes to the fixed error. Note that while the error at any input is fixed, it is not constant over the range of inputs. Thus errors stated in terms of ±%FS by the manufacturer can be interpreted as defining an error band.



Regardless of the input level, the manufacturer is stating that the elemental error will be less than the defined band. If the error exceeds the published specifications, the device is considered to be defective.

In some cases, elemental errors are stated in terms relative to input (RTI) and relative to output (RTO). For these errors, it is necessary that the system gain be used to convert the RTI component to RTO and then to %FS.

Source current is reported in terms of nanoamperes (ηA). The error resulting from a finite current flowing through a sensor whose impedance is Rs can be computed as the product of source current and sensor impedance. Note that this results in an offset RTI. As a result, the system gain must be used to convert this to RTO and then to %FS.

The worst case static crosstalk error occurs with low-level multiplexed systems when Channel N is at 10V and the following scanned channel (Channel N+1) is at 0V. The error voltage appearing at the input of Channel N+1 can be computed using the manufacturer's crosstalk specifications. Note that the error is in RTI terms and must be adjusted by system gain to express as a %FS error.

Static Accuracy (Continued)

The CMRR specification can be used with an estimate of CMV (e_{cmv}) to compute the error voltage that would appear at the output of the differential amplifier. Thus,

$$e_{error} = e_{cmv} \cdot Gain/[\log\text{-}1(CMRR/20)]$$

For consistency, this should be expressed as a %FS, (e_{error} x $100/E_{FS}$).

Computing Total Bias Error at Constant Temperature. Once all elemental errors have been converted to consistent units such as %FS, they can be combined using the RSS technique as follows:

$$B_T = \pm[b1^2 + b2^2 + \cdots + bn^2]^{1/2}$$

where the bi are elemental errors. Note that this is an estimate of the total bias error which can be reasonably expected at any input assuming temperature remains constant. If pre-test procedures such as adjusting zero or span are to be performed prior to collecting data, many of the elemental bias errors will be effectively eliminated.

Effect of Temperature on System Bias. Temperature affects both the offset and gain parameters and is stated by manufacturers in units such as ±X %/°C or ±Y ppm. The effects of temperature may be stated either as a temperature coefficient or as a part of the basic gain accuracy and zero offset specifications. If the DAS temperature can be expected to stay within say ±5°C of some nominal temperature, the effects of this temperature change on both system offset and gain can be computed as follows. The pertinent specification
is multiplied by the expected change of 5°C and is converted to a %FS error. Since offset specifications are generally in RTI/RTO terms, the system gain must be used to convert this to a %FS error. The computed gain and offset errors are considered worst case errors. Both are classified as fixed errors and should be combined with the other elemental bias errors using the RSS technique.

Random Error. The random error associated with a DAS is attributable to noise caused by thermal processes (resistors and conductors) as well as systematic noise. There are variations in how this specification is reported including peak, peak-to-peak, RMS, and as ±3-Sigma noise. Since noise is assumed to have a normal distribution whose scatter is characterized by the statistic sigma, the ±3-Sigma specification can be interpreted as the 99.7% probability interval for noise. Similarly, peak-to-peak can be interpreted as defining the 100% probability interval for noise. Since noise is a function of both gain and bandwidth, the manufacturer's specification must be interpreted accordingly.

Uncertainty Interval. The uncertainty interval or limits-of-error is a function of the total bias error (B_T) and the random error (noise). Since noise is probabilistic, the uncertainty is stated in terms of probability. Thus, the 99.7% confidence interval for uncertainty is:

$$U = \pm(B_T + Noise)$$

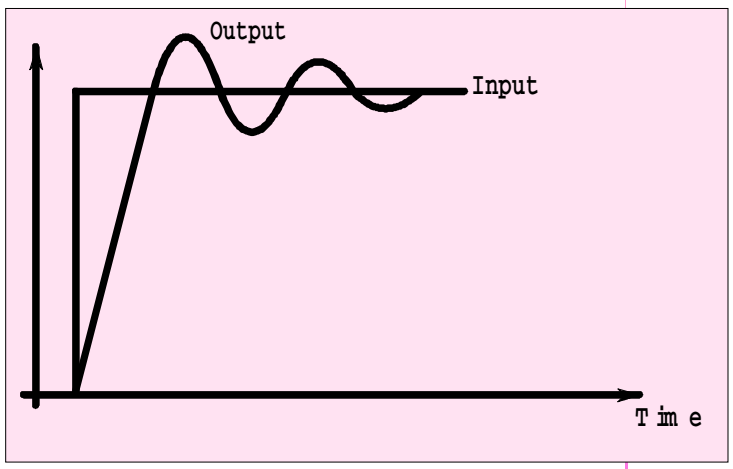
where noise is 3-Sigma. Similarly, the 95% confidence interval for uncertainty would utilize 2-Sigma noise.

Dynamic Accuracy

Measurement error associated with the DAS at non-zero frequency (dynamic accuracy) is a function of static accuracy as well as the dynamic performance characteristics of the DAS components. There are several major areas of concern regarding dynamic accuracy. These include:

o The ability of the DAS to accurately measure a rapidly rising input pulse such as that encountered with shock, impact, or munitions testing (i.e., transients).

o The frequency response characteristics of the DAS with regard to both amplitude accuracy and phase non-linearity.



o For a multiplexed DAS, the channel-to-channel time skew between measurements attributable to the ADC conversion rate and to the number of channels which must be read. To eliminate time skew, a sample-and-hold circuit is used with each channel.

If a step input (or pulse) is applied to an active element such as an amplifier, the amplifier's output does not instantaneously produce an output equal to the product of input and the gain. As shown, the output tends to overshoot and takes a finite time to settle to the final value. While overshoot and settling parameters are of little concern for test applications such as acoustics or vibration, they are of major concern for applications such as impact, shock, or munitions testing.

Points to Consider Regarding Dynamic Measurements

1. Select sensors which have a bandwidth several times greater than the bandwidth of the phenomena to be measured.

2. Select an amplifier-per-channel DAS which has a filtered bandwidth greater than the bandwidth of the phenomena to be measured.

3. Select either Bessel or Butterworth filter. For rapidly changing phenomena, the Bessel may be preferable since the filter does not exhibit any overshoot.

4. Compute required sampling rate. Note that the minimum sampling rate can be computed based on aliasing considerations. The required sampling rate depends upon how the input function is to be reconstructed from the sample data.

5. Implement a low pass digital filter designed to pass the desired frequency band and attenuate all others. Note that digital filters can also produce overshoot as well as passband amplitude ripple.

Terminology

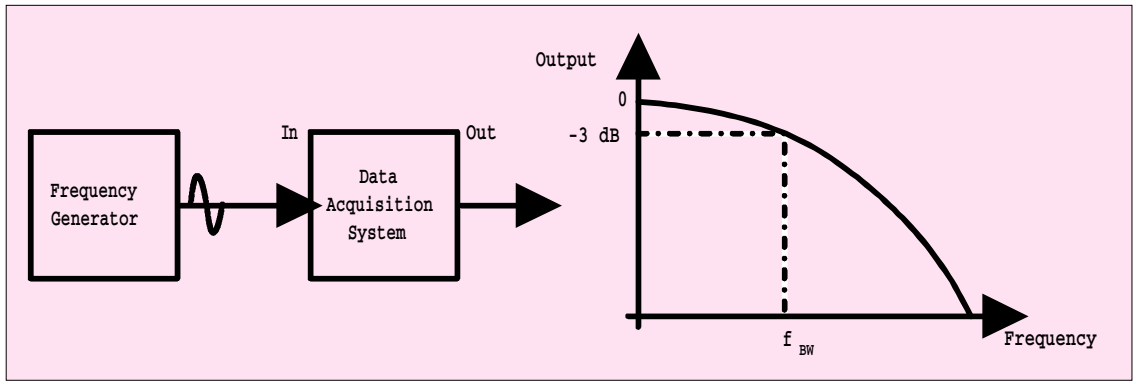
ADC Conversion Rate. The rate at which the analog-to-digital converter (ADC) can establish an n-bit digital representation of the analog signal. Typical conversion rates for converters which utilize the successive approximation technique are 10 KHz, 20 KHz, 50 KHz, 100 KHz, and 1 MHz. Care must be taken to ensure that ADC conversion rate is not confused with aggregate throughput rate.

Aggregate Throughput Rate. The rate at which multiple DAS inputs can be converted and transmitted to a host processor in a sustained manner.

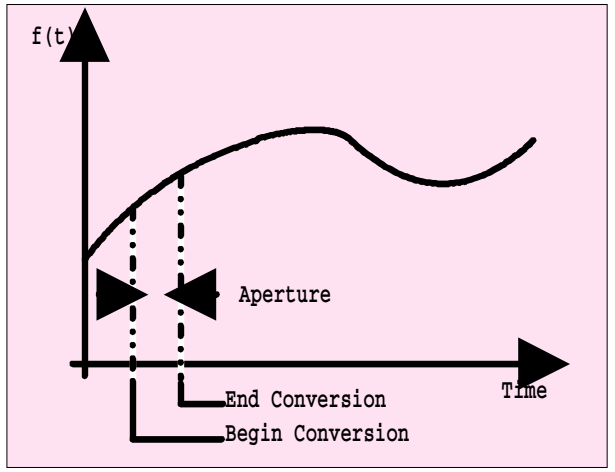
Aperture. The time required for the analog-to-digital converter to establish the digital representation of the unknown analog signal. During the conversion time, the analog input may change thus resulting in an error. To eliminate aperture error, the DAS may incorporate a sample-and-hold circuit before the ADC.

Bandwidth (Small Signal). The band of frequencies extending from zero upwards to the frequency for which the output amplitude is reduced by no more than 3 dB (70.7% RMS of the Voltage Ratio) of the amplitude at zero frequency.

Bandwidth (Full Power). Full power bandwidth differs from small signal bandwidth in that full power bandwidth is defined for sinusoidal signals whose peak-to-peak values are equal to ± full scale.



BANDWIDTH CAN BE ESTABLISHED BY INPUTTING DIFFERENT FREQUENCIES AT CONSTANT AMPLITUDE AND DETERMINING THE FREQUENCY (F_{BW}) AT WHICH THE OUTPUT IS REDUCED TO 70.0%.



AN ADC REQUIRES A FINITE TIME TO ESTABLISH THE DIGITAL REPRESENTATION.

Terminology (Continued)

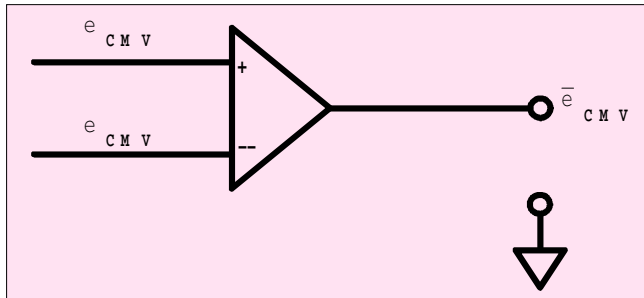
CMRR. The ratio of signal gain to the ratio of normal mode voltage to common mode voltage (CMV) expressed as:

$$CMRR = 20 \log [Gain/(v_{cmv}/e_{cmv})]$$

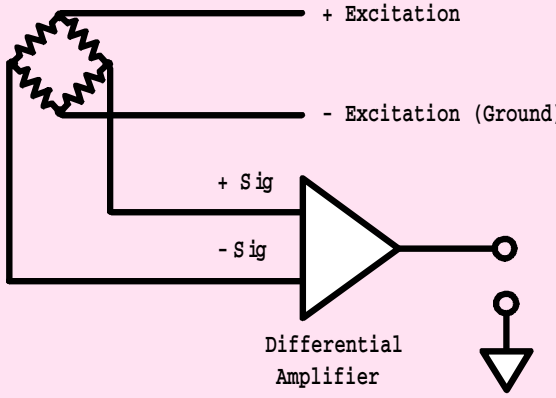
where v_{cmv} is the normal mode voltage appearing at the device's output and e_{cmv} is the CMV. Assuming the gain is 100, the CMV is 5V, and the CMRR is 120 dB, the error signal appearing at the output of the differential amplifier is:

$$v_{cmv} = (100 * e_{cmv})/\log^{-1}(120/20) = 0.0005V$$

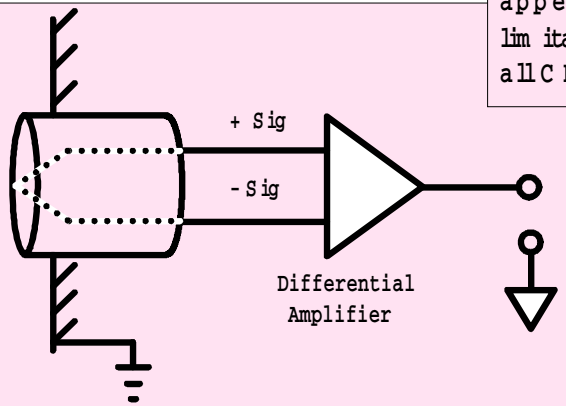
CMV. A voltage which is common to both signal leads is referred to as common mode voltage (CMV). CMV can be measured as the voltage difference that exists between each input terminal and the DAS reference.



Differential amplifiers act on the difference between the input terminals and thus tend to reject any CMV. Some part of the CMV will appear at the output as a result of the inherent limitation of the differential amplifier to reject all CMV.



a. Strain Gage Sensor. CMV is equal to one-half the excitation.



b. Grounded Thermocouple. CMV is equal to difference between transducer ground and system ground.

Note that grounded thermocouples and strain gage transducers are prime candidates for CMV.

Crosstalk. For a multiplexed measurement system, the interaction between consecutively scanned channels caused by a difference in voltage between channels is referred to as crosstalk. This system attribute is generally expressed in terms of dB.

Terminology (Continued)

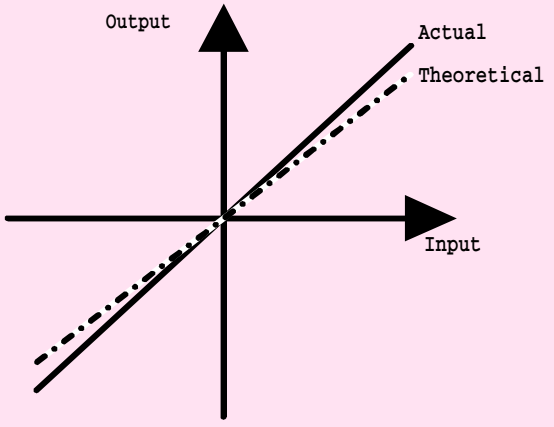
Dynamic Range. The dynamic range of a DAS is a logarithmic expression of the system's measurement range given as:

Dynamic Range, dB = 20 log (2N)

where N is the number of bits, excluding sign. For example, the dynamic range of a 12-bit excluding sign ADC is 72 dB.

Gain Accuracy. Ratio of the true measured gain to the nominal gain. This is classified as a fixed error and is expressed in %FS.

Gain Stability. The variation in voltage gain from nominal attributable to factors other than temperature, expressed as a %FS. This parameter is generally included in the basic gain accuracy specification. If reported separately, gain stability is normally specified in terms of % FS.



Gain error is the difference between the theoretical and actual outputs. The error is fixed at any input.

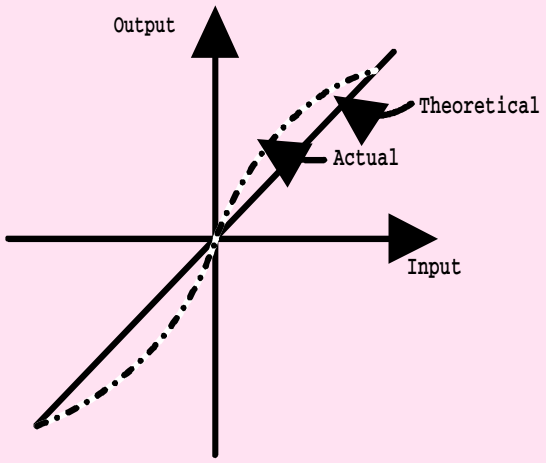
Gain Temperature Coefficient. A quantitative measure of the effects of a variation in operating temperature on gain. This is typically reported in terms of %FS/°C.

Hysteresis. The variation in a device's output for a specific input when the input is approached from different directions. This is classified as a fixed error and is expressed in %FS.

Input Voltage Range. The range of full scale input voltages which will produce full scale digital outputs. Typical full scale input ranges are ±5 mV, ±10 mV, ..., ±10 V. Range selection should be made based on input sensor full scale outputs.

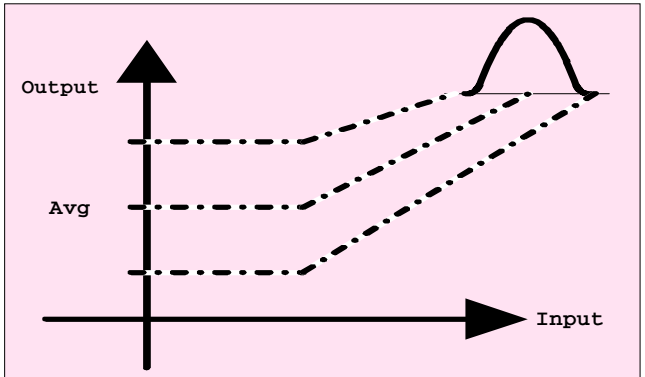
Input Impedance. DAS input impedance is normally stated in terms of resistive and capacitive loads at zero frequency. Typical input impedance is 10M ohm which produces negligible loading for most input sensors.

Linearity. The deviation of the output of a device from a straight line where the straight line may be defined using end-points, terminal points, or best fit it is classified as a fixed error and is expressed in %FS.

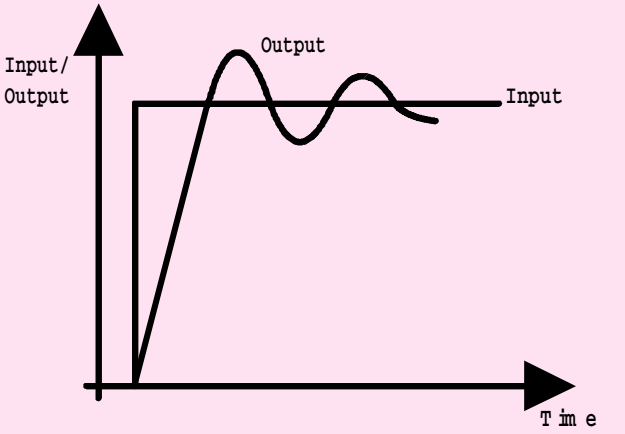


Errors due to a non-linear response are fixed errors at any input.

Noise. Any extraneous or unwanted signal which contaminates the measurement. For measurement systems, noise consists of random noise (thermal processes within conductors), white noise (thermal processes within resistors), and systematic noise (line frequency, power supply ripple, EMI, etc.). This is classified as a random error and is typically reported in terms of %FS, 3-Sigma. Alternative reportings may be in peak-to-peak or RMS units.



Noise has a normal distribution and is reported either as peak-to-peak, RMS or as 3-Sigma. Noise is a function of gain and bandwidth.



System's output overshoots final value.

Overshoot. Whenever a step or pulse input is applied to an amplifier (or certain active filters), the system's output exceeds the final value before settling to a final value.

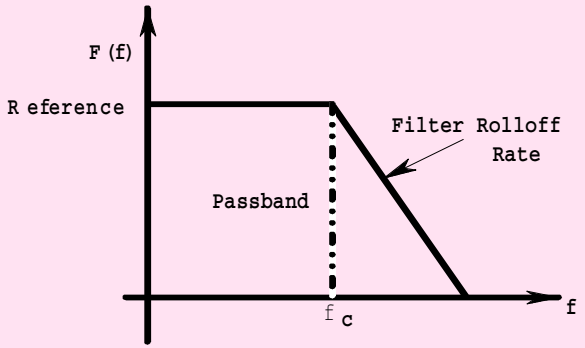
Resolution. The value of the smallest detectable signal that a system can measure. This is classified as a fixed error and for a digital system is expressed in terms of Least Significant Bit. For example, a 12-bit excluding sign DAS which has a full scale input range of ±5 mV has a resolution of:

$$\text{Resolution, mV RTI} = 5\ \text{mV}/2^{12} = 1.2\ \mu\text{V}$$

Alternatively, resolution can be expressed as a percent of full scale. For this example, the resolution is ±0.02% FS. Please note that resolution is not the same as accuracy.

Revisit Rate. See Channel Revisit Rate.

Rolloff Rate. For a low-pass filter, rolloff rate describes the amplitude attenuation characteristics for signal frequencies which lie outside the passband (i.e., frequencies greater than the filter cutoff frequency, f_c).



The Attenuation of a low-pass filter in the stop band is a function of filter rolloff rate.

Terminology (Continued)

Generally it is described in terms of an integer number of poles, where each pole provides 6.02 dB/octave (equivalent to 20 dB/decade) attenuation.

RTI. The expression RTI (Relative to Input) is oftentimes used with specifications to signify that the specification is gain dependent. To quantify the effect, the RTI specification must be adjusted by gain.

RTO. The expression RTO (Relative to Output) is oftentimes used with specifications to signify that the specification is not gain dependent.

Settling Time. The time interval between the application of an input and the time when the output is within an acceptable band of the final steady-state value.

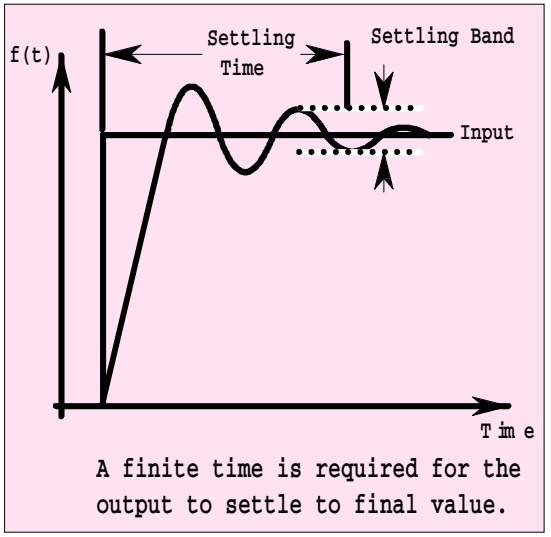
Slew Rate. A measure of the maximum rate-of-change for a device expressed as dV/dT. Slew rate is related to full power bandwidth as follows:

$$\text{Slew Rate} = 2\pi f_p A/10^6$$

where f_p is full power bandwidth and A is full scale output voltage. If f_p is 5 KHz and A is 10V, then Slew Rate is:

$$\text{Slew Rate} = 2\pi \cdot 5000 \cdot 10/10^6 = 0.3\text{V}/\mu\text{S}$$

Static Crosstalk. For a multiplexed measurement system, the interaction between consecutively scanned channels caused by a difference in voltage between channels. This system attribute is generally expressed in terms of dB.



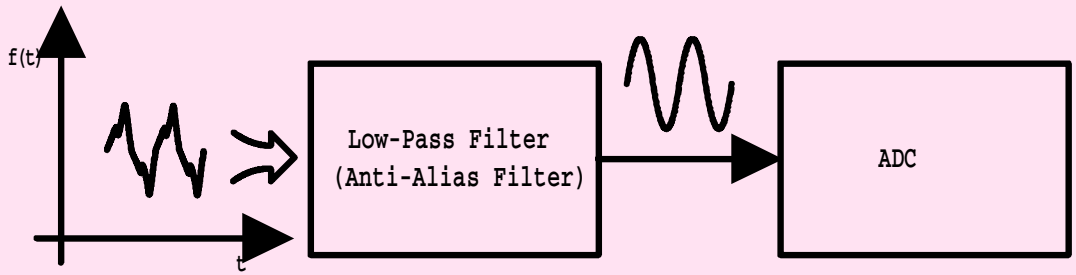
Zero Offset. The deviation from true zero when a shorted input is applied caused by time, temperature, or power supply variations. This is a fixed error which is normally stated in relative to input (RTI) units.

Zero Stability. The variation in offset zero attributable to factors other than temperature. This is normally stated in relative to input (RTI) and relative to output (RTO) terms.

Zero Offset Temperature Coefficient. A quantitative measure of the effects of a variation in operating temperature on offset zero. This is typically reported in units of change per degree RTI.

Low-Pass Filters

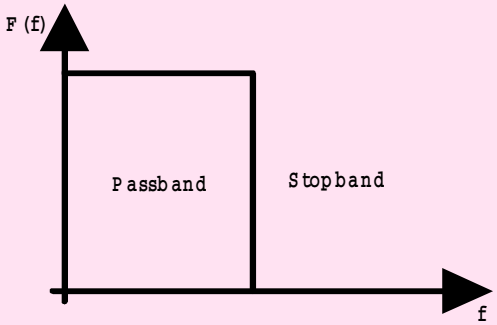
Low-Pass Filters. Analog measurements may be contaminated with noise (unwanted signals which interfere with the signals of interest). For a digital DAS, it is critical that sampling rate be established based on the highest frequencies presented to the ADC (see Sampling). Thus, it is necessary to attenuate all frequency components attributable to noise. To accomplish this, analog measurements are processed through a hardware implemented low- pass filter oftentimes referred to as an anti-alias filter. The low-pass filter's function is to process signal frequencies of interest and to attenuate all others.



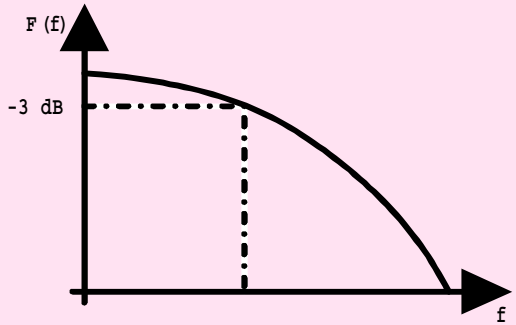
Hardware implemented low-pass filters are used to remove high frequency noise components before digitizing.

The ideal low-pass filter provides zero attenuation for frequencies within the passband and infinite attenuation for all other frequencies. Practical low- pass filters do not exhibit these ideal characteristics. Rather than introducing zero attenuation within the passband, gradual attenuation begins within the passband and is at -3 dB at the filter's cutoff frequency (also referred to as corner frequency). At frequencies which are greater than the cutoff frequency, the attenuation is greater than -3 dB and is a function of the filter's rolloff rate characteristics.

Filter rolloff rate is often implied by describing low-pass filters as 1-pole, 2-pole, etc. This terminology refers to the number of factors which appear in the denominator term of the LaPlace transformed transfer function. Each pole provides -6.02 dB/octave rolloff rate attenuation.



Ideal low-pass filter provides infinite attenuation for all frequencies outside the passband



Practical low-pass filters provide some attentuation within passband

Thus, a 2-pole low-pass filter has a rolloff rate of -12.04 dB/octave. An alternative method of describing rolloff rate is in terms of dB/decade. With this notation, each pole provides -20 dB/decade attenuation.

For low-level multiplexed DAS, the filters are implemented with passive components (resistors and capacitors). The disadvantages associated with passive filters are:

- o limited to two poles (-12dB/octave roll rate);
- o limited corner frequencies (most low-level multiplexed DAS have nominal corner frequencies of 10Hz);
- o sensor impedance affects filter corner frequency.

Amplifier-per-channel systems with low-pass filters provide isolation between sensor and filter so the cutoff frequency is more precisely controlled. Additionally, these are usually active filters with 2 to 8 poles that provide higher rolloff rates.

Active filters are oftentimes described as Butterworth, Chebyshev, or Bessel. This term describes the passband amplitude and phase response characteristics. For multiplexed DAS, Butterworth filters provide the best passband amplitude characteristics and are used for applications where amplitude accuracy is critical. Bessel filters are used for transient measurement applications where overshoot and phase linearity are critical.

Nyquist Theorem. The Nyquist Theorem, based on sampling signals processed through an ideal "brick wall" filter with a cutoff frequency at the 'highest frequency of interest", states that sampling rates must be at least twice that frequency to avoid aliasing. Practical analog low-pass filters do not exhibit the ideal characteristics of zero dB attenuation of signal frequencies below the cutoff frequency and infinite attenuation of signal frequencies above it. Instead, attenuation by 120dB of a full-scale noise signal is accomplished only at frequencies above 6X the cutoff frequency with an 8-pole Butterworth and more than 10X the cutoff frequency using an 8-pole Bessel filter. Sample rates would then have to be 12 to 20 times the cutoff frequency.

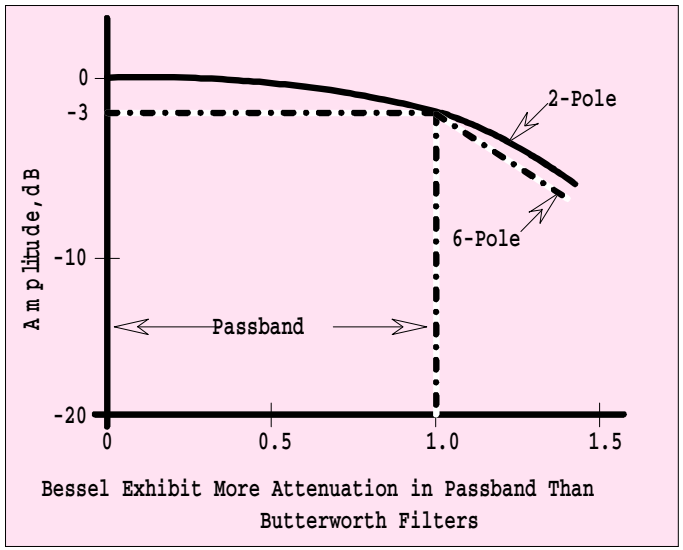
Analog Filter Characteristics. Additional issues with analog filters include phase shift and error in the passband. A Butterworth filter with 8-poles exhibits a phase shift of –360° at the cutoff frequency. If 5% components are used, a variation of ±18° (36° channel to channel) could occur. The Bessel characteristic (linear phase) is less of a problem at –182° at the cutoff frequency, but attenuation of signals using a Bessel filter begins at dc and at only 10% of the cutoff frequency is already at –0.03 dB (0.3%). Attenuation using the Butterworth characteristic reaches –0.04 dB at 75% of the cutoff frequency.

Component tolerances can be tightened and individual channels can be adjusted with attendant higher cost but components drift with time and temperature changes so additional calibration effort is required at intervals.

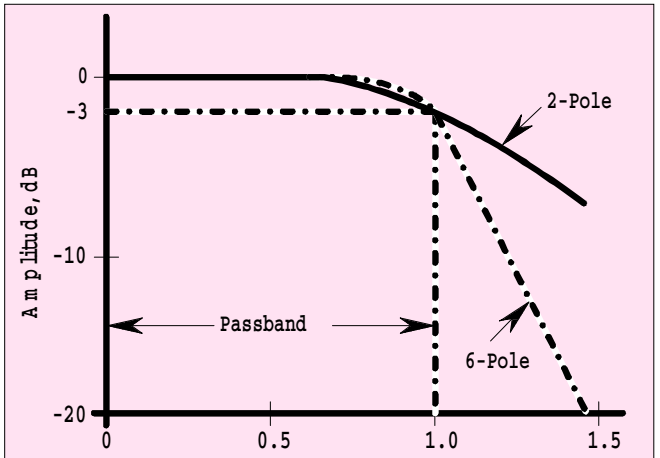
Low-Pass Filters (Continued)

Digital Filters. Compare the performance of analog filters to those of NEFF's System 730 featuring digital filters:

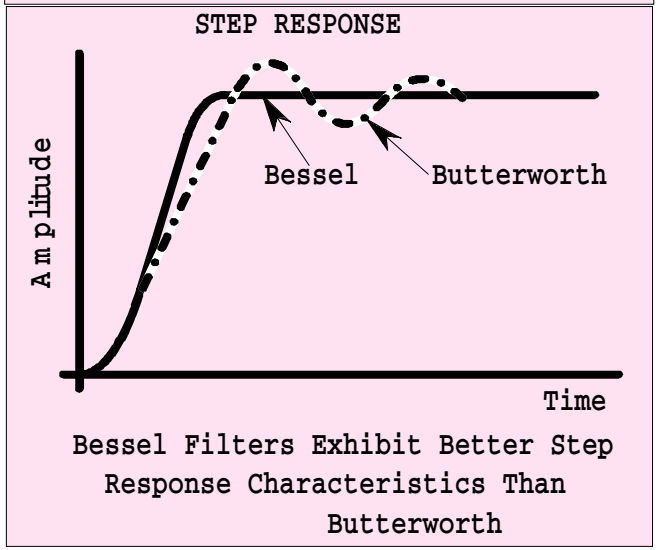
- o Passband defined to be 90.9% of the –3dB frequency.
- o Ripple or attenuation in the passband less than 0.005 dB`
- o Channel-to-channel phase matching is 1
- o Sampling rate needs to be only 2.67 times the passband f r e - quency or 2.43 times the -3dB frequency.



Bessel Exhibit More Attenuation in Passband Than Butterworth Filters



Amplitude Characteristics Of Butterworth Filters Are Relatively Flat In Passband

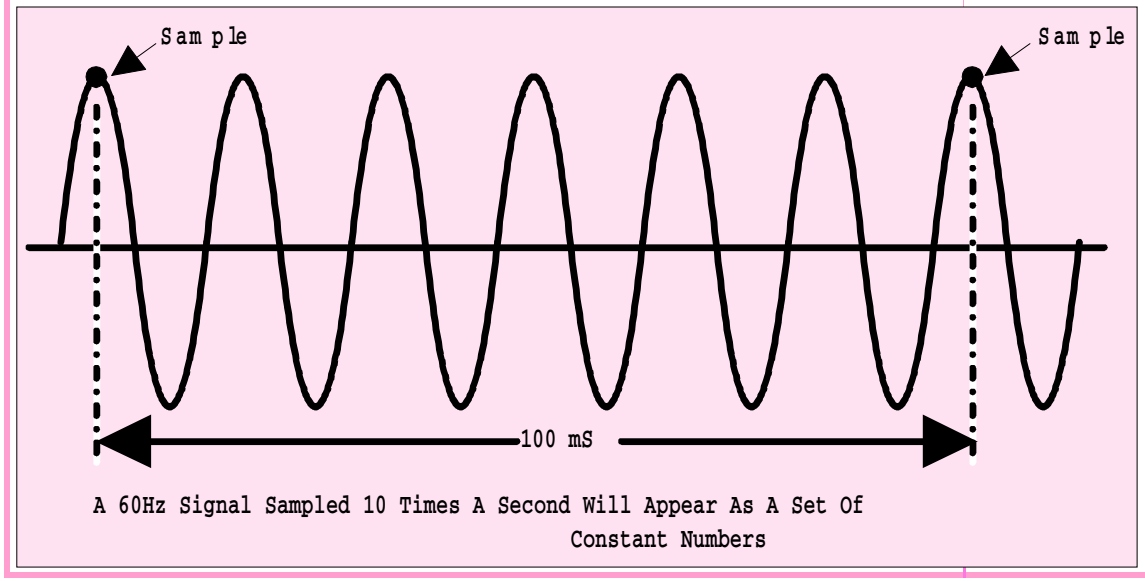


Bessel Filters Exhibit Better Step Response Characteristics Than Butterworth

Establishing Minimum Sampling Rate

Multiplexed DAS convert continuous phenomena into discrete digital values. Since a continuum is being represented by a finite number of samples, there are concerns that information is lost in the process. Thus, the question which arises is "How fast to sample?" Answers to this often asked question range from "sample N times a second" where N is determined empirically to "sample only when you need a measure". While determining how fast to sample a continuous phenomena depends largely upon the application, it is absolutely essential that the minimum sampling rate be established based on aliasing concerns.

To illustrate aliasing, consider a signal which consists of a 1 Vdc level with 10 mV peak 60 Hz noise. If this signal is sampled at say 10 samples/second, the result will be a set of constant numbers falsely implying that the input is constant. This error which is the result of insufficient sampling rate is termed aliasing error. Here, the 60 Hz signal can not be distinguished from zero frequency.



A 60Hz Signal Sampled 10 Times A Second Will Appear As A Set Of Constant Numbers

The sampling frequency, f_s, must be at least twice the highest frequency present. Since the input signal can be contaminated with noise, a low pass filter is used to pass the band of frequencies of interest and attenuate all others. Knowing the filter's cutoff frequency (f_c) and rolloff rate, the frequency beyond which all energy is diminished to an acceptable level (denoted f_c*) can be calculated. To have confidence that the sampled data are representative of the input (i.e., no aliases), it is critical that the minimum sampling frequency (f_s) be computed based on f_c and f_c*.

Steps in Computing Sampling Frequency

1. Determine bandwidth and choose filter cutoff frequency. The input sensor is generally the limiting factor. For example, the thermal mass associated with thermocouples is such that bandwidths of a few hertz are reasonable. Typically, 10 Hz bandwidths are chosen for steady state measurements such as thermocouples, strain gages, RTDs. If lower bandwidth filters are used, the system's response to a changing input becomes excessively slow.

Establishing Minimum Sampling Rate (Continued)

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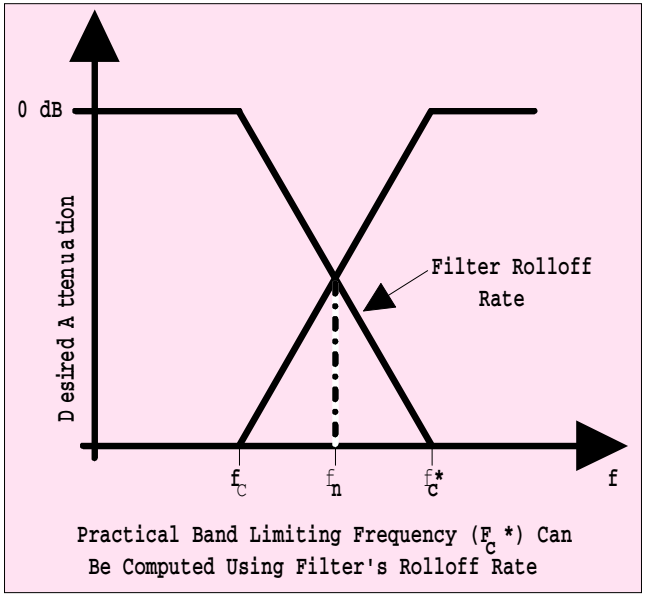


2. Select a filter type (e.g. Butterworth) and rolloff rate.

3. Determine the maximum allowable distortion and express in terms of dB.

Distortion Level	Corresponding dB
0.1%	-60
1.0	-40
5.0	-26
10.0	-20

Note: Noise levels are typically less than signal levels. If noise is 10% of full scale, the given distortion levels can be achieved with filter attenuation of -40, -20, -6, and 0.

4. Compute f_C^*:

   Number of Octaves, N = Allowable Distortion/Rolloff Rate

   $$f_C^* = 2^N f_C$$

5. Determine folding frequency, f_n:

   $$f_n = \tfrac{1}{2}(f_C + f_C^*)$$

6. Compute minimum sampling frequency, f_s:

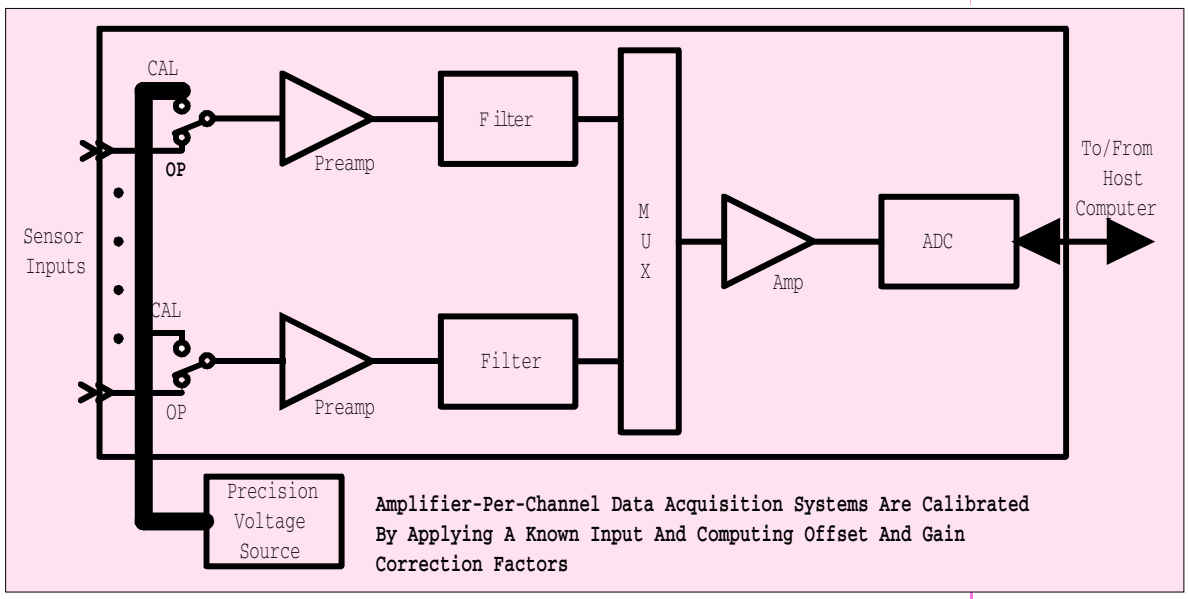
   $$f_S > 2f_n$$

Calibrating Data Acquisition Systems

Measurement system parameters such as offset and gain vary with time and temperature and as a consequence may introduce fixed bias errors in the measurement. Fortunately, these offset and gain errors can be effectively eliminated by periodically "calibrating" the system. As used in this context, calibration refers to the process of identifying, quantifying, and reducing measurement system offset and gain errors.

For a multiplexed data acquisition system, calibration involves inserting known voltages into each input channel and adjusting channel zero and channel gain to obtain the desired output. Rather than manually adjusting each channel, the measured deviations from zero and full-scale can be used to calculate offset zero and gain correction factors for each channel. These correction factors can then be used by software to effectively eliminate offset and gain errors. This technique of compensating for offset and gain through software is commonly used with large multi-channel amplifier-per-channel systems. Since offset and gain are a function of both amplifier gain and filter settings, the calibration must be performed at the appropriate gain/filter setting.

With low-level multiplexed systems, there are subtle design differences which affect calibration. If the system has all gain located past the multiplexer such that the amplifier is shared with all inputs, it is only necessary to calibrate one channel. With this design, there is but one zero and one gain adjustment which are used for all channels thus simplifying calibration.



Amplifier-Per-Channel Data Acquisition Systems Are Calibrated By Applying A Known Input And Computing Offset And Gain Correction Factors

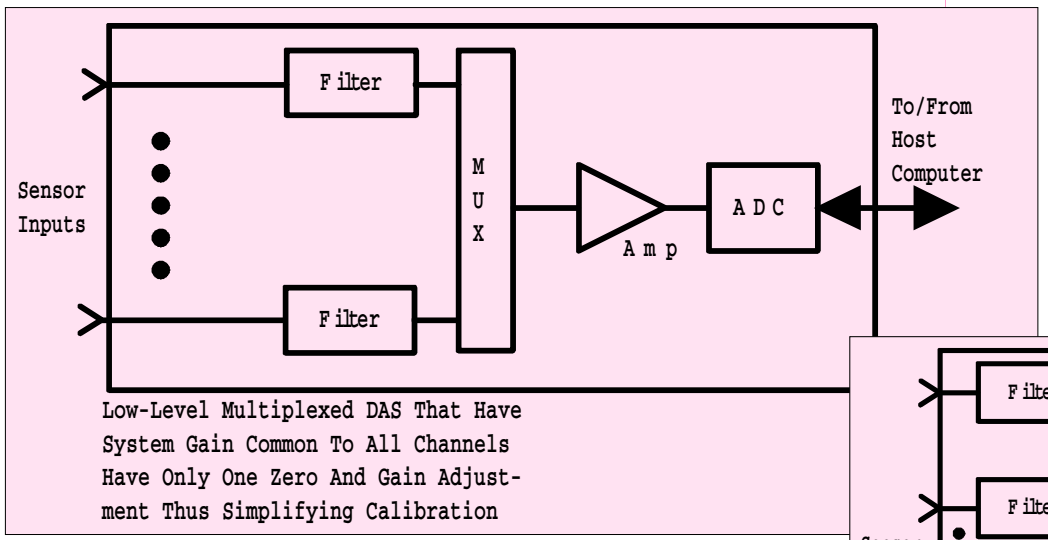
An alternative method of implementing low-level multiplexing utilizes distributed gain. With this design, there are two levels of multiplexing and two levels of gain. Typically, each group of n input channels is multiplexed and amplified and input to a second level multiplexer which is followed by an amplifier. Total gain is the product of the two amplifier gains and total offset is the algebraic sum of the two amplifier offsets. Calibrating distributed gain systems is complicated in that it requires a known input be applied for each group of n inputs.

Neff's low-level multiplexed systems (the System 620/Series 400 and the System 470) utilize the centralized gain concept. As such, all inputs

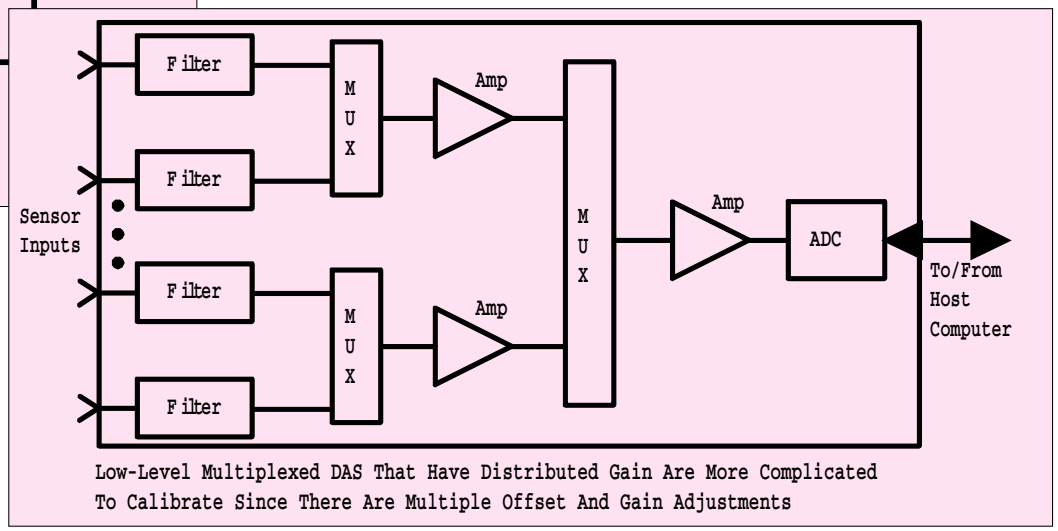
Calibrating Data Acquisition Systems (Continued)

share a common amplifier which operates at programmable gains. The significant advantage of this technique as compared to distributed gain is calibration simplicity. Since the gain is common to all inputs, it is only necessary to input known voltages on one channel. Neff manufactures a calibration card for the System 470 which outputs precise voltages.

These calibration voltages may be continuously read in along with other inputs. Using software, the calibration voltages can be used to establish offset and gain correction factors which can then be applied to the measurements to compensate for offset and gain errors caused by time and temperature.



Low-Level Multiplexed DAS That Have System Gain Common To All Channels Have Only One Zero And Gain Adjustment Thus Simplifying Calibration



Low-Level Multiplexed DAS That Have Distributed Gain Are More Complicated To Calibrate Since There Are Multiple Offset And Gain Adjustments