Chapter 12

IC693ALG442 Analog Combination I/O Module

Analog Current/Voltage Combination Module 4 Input/2 Output Channels - IC693ALG442

The ***Analog Current/Voltage Combination Input/Output*** module provides up to 4 differential input current or voltage channels and 2 single-ended output channels with either current loop outputs or voltage outputs. Each channel can be individually configured for the current or voltage range, as applicable, required for your application. All module configuration is done through software, except for a jumper required for selecting the current input mode. All ranges can be configured using either the Logicmaster 90-30/20/Micro programming software configurator function or the Series 90-30 Hand-Held Programmer.

Note that in this module's description, the module will be simply referred to as the ***Analog Combo Module.***

Each analog input is capable of providing five input ranges (two voltage and three current), which are:

- 0 to +10 volts (unipolar) - default range for both input and output channels.
- –10 to +10 volts (bipolar)
- 0 to 20 mA
- 4 to 20 mA
- 4 to 20 mA Enhanced

The default input range is voltage mode 0 to +10 volts (unipolar) with user data scaled so that 0V corresponds to a count of 0 and 10V corresponds to a count of 32767.

Each analog output is capable of providing four output ranges (two voltage and two current):

- 0 to +10 volts (unipolar) - default range for both input and output channels.
- –10 to +10 volts (bipolar)
- 0 to 20 milliamps
- 4 to 20 milliamps

Each output channel is capable of converting 15 to 16 bits (depending on the range selected) of binary (digital) data to an analog output for use as required by your application. User data in

the%AI and %AQ registers is in a 16-bit 2's complement format. In current modes, an *open-wire fault* is reported to the CPU for each channel. The module can go to a known last state when system power is interrupted. As long as user power is applied to the module, each output will maintain its last value, or reset to the low end of the scale (range), as determined by how you have configured the module.

Each output channel can be configured to operate in ramp mode using ladder logic. In ramp mode, changes in %AQ data cause the corresponding output channel to ramp to the new %AQ value. The ramp output consists of steps taken each millisecond until the final value is reached.

High and low alarm limits can be set for all input channels and an *open-wire fault* (current output modes) is reported to the CPU for each output channel. All six analog channels may be updated on every scan, depending on the scan time.

Table 12-1. Specifications for IC693ALG442

Analog Output Specifications	
Number of Output Channels	2, Single-Ended
Update Rate	4 milliseconds (approximate - both channels)
Analog Current Output	
Output Current Ranges	0 to 20 mA 4 to 20 mA
Resolution	
0 to 20 mA	0.625 µA (1 LSB = 0.625 µA)
4 to 20 mA	0.5 µA (1 LSB = 0.5 µA)
Absolute Accuracy[1]	
All Current Modes	± 0.1% of full scale @25°C (77°F), typical ± 0.25% of full scale @25°C (77°F), (maximum) ± 0.5% of full scale over operating temperature range (maximum)
Maximum Compliance Voltage	V_{USER} –3V (minimum) to V_{USER} (maximum)
User Load	0 to 850 Ω (minimum) at V_{USER} =20V, maximum 1350Ω at V_{USER} =30V
Output Load Capacitance	2000 pF (maximum)
Output Load Inductance	1 H (maximum)
Analog Voltage Output	
Output Ranges	–10 to +10V (bipolar) 0 to +10V (unipolar)
Resolution	
–10 to +10V	0.3125 mV (1 LSB = 0.3125 mV)
0 to +10V	0.3125 mV (1 LSB = 0.3125 mV)
Absolute Accuracy[2]	
Both Voltage Modes	± 0.25% of full scale @25°C (77°F), typical ± 0.5% of full scale @25°C (77°F), (maximum) ± 1.0% of full scale over operating temperature range (maximum)
Output Loading	5 mA (2K ohms minimum resistance)
Output Load Capacitance	1 µF (maximum capacitance)
Analog Input Specifications	
Number of Input Channels	4, differential
Update Rate	8 milliseconds (approximate for all 4 channels)
Analog Current Input	

Input Ranges	0 to 20 mA 4 to 20 mA 4 to 20 mA Enhanced
	(Table continued on next page)
(Continued from previous page)	
Resolution	
0 to 20 mA	5 µA (1 LSB = 5 µA)
4 to 20 mA	5 µA (1 LSB = 5 µA)
4 to 20 mA Enhanced	5 µA (1 LSB = 5 µA)
Absolute Accuracy[3]	
All Current Modes	± 0.25% of full scale @25°C (77°F) ± 0.5% of full scale over specified operating temperature range
Linearity	<1 LSB
Common Mode Voltage	200V (maximum)
Common Mode Rejection	>70 db at DC; >70 db at 60 Hz
Cross Channel Rejection	>80 db from DC to 1 kHz
Input Impedance	250 Ω
Input Filter Response	29 Hz
Analog Voltage Input	
Input Ranges	0 to +10V (unipolar) –10 to +10V (bipolar)
Resolution	
0 to +10V	2.5 mV (1 LSB = 2.5 mV)
–10 to +10V	5 mV (1 LSB = 5 mV)
Absolute Accuracy[3]	
Both Voltage Ranges	± 0.25% of full scale @25°C (77°F) ± 0.5% of full scale over specified operating temperature range
Linearity	<1 LSB
Common Mode Voltage	200V (maximum)
Common Mode Rejection	>70 db at DC; >70 db at 60 Hz
Cross Channel Rejection	>80 db from DC to 1 kHz
Input Impedance	800K Ω (typical)
Input Filter Response	29 Hz
Power Requirements	
External Supply Voltage Range	20 to 30 VDC (24 VDC typical)
Power Supply Rejection Ratio (PSRR)[4]	5 µA/V (typical), 10µA/V (maximum)
Current	25 mV/V (typical), 50mV/V (maximum)
Voltage	
Voltage Ripple	10%
Current Consumption	
From Internal +5V Supply	95 mA
From External User Supply	129 mA

[1]In the presence of severe RF interference (IEC 801-3, 10V/m), accuracy may be degraded to ±1% FS.

[2]In the presence of severe RF interference (IEC 801-3, 10V/m), accuracy may be degraded to ±4% FS.

[3]In the presence of severe RF interference (IEC 801-3, 10V/m), accuracy may be degraded to ±2% FS.

[4]PSSR is measured by varying V_{USER} from 24V to 30V.

Refer to Appendix B for product standards and general specifications.

IC693ALG442 Input Modes and Current/Voltage Ranges

Current Operation

In the *4 to 20 mA range*, user data is scaled so that 4 mA corresponds to a count of 0 and 20 mA corresponds to a count of 32000. The other ranges are selected by changing the configuration parameters using the Logicmaster 90-30/20/Micro configurator software or the Hand-Held Programmer. In the *0 to 20 mA range* user data is scaled so that 0 mA corresponds to a count of 0 and 20 mA corresponds to a count of 32000. Full 12-bit resolution is available over the 0 to 20 mA range.

A *4 to 20 mA Enhanced range* can also be selected. When this range is selected, 0 mA corresponds to a count of –8000, 4 mA corresponds to a count of 0 (zero) and 20 mA corresponds to a count of +32000. The Enhanced range uses the same hardware as the 0 to 20 mA range but automatically provides 4 to 20 mA range scaling with the exception that negative digital values are provided to the user for input current levels between 4 mA and 0 mA. This gives you the capability of selecting a low alarm limit that detects when the input current falls from 4 mA to 0 mA, which provides for open-wire fault detection in 4 to 20 mA applications. High and Low alarm limits are available on all ranges. Ranges can be configured on a per channel basis.

User data in the %AI registers is in 16-bit 2's complement format (0 to 20 mA range only). Resolution of the converted signal is 12 bits binary (1 part in 4096) on the 0 to 20 mA range. The placement of the 12 bits from the A/D converter in the %AI data word is shown below.

MSB															LSB
X	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	X	X	X

X=not applicable to this discussion.

The relationship between the current input and the data from the A/D converter is show below.

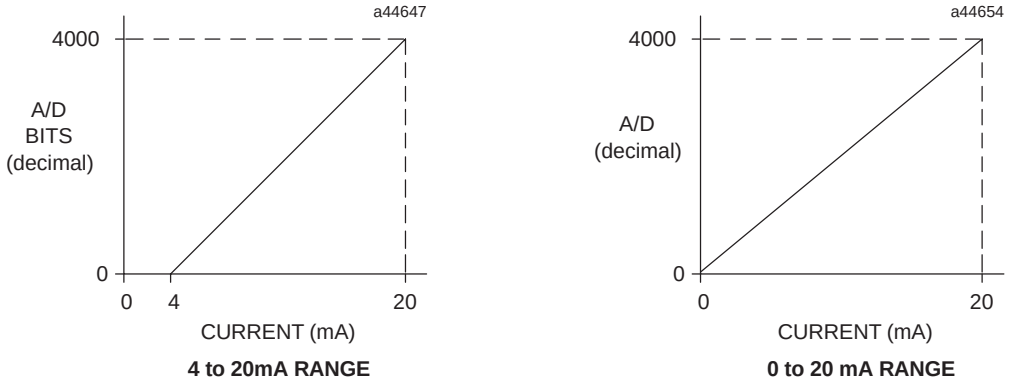


Figure 12-1. A/D Bits vs. Current Input

If the current source is reversed into the input, or is less than the low end of the current range, then the module will output a data word corresponding to the low end of the current range (0000H in %AI). If an input that is out of range is entered (that is, it is greater than 20 mA), the A/D converter will output up to full scale (corresponding to 7FFFH in %AI).

Voltage Operation

In the *0 to +10 V default range*, user data is scaled so that 0 volts corresponds to a count of 0 and +10 volts corresponds to a count of 32000. The –10 to +10 volt range is selected by changing the

configuration parameters using the Logicmaster 90-30/20/Micro configurator software or the Hand-Held Programmer. In the *–10 to +10 volt range* user data is scaled so that –10 volts corresponds to a count of –32000 and +10 volts corresponds to a count of +32000. Full 12-bit resolution is available over either range.

Since converters used in the analog input channels are 12-bit converters, not all of the 16 bits in the data tables contain data required for the conversion. A version of the 12 bits is placed within the 16-bit data word corresponding to the analog point (in the %AI table). The Series 90-30 PLC system handles the integration differently for the various analog modules.

The CPU does not manipulate the data from the input channels before placing it within the word in the %AI data table. The bits in the %AI data table which were not used in the conversion by the input channel are forced to 0 (zero) by the analog input channel. Placement of the 12 data bits from the A/D converter for an analog current input data word for the 16-Channel Analog Voltage Input module in unipolar range is shown below.

MSB LSB

X	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	X	X	X

X=not converted bits

Analog values are scaled over the range of the converter. Factory calibration adjusts the analog value per bit (resolution) to a multiple of full scale (that is, 2.5 mV/bit for unipolar; 5 mV/bit for bipolar). This calibration leaves a normal 12-bit converter with 4000 counts (normally 2^{12} = 4096 counts). The data is then scaled with the 4000 counts over the analog range. For example, the data to the A/D converter for the Analog Voltage Input is scaled as shown below.

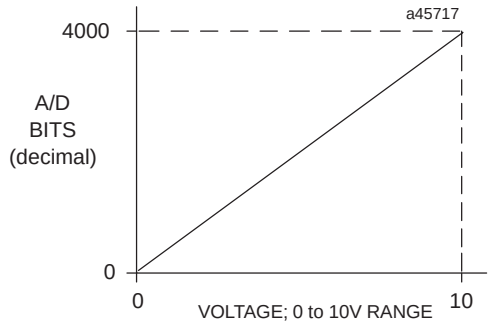
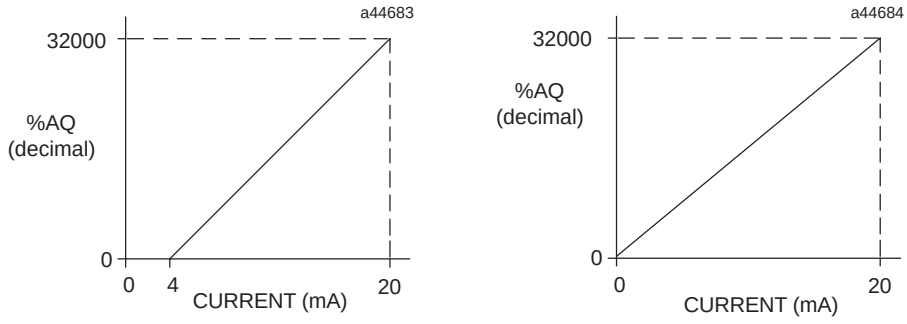


Figure 12-2. A/D Bits vs. Voltage Input

IC693ALG442 Output Modes and Current/Voltage Ranges

Current Operation

In the 4 to 20 mA range user data is scaled so that 4 mA corresponds to a count of 0 and 20 mA corresponds to a count of 32767. In the 0 to 20 mA range, user data is scaled so that 0 mA corresponds to a count of 0 and 20 mA corresponds to 32000. Note that in the 0 to 20 mA mode, you can enter a value up to 32767 which provides a maximum output of approximately 20.5 mA. Scaling of the current output for both the 4 to 20 mA range and the 0 to 20 mA range is shown below. In current mode the module also provides an open loop fault detect which is reported to the PLC in the %I table.



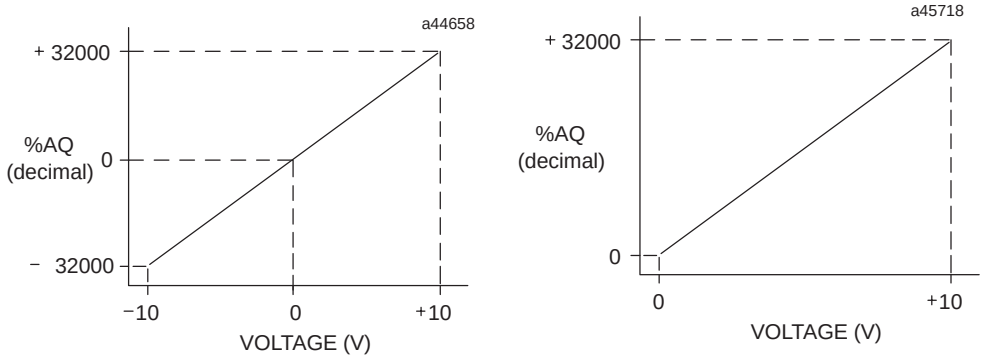
4 to 20 mA Range **0 to 20 mA Range**

Figure 12-3. Scaling for Current Output

Voltage Operation

For *Voltage Operation* in the default unipolar mode (0 to +10 volts), user data is scaled so that 0 volts corresponds to a count of 0 and +10 volts corresponds to a count of 32000. In this mode, you can enter up to 32767 for an overrange of approximately 10.24 volts output. In the –10 to +10 volt range user data is scaled so that –10 volts corresponds to a count of –32000 and +10 volts corresponds to a count of +32000. In this range, you can enter –32768 to +32767 for an overrange of approximately –10.24 volts to +10.24 volts.

Scaling of the voltage output for both the 0 to +10 volt range and the –10 to +10 volt range is as shown below.



Bipolar Mode **Unipolar Mode**

Figure 12-4. Scaling for Voltage Output

CPU Interface to the IC693ALG442 Analog Combo Module

The Series 90-30 PLC uses the data within the %AI and %AQ data table to record analog values for use by the programmable controller. For detailed information on the CPU interface to analog modules, refer to the "Hardware Description of Analog Module" section at the beginning of this chapter.

Status Reporting

The Analog Combo module module provides status information to the PLC. This status information is updated once each PLC sweep and consists of the following items:

- *health of the module* (all ranges)
- o*verload or open wire detect* (current output mode only)
- *alarm low and high status* (input channels)
- *status of the user-supplied power to the module* (all ranges)

Power Requirements and LEDs

This module requires a maximum of 95 mA from the 5V bus on the PLC backplane for the logic side. The module's analog power *must be supplied* by a single, user supplied+24 VDC power source. This includes current loop output power and voltage output load power. This user supply requires a maximum current of 129 mA.

There are two green LED indicators on the module which provide module and user supply status. The top LED, **OK,** provides module status information, and the bottom LED, **USOK,** indicates whether the user supply is present and is above a minimum designated level. Note that both LEDs are powered from the +5V backplane power bus.

The LEDs have six possible status combinations, which are described below.

LED Status Indications for IC693MDL442			
Combination	**LED**	**Status**	**Description**
1	OK	ON	Module OK and configured
	USOK	ON	User power is present
2	OK	FLASH	Module OK but not configured
	USOK	OFF	No user power
3	OK	FLASH	Module OK but not configured
	USOK	ON	User power is present
4	OK	ON	Module OK and configured
	USOK	OFF	No user power
5	OK	OFF	Module is defective or no +5V backplane power present
	USOK	OFF	User power may or may not be present
6	OK	OFF	Module not OK
	USOK	ON	User power is present

Location in System

The Analog Combo module is compatible with all Series 90–30 CPU models and may be installed in any I/O slot of any Series 90–30 baseplate.

References Used and Maximum Modules per System Considerations

The number of IC693ALG442 Analog Combo modules that can be installed in a system depends on the amount of %AQ, %AI, and %I references available. Each module uses 2 %AQ references and 4 %AI references (depending on status configuration) and 8, 16 or 24 %I references (depending on alarm status configuration). The number of these references is dependent on the type of CPU in your system.

Please refer the the "Maximum Number of Analog Modules per System" table in Chapter 8 to determine how many Analog Combo modules can be installed for the various CPU models.

IC693ALG442 Analog Module Field Wiring Connections

Connections to this module from user devices are made to screw terminals on a removable 20-terminal connector block mounted on the front of the module. The actual terminals used are described in the following table and are shown in the following wiring diagrams.

Terminal Assignments

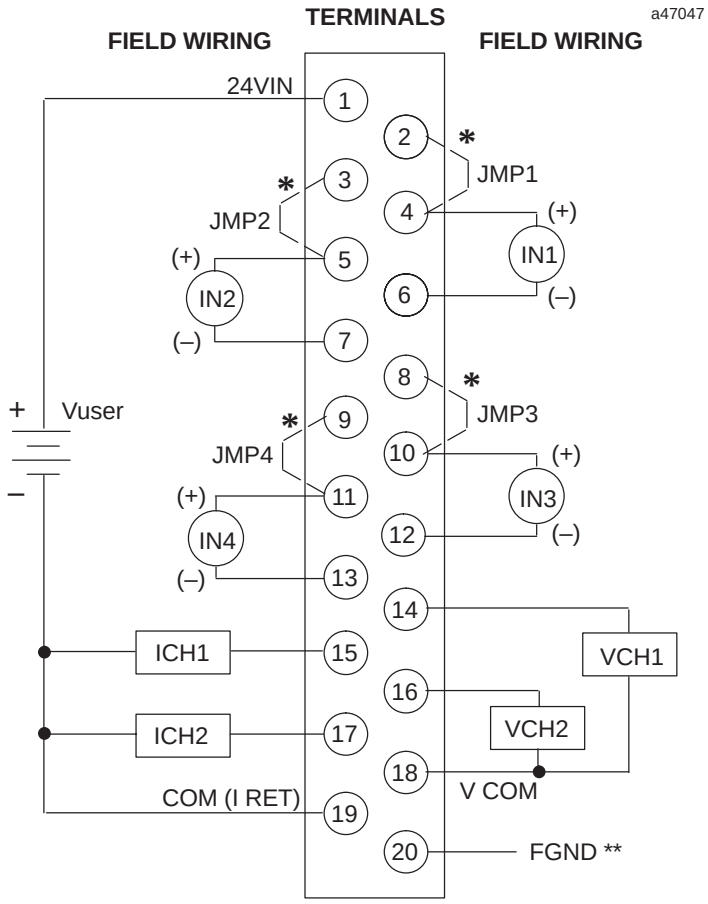
Pin assignments for the 20 terminal I/O connector on the Analog Combo module are as shown in the following table.

Table 12-2. Terminal Pin Assignments for IC693ALG442

Pin Number	Signal Name	Signal Definition
1	24VIN	User Supplied +24 Volt Input
2	JMP1	Jumper terminal for connecting 250Ω sense resistor for CH1
3	JMP2	Jumper terminal for connecting 250Ω sense resistor for CH2
4	+CH1	Positive connection for differential analog input channel 1
5	+CH2	Positive connection for differential analog input channel 2
6	–CH1	Negative connection for differential analog input channel 1
7	–CH2	Negative connection for differential analog input channel 2
8	JMP3	Jumper terminal for connecting 250Ω sense resistor for CH3
9	JMP4	Jumper terminal for connecting 250Ω sense resistor for CH4
10	+CH3	Positive connection for differential analog input channel 3
11	+CH4	Positive connection for differential analog input channel 4
12	–CH3	Negative connection for differential analog input channel 3
13	–CH4	Negative connection for differential analog input channel 4
14	V_{out} CH1	Voltage output for channel 1
15	I_{out} CH1	Current output for channel 1
16	V_{out} CH2	Voltage output for channel 2
17	I_{out} CH2	Current output for channel 2
18	V COM	Common return for voltage outputs
19	I RET	Common return for User supplied +24 V and current outputs
20	GND	Frame ground connections for cable shields

IC693ALG442 Analog Combo Module Field Wiring Diagram

The following figure provide information for connecting field wiring to the user terminal board on the Analog Combo module.



* ADD JMP1 - JMP4 for 250Ω SENSE RESISTOR (CURRENT INPUT MODE ONLY)

** OPTIONAL SHIELD CONNECTION

Figure 12-5. Field Wiring for Analog Combo Module - IC693ALG442

Notes

1. Each Input channel can be configured independent of other Input channels to operate as a voltage input ***or*** a current input – *not both simultaneously.*
2. Each Output channel can be configured independent of other Output channels to operate as a voltage output ***or*** a current output – *not both simultaneously.*
3. **Please see Chapter 2 for wiring and shield ground connection information.**

IC693ALG442 Analog Combo Module Block Diagram

The following figure is a block diagram of the Analog Combo module.

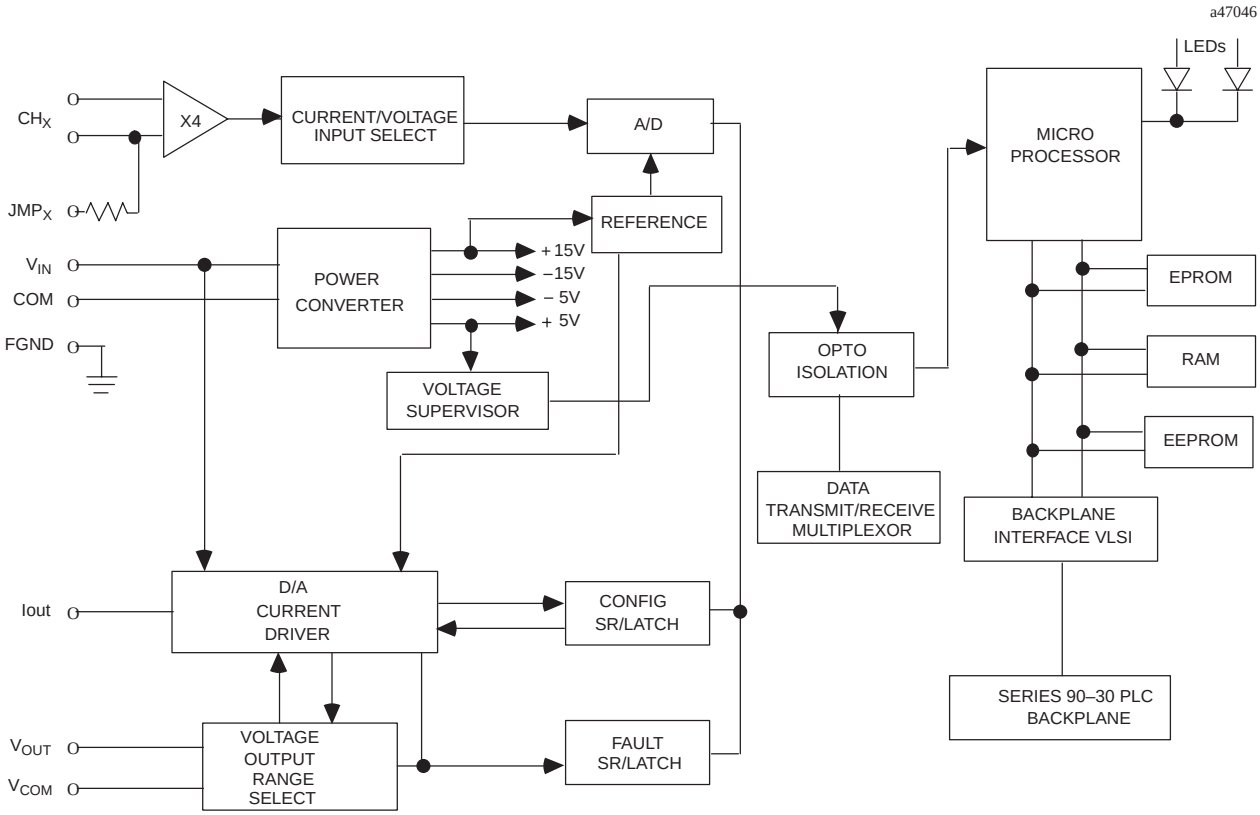


Figure 12-6. Analog Combo Module Block Diagram - IC693ALG442

Configuring the IC693ALG442 Analog Combo Module

The Analog Combo module can be configured using the Logicmaster, VersaPro, or Control programming software configurator function, or with the GE Fanuc Hand-Held Programmer.

The parameters that can be configured are described in the following table. Configuration procedures using Logicmaster 90-30/20/Micro Programming Software and the Hand-Held Programmer are described in the following pages.

Table 12-3. Configuration Parameters for IC693ALG442

Parameter	Description	Values	Defaults	Units
STOP MODE	Output state when module toggled from RUN to STOP mode	HOLD or DEFLOW	HOLD	N/A
%AI ADR	Starting address for the %AI reference type	standard range	%AI0001, or next highest available reference	N/A
%AQ ADR	Starting address for the %AQ reference type.	standard range	%AQ0001, or next highest available reference	N/A
%I ADR	Starting address for the %I reference type	standard range	%I0001, or next highest available reference	N/A
%I SIZE	Number of %I status locations	8, 16, 24	8	bits
RANGE OUTPUT	Type of output range	0,+10 V, –10,+10 V, 4,20 mA, 0, 20mA	0,+10 V	volts (Voltage) mA (Current)
RANGE INPUT	Type of input range	0,+10 V, –10,+10 V, 4,20 mA, 0, 20mA, 4-20 mA Enhanced	0,+10 V	volts (Voltage) mA (Current)
ALARM LO	Low limit alarm value	–32768 to 32759	0	User counts
ALARM HIGH	High limit alarm value	–32767 to 32760	+32000	User counts

For detailed information on configuration of the Analog Combo module, see

- *Configuration Using Logicmaster 90-30/20/Micro Programming Software* beginning on page 3-93.
- *Configuration Using the Hand-Held Programmer* beginning on page 3-104.