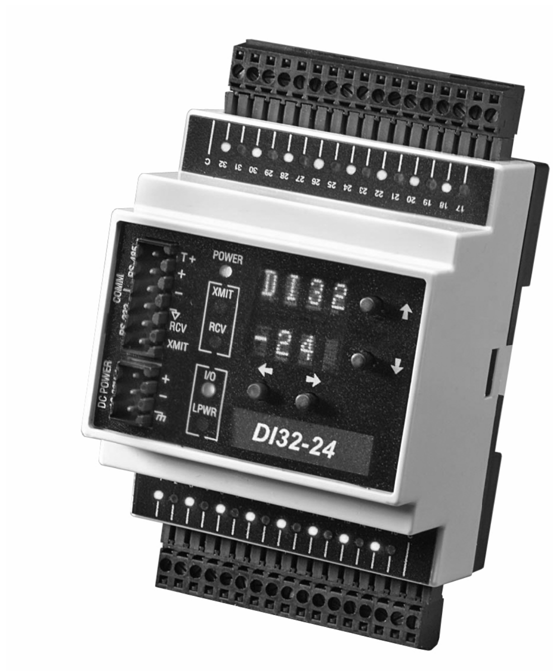
Technical Reference Manual

ScadaFlex MicroBrick

Distributed I/O & RTU Modules



- Multiple Models Available:
  32 Discrete Inputs (12/24 or 120V)
  16 Discrete Relay Outputs
  32 Discrete FET (protected transistor) Outputs
  16 Discrete Inputs 16 Discrete FET Outputs
  16 16-bit Analog Inputs
  8 16-bit Universal (AI/Sensor) Isolated Inputs
  12 16-bit Universal (AI/Sensor) Inputs
  8 16-bit Analog Inputs and 8 12-bit Analog Outputs
  Combo [6 16-bit AI, 10 DI (12/24 or 120V), 4 DO]
- Modular I/O Expansion to 8000 points distributed over 4,000ft.
- Built-in local Operator Interface; View and Force I/O, configure module locally
- Support for Modbus RTU, BrickNet peer-to-peer, and DF1 communications
- Back-to-back I/O bridge – Master Mode
- Built-in “store-and-forward” messaging for radio based systems
- Isolated dual-standard communications interface; RS-232 and RS-485
- All I/O is isolated and transient, surge, overload and polarity protected
- All Discrete Inputs have pulse and runtime totalizers, and rate
- All Discrete Outputs have programmable Flash function
- All Analog Inputs have totalizers with programmable sampling time
- Dual Watchdog Timers; Comm & Module CPU
- Low-power DC for battery/solar applications
- Hot-swappable with removable terminal blocks
- Discrete I/O have individual LED status indicators
- Compact & DIN rail mounting for lower panel cost
- -40ºC to +75ºC Operating Temperature Range
- 3-year factory warranty

MicroBrick Distributed I/O

Technical Reference Manual

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Acknowledgments

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ISaGRAF is a trademark of ICS Triplex, Inc.

In This Manual . . .

This manual provides the technical hardware information required for system design and installation of MicroBrick Distributed I/O Modules.

If you have just purchased a MicroBrick, we hope that you are as pleased using it as we have been developing it.

If you are reading this manual looking at a future purchase, we hope that you will consider MicroBrick I/O when you have an application that needs modular I/O expansion, either locally or over several thousand feet.

Support

If you have questions or need help with an application, we hope that you'll take advantage of our free technical support. Simply call us at:

(800) 888-1893

If you need to send us a fax, use either:

(530) 888-1300 or (530) 888-7017

If you prefer e-mail, especially if you want to send us a sample of a program or other files, you can e-mail us at:

support@www.iclinks.com

For additional technical information including datasheets, manuals and software, visit our web site at:

www.iclinks.com

Certifications

Microbricks are tested to the following certifications:

North America:

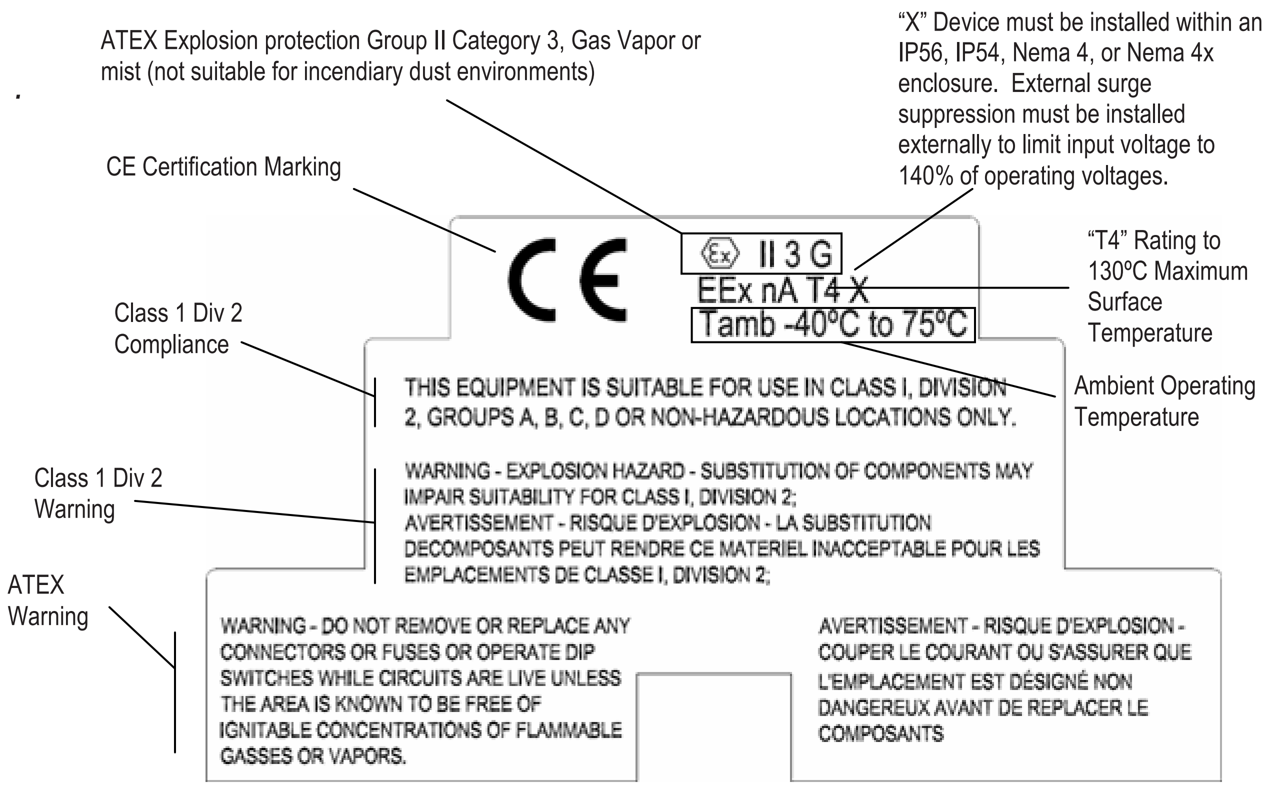
UL 508, CSA 142, ANSI/ISA-12.12.01-2000: April , CSA-C22.2 NO. 213-MI987 (R 1999); Class I Division 2 Groups A, B, C, and D: by INTERTEK.

European Union:

EN 60079-15: Sept 2003 ATEX Group II Category 3 Gas Vapor or Mist Explosion protection

Protection Type nA: In normal and some abnormal conditions, the equipment is not capable of igniting an explosive gas atmosphere.

All certified PicoBrick I/O Modules come with the following compliance marking tag



Contents

Introduction

MicroBricks are easy-to-use distributed I/O modules. They can be interconnected with ScadaFlex or EtherLogic controllers for I/O expansion, connected to Programmable Logic Controllers (PLCs) or PC computers as rugged field I/O, or used with radios or leased-line modems to serve as low-cost Remote Terminal Units (RTUs).

MicroBricks go beyond traditional “dumb” I/O modules by providing local intelligent signal conditioning and data acquisition functions, as well as a local operator interface that can eliminate the need for laptop PCs, simulators or display terminals in the field.

Modular I/O Expansion

MicroBricks provide a very modular means of adding I/O capacity as needed, without the extra cost, wasted space and constraints of card racks. Need more I/O? Snap on a module. Want to add some I/O a few hundred yards away? String a single twisted pair of wires and you’re up and running!

Operator Interface

All MicroBricks come with a built-in alphanumeric operator interface and a simplified 4-key keypad. This interface allows analog input and output levels to be displayed (like a panel meter), and allows both analog and discrete inputs and outputs to be forced (local override). The operator interface also supports I/O Module configuration functions such as network address, display brightness and power-saver timeout. The LED display is bright enough for readability outdoors, and rated to withstand the wide temperature extremes that MicroBricks are designed for; -40°C to +75°C.

Built-in Networking

MicroBricks come network-ready with an isolated, dual-function (RS-485 and RS-232) serial communications interface. The RS-485 port can be used for low-cost 2-wire networking while RS-232 is a simple point-to-point interface to radios and modems as well as PCs. MicroBricks support “store-and forward” messaging to extend the effective range of radio based systems by using the RTU as a digital repeater, without additional radio hardware.

Open Architecture

MicroBricks use the Modbus RTU protocol, one of the most common protocols used in control systems. This protocol is supported by thousands of other hardware and software products including all of the common PC-based MMI software packages from manufacturers such as Wonderware, Intellusion, Iconics, and National Instruments.

Peer-To-Peer Communications

For true peer-to-peer operation MAXIO modules support ICL’s BrickNet protocol for use with ICL EtherLogic and ScadaFlex Plus controller families. Protocol detection between Modbus and BrickNet is automatic.

Back-To-Back I/O Bridge – Master Mode

Some MicroBrick modules support a back-to-back I/O mirroring operation. This "Master mode" feature allows for the inputs on one module to be mirrored as outputs on a remote module, and visa versa. This setup is designed to work with only a two-unit network.

Local I/O Processing

MicroBricks perform local I/O processing to off-load time-sensitive operations from a Host system.

MicroBricks with Discrete Inputs totalize input transitions and on-time (runtime) and calculate pulse rates for every input. Applications include using digital pulse output meters for precise totalized flow and wattage calculations, as well as real-time flow rate and power usage information. Runtime is widely used for wear leveling between pumps or motors, and as the basis of an equipment preventive maintenance program.

MicroBricks with Analog Inputs totalize the value of every Analog Input at a periodic sampling rate, especially useful for totalized flows and wattage applications using analog output type meters.

MicroBricks with Discrete Outputs can be commanded to flash individual outputs at a precise periodic rate independent of communications and I/O scan rates, primarily for visual alarm annunciation.

Wide Power Range and Low Power Operation

MicroBricks are designed for use in solar and battery backed applications. They operate over a wide range of DC power (10 to 30Vdc) and have built-in features to minimize their power usage. For example, the bright LED display used for the operator interface represents a significant portion of the modules power consumption. A user configurable power saver timer turns off the display when there has been no activity at the keyboard for a while, but automatically turns on the display when any key is pressed.

Rugged I/O

All I/O and communications interfaces are isolated and protected against overloads, transients, surges, and reverse polarity. Self resetting polymer fuses are used throughout. When the fault condition is corrected, the module automatically resumes normal operation.

Industry Leading Warranty

MicroBricks are backed by an industry leading 3-year factory warranty.

Register Map – ALL MICROBRICKS

STATUS (Read Only Input Bits - Modbus Type 10xxx)

I/O specific only (no common Statusess)

COILS (Read/Write Output Bits - Modbus Type 00xxx)

I/O specific only (no common Coils)

INPUT REGISTERS (Read Only 16-bit - Modbus Type 30xxx)

Start	*End*	*Description*
248	249	Reserved - ICL Test ONLY
250	-	Input Voltage (power) x 10 (143 = 14.3 volts)
251	254	Reserved - ICL Test ONLY
255	-	Firmware Revision
256	-	Device ID (DI32-24 = 2211, DI32-120 = 2212, DO32-24 = 2221, DO16-RLY = 2222, AI16-16 = 2231, UI8I = 2233, UI12 = 2232, DIO16/16-24 = 2255, DIO 16/16-120 = 2256, AO8-12I=2142, Combo-24 = 2251, and Combo-120 = 2252)

HOLDING REGISTERS (Read/Write 16-bit - Modbus Type 40xxx)

Start	*End*	*Description*
149	-	Input Power (voltage) calibration numerator (denominator = 65,535)
239	-	Bricknet/DF1 Character Gap Message Timeout
240	-	Master Mode Poll Retries (if Master Mode supported)
241	-	Master Mode Poll Time 10mS Increments (if Master Mode supported)
242	-	Master Mode Response Timeout 10mS Increments (if Master Mode supported)
245	-	Store & Forward - Incoming Base Address
246	-	Store & Forward - Outgoing (remapped) Base Address
247	-	Store & Forward - Address Range (block size)
248	-	Communications Watchdog Timer (10mS increments)
249	-	Xmit Enable Delay (Xmit Enable to Xmit Data in 10mS increments)
250	-	Power Save Time (No keypad activity to display turn off in seconds, 0=disable)
251	-	Display Brightness (0 to 127, 0 is OFF)
252	-	DF1 mode (0x00 = Modbus/BrickNet, 0xDF = DF1)
253	-	Baud Rate Index (0 = 2400, 1 = 4800, 2 = 9600, 3 = 19200, 4 = 38400, 5 = 115200)
254	-	Status Register (0001h = restarted, 0002h = comm. timed out, 0010h = keyboard locked)
255	-	Reserved - Test Register - ICL Test ONLY
256	-	Reserved - Control Register - ICL Test ONLY

Specifications – ALL MICROBRICKS

COMMUNICATIONS (all models)

Serial Ports	1
Serial Port Interfaces	Isolated RS-232 and RS-485
Data Rate	2400 baud to 115K baud
Communications Protocol	Modbus RTU

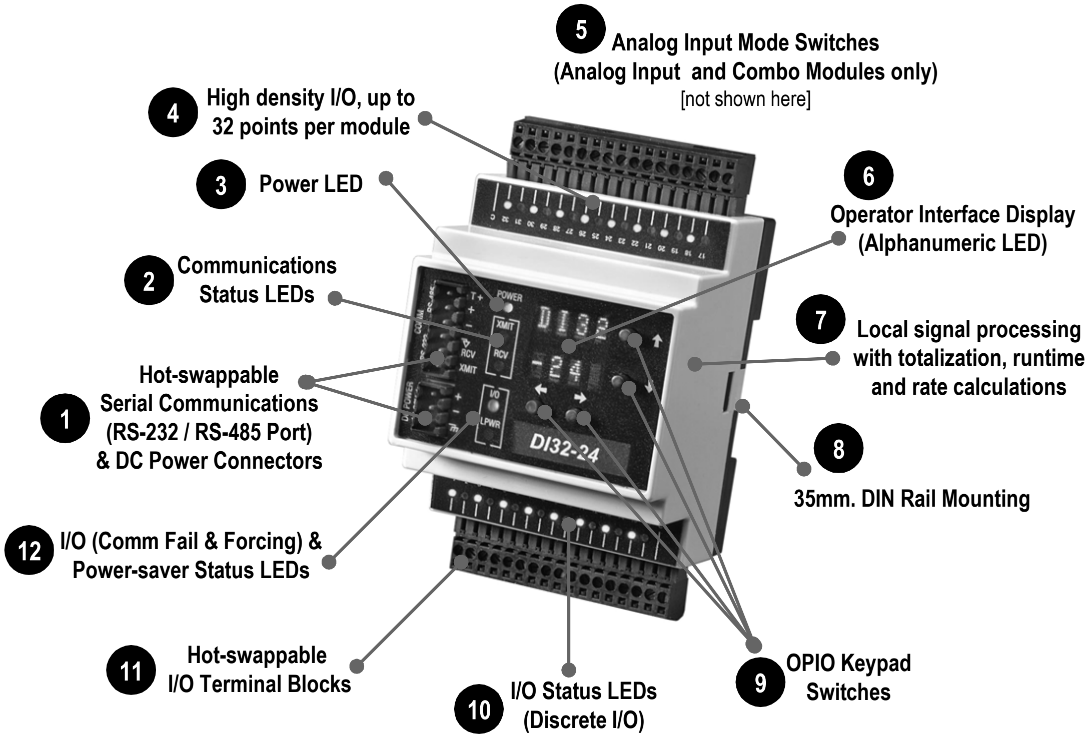
ENVIRONMENTAL SPECIFICATIONS (all models)

Dimensions	2.75” W x 4.60” L x 2.85” D (70mm x 117mm x 72mm)
Power	10 to 30Vdc, 125mA maximum (actual current draw will be less for some modules)
Temperature, operating	-40°C to 75°C (-40°F to 167°F)

Temperature, storage	-40°C to 100°C (-40°F to 212°F)
Isolation, Field to Logic	2000 volts
Isolation, Comm to Logic	2000 volts
Humidity	*5 to 85% RH, (non-condensing)*
Wiring Terminations	Removable Terminal Blocks
Wire Size	#14 to #26 stranded, #12 solid

MicroBrick Familiarization

The diagram below highlights the main physical features of MicroBrick I/O Modules that are discussed in the following pages.



1 Hot-swappable Serial Communications & DC Power Connectors

Removable terminal blocks for RS-232/RS-485 Communications (isolated) and DC Power. The RS-485 interface supports up to 256 MicroBricks on a single network. DC Power is 10 to 30Vdc.

2 Communications Status LEDS

Transmit and Receive Data LED indicators show network communications activity.

3 Power LED

The Power LED is always ON when power is applied (even in power-saver mode).

4 High Density I/O

Up to 32 Discrete I/O points or 16 Analog I/O points per module. The compact MicroBrick package saves precious panel space and makes it easy to retrofit systems with more I/O.

5 Analog Input Mode Switches

Modules with Analog Inputs (AI16 and Combo modules) have built-in precision current sense resistors that are switched in or out for selecting Voltage or Current mode on each analog input channel. This accommodates both voltage and current output sensors without buying two separate modules.

6 Operator Interface Display

Local alphanumeric LED Operator Interface for viewing analog input/output levels, forcing analog and discrete Input/Output levels, and examining/setting controller configuration parameters.

7 Local Signal Processing

MicroBricks totalize Discrete Input transitions, runtime and pulse rate. Discrete Outputs have programmable Flash function. Analog Inputs have noise rejection signal processing and totalization.

8 35mm. DIN Rail Mounting

MicroBricks snap onto a standard 35mm. DIN rail. A release catch is accessible under the lower I/O terminal block (unplug terminal block for access).

9 OPIO Keypad Switches (4)

Used to select and view analog levels, force analog and discrete I/O values, and view and set configuration parameters on the OPIO display.

10 Discrete I/O Status LEDs

Modules with Discrete Inputs/Outputs have amber LED status indicators right above the field wiring terminal blocks to simplify system test and troubleshooting.

11 Hot-swappable I/O Terminal Blocks

I/O Terminal Blocks can be removed and reinserted easily, without taking your system down.

12 I/O & Power-Saver Status LEDs

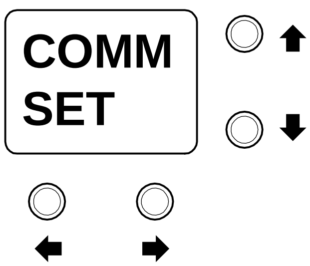
The I/O Status LED (“I/O”) is on solid whenever any I/O channel is forced, and flashes if communications fails (times out), causing the module to automatically shut OFF all outputs (user configurable). A power-saver LED (“LPWR”) comes ON and flashes whenever the MicroBrick goes into power saver mode, which turns OFF the operator interface display.

Operator Interface

MicroBrick I/O modules come with a built-in operator interface. The operator interface consists of a two-line alphanumeric display and 4-key keypad.

The operator interface display uses bright LED technology that operates over the same wide operating temperature range as the rest of the MicroBrick module. It has two-lines of four alphanumeric characters each. To save power, MicroBricks can be configured to turn the display off after the keypad is not used for a period of time. The display turns ON automatically when a key is pressed.

Associated with the display are four pushbutton switches. One pair of switches is marked with left and right arrows. The second pair is marked with up and down arrows. The up and down arrow keys are used to scroll through selections or increment and decrement values. The left and right arrow keys are used to enter and exit “in and out” of menu items.



Depending on the type of MicroBrick, the operator interface can be used to:

1) View the Analog levels (Analog and “Combo” I/O Modules)

2) “Force” Analog and Discrete Inputs and Outputs

3) Configure the Analog Inputs (Voltage, Current or “Raw”)

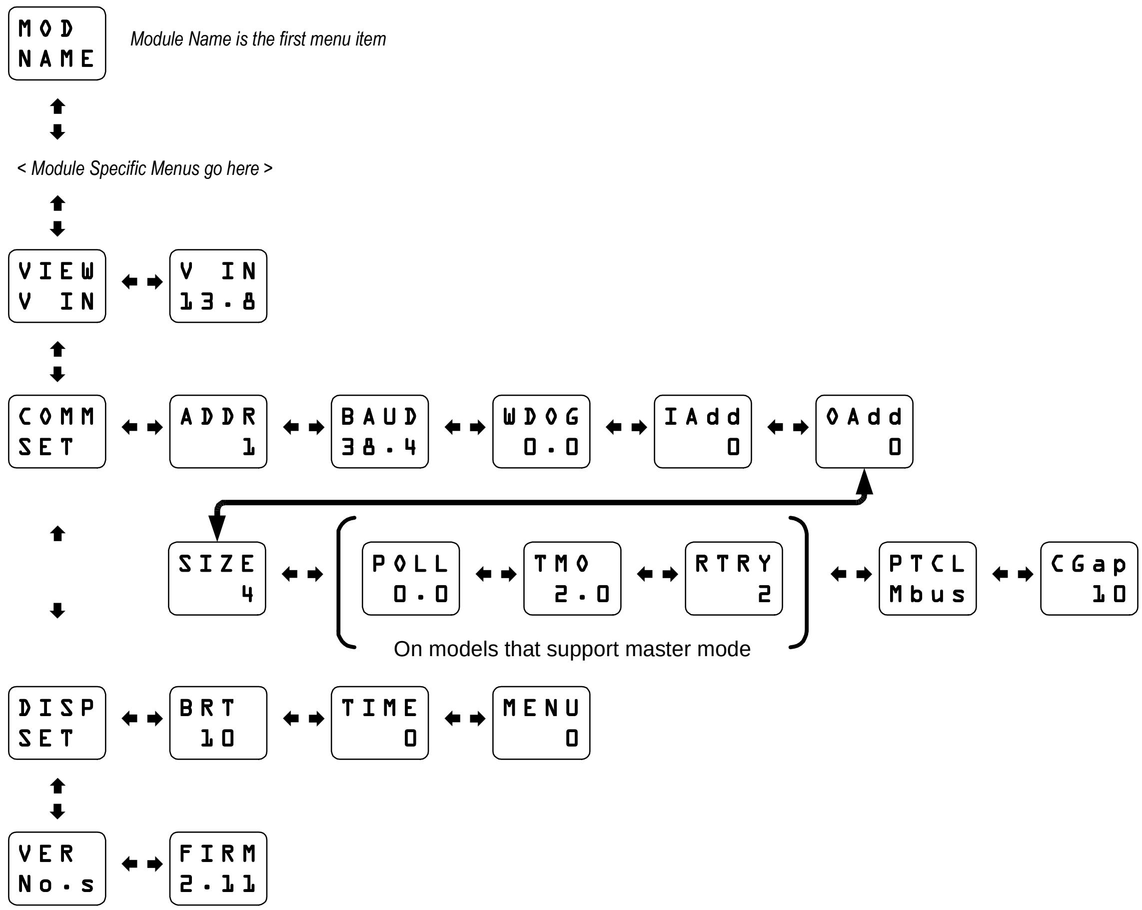
4) View or set communications parameters

5) View or set the display brightness and power-saver/menu time-out times

6) Display firmware version information

The keypad keys support “typematic” operation. Holding a key down for more than half a second will cause the key to automatically “repeat”.

A “map” of the general MicroBrick operator interface menus is pictured on the next page, followed by brief description of each function.


MOD NAME
Module Name is the first menu item
< Module Specific Menus go here >
VIEW V IN
V IN 13.8
COMM SET
ADDR 1
BAUD 38.4
WDOG 0.0
IAdd 0
OAdd 0
SIZE 4
POLL 0.0
TMO 2.0
RTRY 2
On models that support master mode
PTCL Mbus
CGap 10
DISP SET
BRT 10
TIME 0
MENU 0
VER No.s
FIRM 2.11

Main Menu

This is the default “top” menu that identifies the MicroBrick model.

DI32
-24

DI32-24 Module

32 Discrete Inputs, 12/24 Volt

DI32
-120

DI32-120 Module

32 Discrete Inputs, 120V Volt

DO16
-RLY

DO16-RLY Module

16 Discrete Outputs, Mechanical Relay

DIO
-24

DIO16/16-24 Module

16 Discrete Inputs, 16 Discrete Outputs, 12/24 Volt

DIO
-120

DIO16/16-120 Module

16 Discrete Inputs, 16 Discrete Outputs 120 Volt

DO32
-24

DO32-24 Module

32 Discrete Outputs, FET (protected transistor)

AIO
8/8

AIO8/8 Module

8 16-bit Analog Inputs, 16-bit resolution, 5V/20mA/300mV
8 12 bit Isolated Analog outputs

AI16
-16

AI16 Module

16 16-bit Analog Inputs, 16-bit resolution, 5V/20mA/300mV

UI8I
UNIV

UI8I Module

8 Individually Isolated Analog Inputs, 16-bit Analog Inputs, 16-bit resolution, 5V/20mA/TC/Thermistor

UI12
UNIV

UI12 Module

12, 16-bit Analog Inputs, 16-bit resolution, 5V/20mA/TC/Thermistor

CMBO
-24

COMBO-24 Module

10 Discrete Ins (12/24V), 4 FET Discrete Outs, 6 16-bit Analog Ins

CMBO
-120

COMBO-120 Module

10 Discrete Ins (120V), 4 FET Discrete Outs, 6 16-bit Analog Ins

MicroBrick Type Specific Menus

These menus are specific to individual MicroBrick models. They include menus to view and set I/O forcing states and configuration settings. The function of each of these menus is described in greater detail in each of the MicroBrick module section, but are summarized below:

DISCRETE INPUT MODULES (DI32-24 and DI32-120)

FORC DIs	Examine or set the forcing state of individual Discrete Inputs.

DISCRETE OUTPUT MODULES (DO16-RLY and DO32-24)

FORC DOs	Examine or set the forcing state of individual Discrete Outputs.

DISCRETE I/O MODULES DIO16/16-24 and DIO16/16-120)

FORC DIs	Examine or set the forcing state of individual Discrete Inputs.
FORC DOs	Examine or set the forcing state of individual Discrete Outputs.

ANALOG INPUT MODULES (AI16-16, AIO 8/8, UI8I and UI12)

VIEW AIs	Display the level of individual Analog Inputs.
FORC AIs	Examine or set the forcing state of individual Analog Inputs.
CFG AIs	Examine or set the configuration (Raw/5V/20mA) of individual Analog Inputs. (UI8I - Raw/5V/20mA/Thermocouple/)

COMBO I/O MODULES (COMBO-24 and COMBO-120)

VIEW AIs	Display the level of individual Analog Inputs.
FORC DIs	Examine or set the forcing state of individual Discrete Inputs.
FORC DOs	Examine or set the forcing state of individual Discrete Outputs.
FORC AIs	Examine or set the forcing state of individual Analog Inputs.
CFG AIs	Examine or set the configuration (Raw/5V/20mA) of individual Analog Inputs.

VIEW INPUT POWER (Voltage)

VIEW
V IN

Scroll down to this menu and press the Right Arrow key to enter the "View Input Power" section.

The current input voltage will be displayed.

V IN
13.8

This feature is especially useful to verify that the system power supply is functioning properly under load.

COMMUNICATION SETTINGS

COMM
SET

Scroll down to this menu and press the Right Arrow key to enter the "Communications Settings" section.

The first item is:

ADDR
1

Network Address (ADDR)

Use the Up and Down arrow keys to select the MicroBricks Modbus address, from 1 to 255.

BAUD
115K

Communications Baud Rate (BAUD)

Use the Up and Down arrow keys to select the MicroBricks communications Baud Rate from the following list:

2.4	2.4K or 2400 baud
4.8	4.8K or 4800 baud
9.6	9.6K or 9600 baud
19.2	19.2K or 19,200 baud
38.4	38.4K or 38,400 baud
115K	115K or 115,200 baud

WDOG
3.0

Com Failure Watchdog Timer (WDOG)

Use the Up and Down arrow keys to set the MicroBricks Communications Watchdog Timer in 100mS increments. This feature is often used when the unit is set up to be a slave device. If no message is received from a master device within the set time the unit will go into communications failure mode and will flash the I/O Status LED. A value of 0.0 disables this feature.

IAdd
10

Incoming Base Address (IAdd)

Use the Up and Down arrow keys to set the MicroBricks Incoming Base Address. This setting is used in networks taking advantage of the MicroBrick's Store and Forward feature. A value of 0.0 disables this feature. For more information, please refer to the section below entitled "Store and Forward."

OAdd
20

Outgoing Base Address (OAdd)

Use the Up and Down arrow keys to set the MicroBricks Outgoing Base Address. This setting is used in networks taking advantage of the MicroBrick's Store and Forward feature. A value of 0.0 disables this feature. For more information, please refer to the section below entitled “Store and Forward.”

Size
5

Block Size (Size)

Use the Up and Down arrow keys to set the MicroBricks Block Size setting. This setting is used in networks taking advantage of the Microbrick’s Store and Forward feature. A value of 0.0 disables this feature. For more information, please refer to the section below entitled “Store and Forward."

Ptcl
Mbus

Communications Protocol (Ptcl)

Use the Up and Down arrow keys to set the MicroBricks communications protocol. The Modbus setting is used for both Modbus and BrickNet. The DF1 option is for use in Allen-Bradley DF1 networks.

CGap
10

Character Gap (CGap)

Use the Up and Down arrow keys to set the MicroBricks Bricknet/DF1 character Gap. The default value will usually work but in some networks timing requirements may mandate a longer character gap setting.

Master Mode Settings

POLL
5.0

Master Mode Polling Timer (POLL)

Use the Up and Down arrow keys to set the MicroBricks Master Mode Polling Timer in 100mS increments. MicroBricks configured for master mode will poll their slave unit at the set polling frequency. A value of 0.0 disables this feature.

TMO
0.0

Master Mode Message Timeout

Use the Up and Down arrow keys to select the MicroBricks Master Mode Message Timeout in 100mS increments. A value of 0.0 disables this feature.

RTRY
2

Master Mode Message Retries

Use the Up and Down arrow keys to select the MicroBricks Master Mode Message Retries. Message Timeout multiplied by the number of Message Retries determines the time before a COM fail is triggered. A value of 0 disables this feature.

DISPLAY SETTINGS

DISP
SET

Scroll down to this menu and press the Right Arrow key to enter the “Display Settings” section. The first item is:

BRT
10

Display Brightness (BRT)

Use the Up and Down arrow key to select the brightness of the MicroBricks operator interface display. The value can be set from 1 (dim) to 10 (bright). A bright display is easier to view in high ambient light conditions at the expense of consuming more power when the display is lit (power saver OFF).

TIME
0

Power-Saver Time (TIME)

Use the Up and Down arrow key to select the MicroBricks Power Saver Timeout time from 5 to 255 seconds in 1 second increments. This sets the amount of time that the display will stay lit without keypad activity. A value of “0” for this parameter disables the power saver feature, leaving the display on continuously.

In the Power Saver state, the “LPWR” status LED is lit.

MENU
0

Menu Timeout (MENU)

Use the Up and Down arrow key to select the MicroBricks Menu Timeout time from 5 to 999 seconds in 1 second increments. This sets the amount of time that the display will stay on a menu before resetting to the root menu without keypad activity. A value of “0” for this parameter disables the menu timeout feature.

FIRMWARE VERSION

FIRM
VER

Scroll down to this menu and press the Right Arrow key to display the MicroBricks Firmware Version.

Industrial Control Links may periodically enhance the functionality of MicroBricks by making firmware changes. The user can upgrade the MicroBrick firmware by downloading the BOOTLOADER software and firmware update files from www.iclinks.com

FIRM
2.11

Before upgrading the MicroBrick firmware, be sure to check the current version using this menu item.

Follow the upgrade process described in a later section in this manual and supplied with the bootloader software. The files are loaded through the RS-232 serial port. It takes only a few seconds and will not affect any configuration or calibration settings.

Power

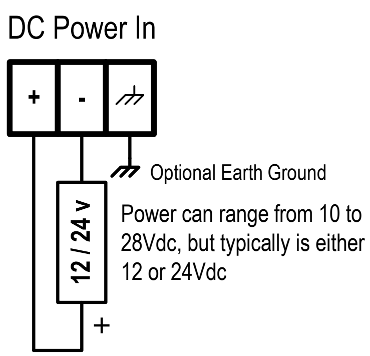
MicroBricks are designed to operate on DC power, typically either 12 or 24 volts, although they are specified to operate over a range of 10 to 30Vdc. The power consumption of a MicroBrick is very low; typically about 1.5 watts with the display turned ON, about half of that with the display OFF (power saver mode). Because of their low power consumption and wide input power range, they are ideal for solar or battery backed applications.

The ScadaFlex DC Power Supply or ScadaFlex UPS are recommended power sources because they both have the same wide range temperature rating as MicroBricks as well as ICL's ScadaFlex Plus and EtherLogic Series Controllers. The ScadaFlex UPS is especially worth considering as economical insurance against unreliable "brownout" prone AC power sources.

Power Wiring

The power connector is a 3-position removable terminal block. Besides the DC power (+) and "Ground" terminal (-), there is a third optional Earth Ground terminal. This DC power connector is a standard configuration for all of the ScadaFlex family. In the case of the MicroBrick series, the Earth Ground pin is not connected internally and not required for use of the MicroBricks in a system.

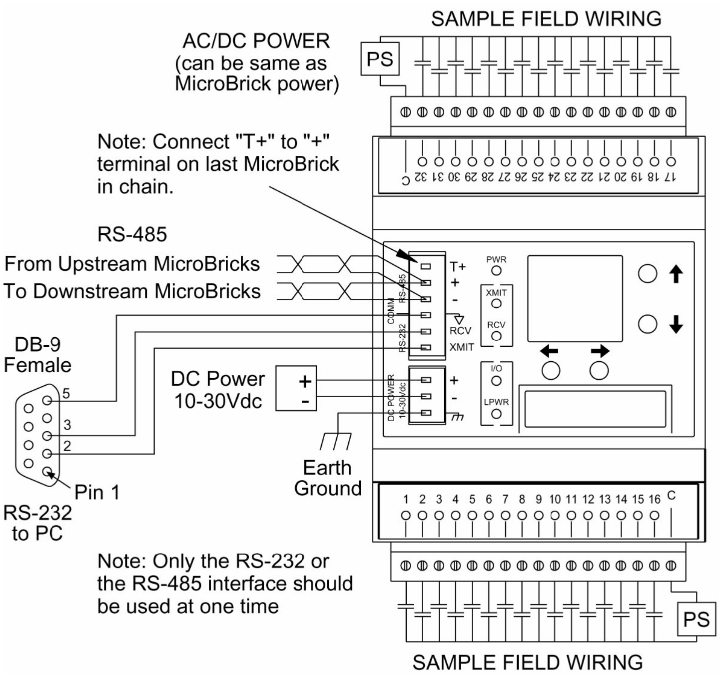
Typical DC power wiring to a MicroBrick I/O module is shown below:



Typical DC Power Wiring - MicroBrick I/O Module

Communications Interfaces

The most common serial communications standards for SCADA and industrial control systems is RS-232 for short point-to-point connections and RS-485 for longer point-to-point and networked communications. MicroBricks have a dual-interface serial port that supports both RS-232 and RS-485 operation. The location and typical RS-232 and RS-485 wiring terminations to a MicroBrick are shown in the diagram below.



RS-232 Serial Communications Interface

The MicroBrick RS-232 interface is a simple 3-wire configuration. It does not require (or support) any modem control lines. The RS-232 port connections are available on a removable terminal block for ease of wiring in the field. The typical wiring to a female 9-pin “D” connector (such as for a PC computer) is shown in the diagram above.

RS-485 Serial Communications Interface

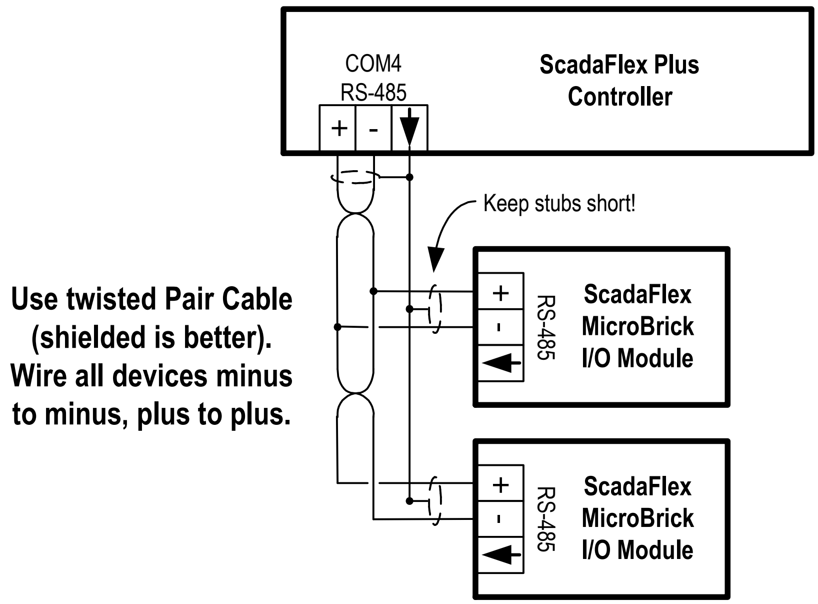
RS-485 is a 2-wire communications interface designed for networked operation spanning distances of up to 4,000 ft. MicroBrick I/O modules are frequently used with ScadaFlex Plus and EtherLogic Controllers for I/O expansion. These controllers have one or more RS-485 ports that are the easiest to wire in the field and have the best noise immunity for industrial environments. Since the MicroBrick RS-485 port is optically isolated, there is no concern for creating ground loops through the Controller or other I/O modules. An RS-485 network of MicroBricks can be distributed over a distance of 4,000ft., allowing the MicroBricks to be located near field devices to minimize field wiring run lengths and cost.

Although the original RS-485 standard allowed for only 32 devices on a network, the RS-485 interface in MicroBrick I/O modules (as well as ScadaFlex Plus and EtherLogic Controllers) is specially designed to allow up to 256 devices to share the same network.

With up to 32 I/O points per module, a network of 255 MicroBricks provides over 8,000 I/O points!

The RS-485 connections on a MicroBrick consists of 4 pins on a removable terminal block, 2 data pins, an isolated ground pin, and a termination pin.

A typical MicroBrick RS-485 network uses a twisted pair cable. If the cable is shielded, the shield should be connected to the ground pin. The typical RS-485 wiring of a Controller to two MicroBricks is shown below.



Typical ScadaFlex Plus/MicroBrick RS-485 Network

Traditionally, RS-485 networks use a 120Ω resistor termination at each end of the network. This technique does not work well with certain protocols such as Modbus that do not have a lead-in message header to eliminate garbage on the beginning of a message caused by a “floating” (non-driven) cable. The MicroBrick I/O modules have series termination resistors that eliminate this problem. In most cases, even on longer networks, separate termination is not required. If termination is required, an AC termination connection (T+) is built into all MicroBricks. The terminator is activated by connected the (T+) connection to the + Data Line. This should only be done at either end of the network, and only if it is determined to be needed.

Modbus Communications

MicroBricks support the Modbus RTU communications protocol. This protocol was originally developed for Modicon Programmable Logic Controllers (PLCs). Now, Modbus is supported by nearly any PLC and RTU, and most HMI/MMI software packages. MicroBricks can be used in a large number of existing systems and will work without special drivers with many different “Hosts”.

MicroBrick modules support the following four standard Modbus data types:

Data Type	**Modbus Type**	**Description**
Status	10xxx	Read Only bits
Coils	00xxx	Read/Write bits
Input Registers	30xxx	Read Only 16-bit values
Holding Registers	40xxx	Read/Write 16-bit values (two combined for 32-bit values)

Note: Do not confuse the Modbus Type with the command codes used to access the various data types.

Both the single and multiple element forms of the Modbus commands that access these data types are supported. For example, there is a command to read or write a single Holding Register, and another command to access a block of Holding Registers. MicroBricks support both command types.

Most totalizers in MicroBricks are 32-bit registers. These registers are accessible as two consecutive 16-bit Modbus registers. The Most Significant (high order) portion of the 32-bit value is accessed in the first register, immediately followed by a second register with the Least Significant (low order) portion of the 32-bit value. 32-bit values should always be accessed with the Read/Write multiple registers form of Modbus messaging so that both portions of the 32-bit value are read together in a single message.

MicroBricks allow up to 128 registers of any type to be accessed in a single message. Be careful to only access valid registers. In general, messages that access unassigned registers are rejected as invalid messages, unless they are reserved for future use.

Detailed information on the Modbus protocol is available at: **www.modbus.org**

Network Addressing

MicroBricks have a menu selection in the built-in operator interface for viewing and changing the Modbus network address. The network address may also be changed via a Modbus holding register. In order to simplify this setup function, MicroBricks always respond to address 255 regardless of the current network address setting. Do not use 255 as an address in a network! Address 0 is also not supported and should not be used.

Store & Forward

MicroBricks can be used as Remote Terminal Units (RTUs) in radio based systems. To extend the effective range of radio systems, MicroBricks may be configured to digitally repeat messages destined for other PicoBrick or MicroBrick modules that are not directly accessible to the Modbus Master. Although the Modbus standard has no definition for this function, PicoBricks and MicroBricks use a simple form of block address translation to support Store & Forward operation within the Modbus specification framework.

The following "rules" are used for Store and Forward operation:

The network addresses to be translated and forwarded must be in a single contiguous block.

The translated addresses must be unique and NOT include the local RTUs address.

The Master must be capable of ignoring the messages generated with translated addresses (ICL controllers do this automatically). Some Modbus Masters may not like seeing what appears to be a response message with a different address. Since the repeater is by definition "in radio range", the Master is certain to "see" these messages.

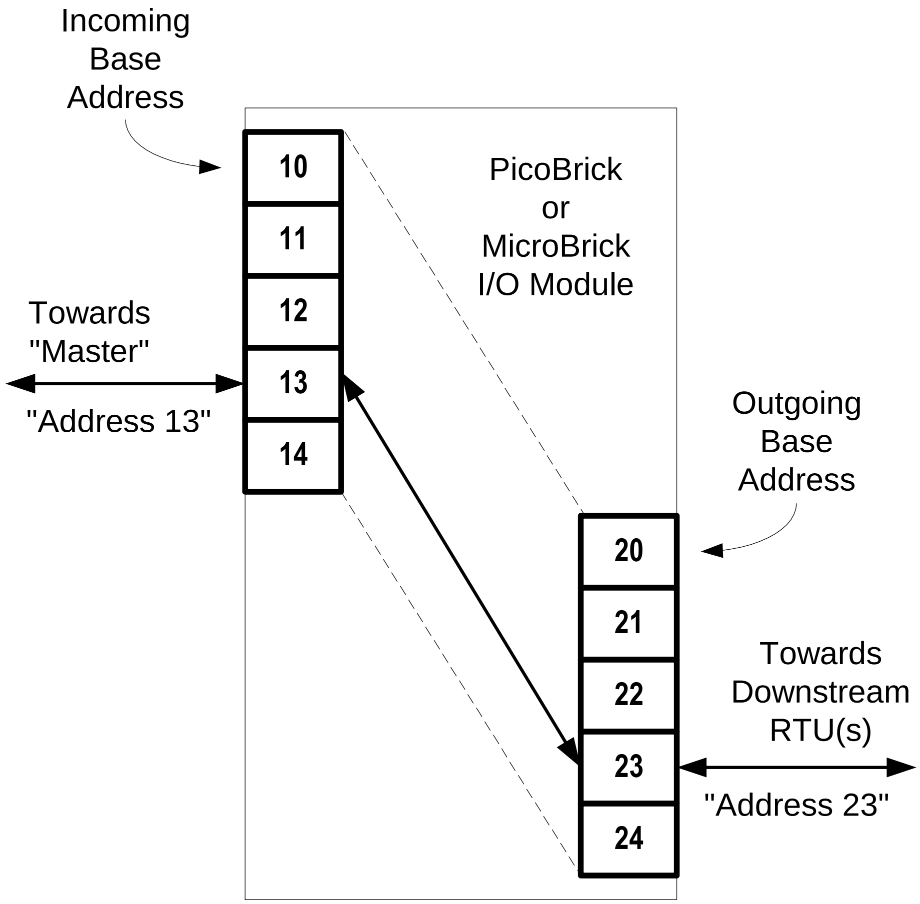
MicroBricks have three holding registers that control the Store and Forward address translation functions; an "Incoming Base Address" register, an "Outgoing Base Address" register, and a "Block Size" register.

When a message is received by a MicroBrick, it first checks to see if the message is intended for itself. If not, it then checks to see if the message falls within the Incoming range of addresses (Incoming Base through Incoming Base + Block Size - 1) or within the Outgoing range of addresses (Outgoing Base through Outgoing Base + Block Size - 1).

If a message falls within the Incoming Range, then the RTU knows that the message came from the Master (or a previous repeater en route from the Master) and it translates the address to the Outgoing Range, calculates a new message CRC check block, and retransmits the modified message. Likewise, if a message falls within the Outgoing Range, then the RTU knows that the message came from a downstream RTU (or a previous repeater) and it translates the address to the Incoming Range, calculates a new message CRC check block, and retransmits the modified message back towards the Master.

There is no limit to the number of repeater hops that can be used other then the total number of available addresses (255).

The Store and Forward translation process is pictured below.



Modbus Message Store and Forward Address Translation

In this example, the Incoming Base Address is set to “10”, the Outgoing Base Address is set to “20”, and the Block Size is set to “5”.

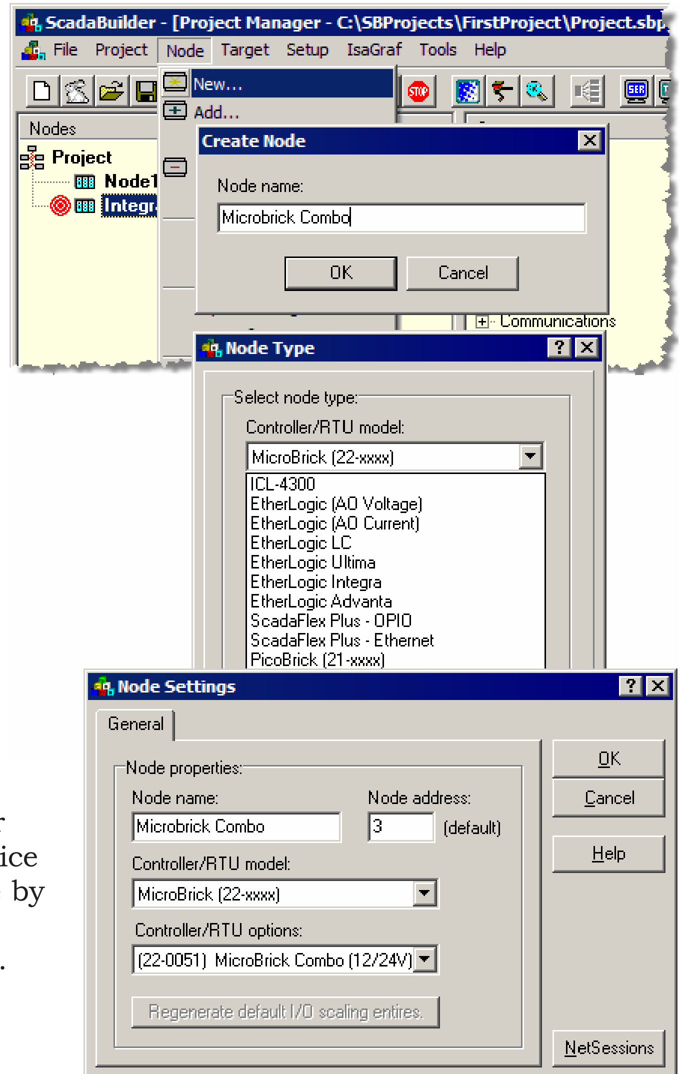
A message that comes from the direction of the Master with an address of “13” is translated to an address of “23’ and rebroadcast. Likewise, when the downstream unit responds, the message will come from address “23” and be translated and rebroadcast as address “13”. As far as the Modbus Master is concerned, it is communicating with address “13”, but with some additional delay caused by the repeating process.

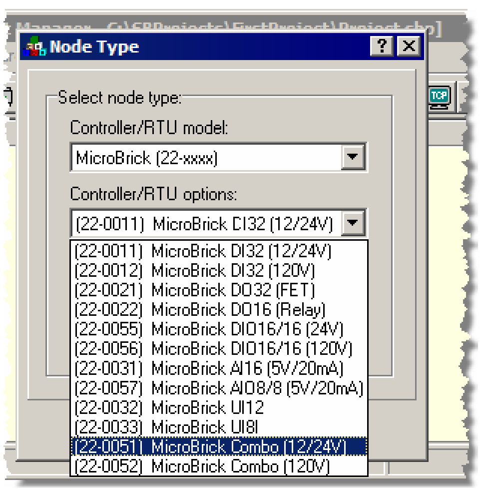
BrickNet Communications

All I/O Expansion modules available from ICL talk ICL's BrickNet Protocol. ScadaBuilder (ICL's controller programming software) is aware of the register map of every I/O module and can access those registers directly by name and block.

To utilize this feature, you first have to create a new Node in the ScadaBuilder project where you want to use the I/O module. We will use a MicroBrick Combo module for this exercise but the concepts are the same for all other *PicoBricks, MicroBricks, MAXIO's and ScadaFlex RTU's.*

To create a MicroBrick Combo Node, select the Node | New menu. Enter a name a click OK.

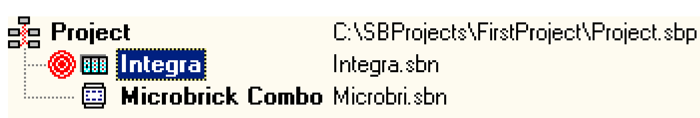




Select the MicroBrick type (or whatever your device might be by model number).

Enter a Node address that is something other than what you main controller's address is going to be. See Creating a BrickNet Session in the ScadaWorks Technical Reference Manual for details.

You should have a project that looks like the following:



Create a BrickNet Network Session.

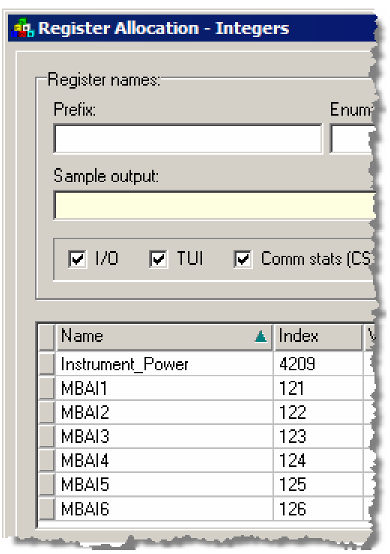
See Creating a Bricknet Session in the ScadaWorks Technical Reference Manual for details.

You must create registers to store locally the I/O points of the combo module. Declare the following points in the Registers section of the Setup window of ScadaBuilder. See the Registers section of the ScadaWorks Technical Reference Manual for details.

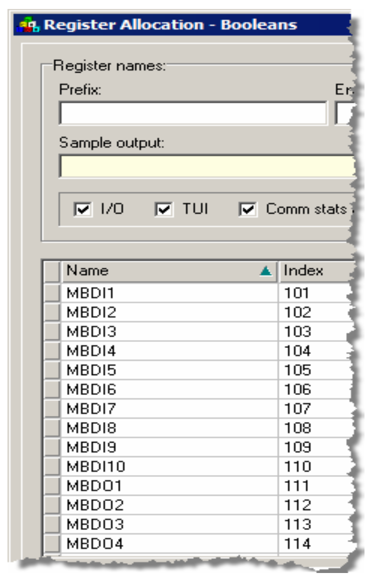
Create the following registers to store the values into:

Booleans	Booleans	Integers
MBDI1 101	MBDO1 111	MBAI1 121
MBDI2 102	MBDO2 112	MBAI2 122
MBDI3 103	MBDO3 113	MBAI3 123
MBDI4 104	MBDO4 114	MBAI4 124
MBDI5 105		MBAI5 1251
MBDI6 106		MBAI6 126
MBDI7 107		
MBDI8 108		
MBDI9 109		
MBDI10 10		

Your Boolean register list should look like this.

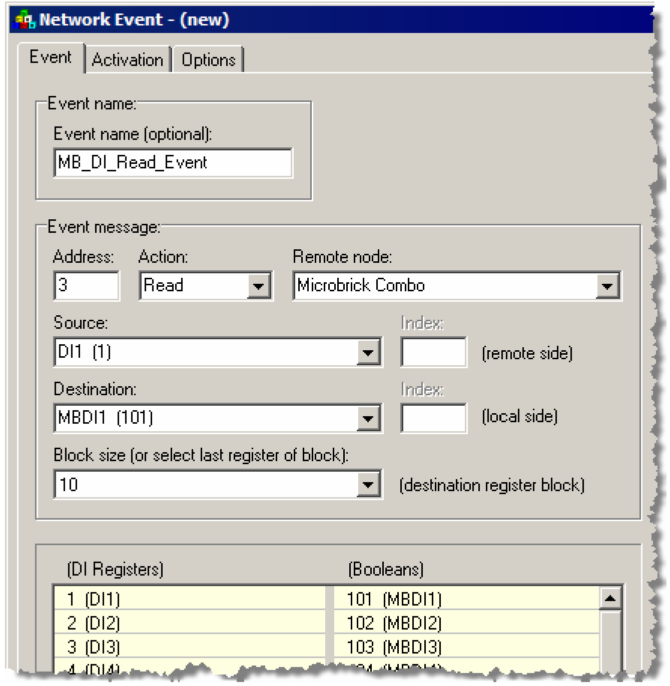


And your integer register list should look like this:



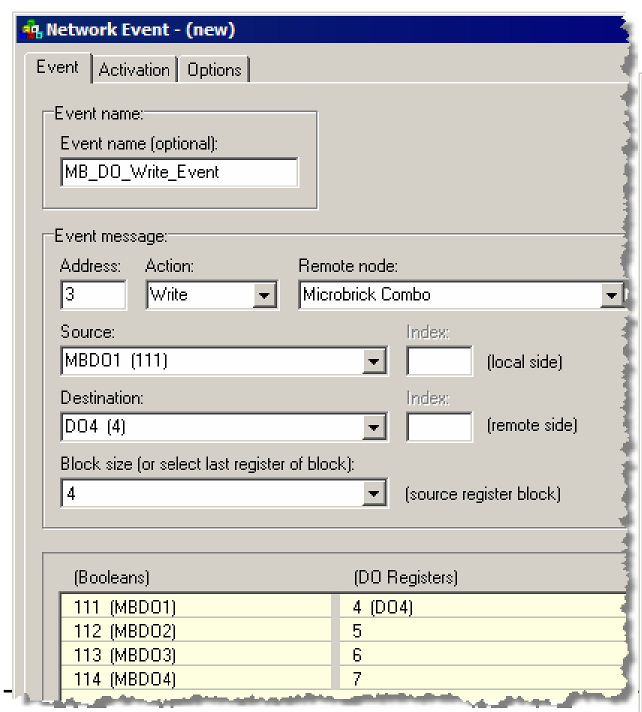
Next we need to create the Network Events.

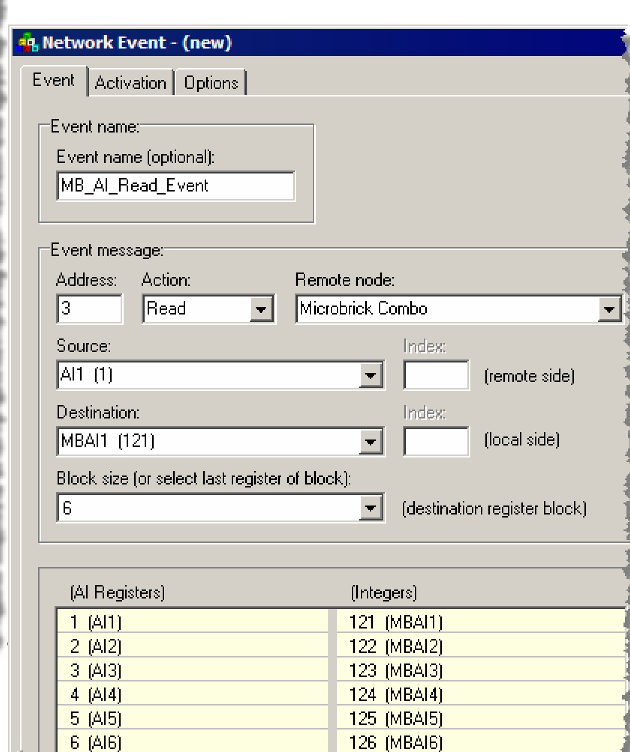
Click on the Events button in the lower right hand corner of the BrickNet Network Session you created above. This will give you the Network Event List. Click on the New button to get the following dialog. See Creating BrickNet Network Events in the ScadaWorks Technical Reference Manual.



- Name the Event (we will be reading the DI's from the MB Combo.
- Select the Action (Read),
- Select the Remote Node (which is the Module you setup).
- Select the Destination (this tells ScadaBuilder what data type you are going to use.
- Select the source of the first DI register of the MicroBrick.
- Enter the block size to get all 10 DI's.
- Click on the Activation tab, Enter Cyclic and 1 and click the Add button

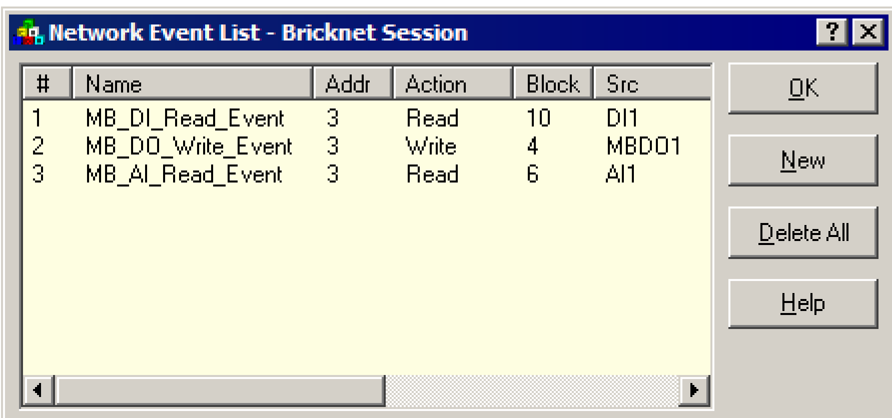
To write to the Digital Outputs of the MicroBrick Combo Module, enter the following with the same Cyclic 1 Activation:





Reading the Analog Inputs on the MicroBrick is the same as reading the DI's only a different data type:

You should now have a Network Event List like the following:



The setup is complete. Connect your I/O module to the port defined, make sure the Slave number and baud rate are correct and download the application to the controller.

Consult your hardware manual for the appropriate cabling to connect your I/O module.

> *Different products have different I/O based on the model number and type. Interfacing to all of them is similar to what is shown here.*

DF1 Communications

Due the installed base of Allen-Bradley programmable logic controllers and the high cost of protocol adapter modules, the DF1 protocol is a popular means of interfacing these PLCs with ICL controllers. In the DF1 protocol, a single Master communicates with up to 254 slaves. Slaves do not send messages on their own; they respond to messages from the Master. DF1 is designed to operate over serial networks; RS-232 for short point-to-point connections, RS-485 for longer distance hard-wired networks, and radios and modems for even longer distances. DF1 can support three types of data; bits, integers and floating point numbers. DF1 over Ethernet is not supported at this time.

MicroBrick units can communicate using Allen-Bradley's DF1 protocol using the DH-485 transport layer. This protocol allows the RTU to respond to messages that are sent from a DF1 master device. These messages can read and write information stored in registers.

Data Type	DF1 Type	Description
Digital Input	B3	Read Only bits
Digital Output	B13	Read/Write bits
Analog Input	N7	Read Only 16-bit values
Analog Output	N17	Read/Write 16-bit values

Note: 32-bit registers are not currently supported in ICL's RTU implementation of DF1.

Note: ScadaWorks users will not use the 'N' character when setting up r/w DF1 events. Instead they will select the 'Number' option from the 'Source' dropdown in the network event configuration window and enter in either '13' or '17'.'

ICL RTUs support the serial, half-duplex version of DF1with CRC error checking. BCC error checking in RTU units is not supported at this time

Maintenance

MicroBricks are designed for long-term maintenance-free operation. The only maintenance item is periodic calibration of the Analog and Combo MicroBricks, and possible firmware updates.

Analog Calibration

Industry standard practice is to recommend checking the calibration of analog measurement devices typically once a year. The calibration values for MicroBricks with analog inputs are retained in nonvolatile EEROM memory, and may be viewed and changed using the “ScadaFlexIO Toolbox” software available from Industrial Control Links.

A backup copy of all calibration values, as determined by an automated test system in the factory, is always retained separately in another area of nonvolatile memory, “just in case”. The “ScadaFlexIO Toolbox” software can restore the factory calibration values if needed.

Firmware Updates

The internal MicroBrick microprocessor firmware is easily and quickly updated using a standalone Bootloader Windows program or the “ScadaFlexIO Toolbox” software. With the program running on a PC or laptop computer plugged into the MicroBricks RS-232 port, and a path to the new firmware selected, the MicroBrick microprocessor firmware will be updated by simply cycling power for the MicroBrick when prompted. The new update can be verified by checking the firmware revision level using the MicroBricks operator interface display.

Installation

Mechanical Installation

MicroBricks are designed to be installed in a protective enclosure with the appropriate NEMA rating for the environment that the controller will be used. Typical NEMA ratings are as follows:

North America:

Indoor applications only: NEMA 1 Indoor or Outdoor applications: NEMA 4, 4X or 12 rated enclosures.

European Union:

Must be installed inside IP54 or IP56 rated enclosures.

The enclosure material must be a minimum of 1.14mm (0.045”) thick. Typically, the controller is mounted vertically in such an enclosure on a steel backplate. If an alternative mounting scheme is used, it is recommended that the controller be ounted on a noncombustible surface.

The modules are designed to snap onto 35mm. DIN rail installed on the back mounting plate of the enclosure. The DIN rail may be oriented horizontally or vertically as required.

Electrical Installation

All field wiring connections to and from the MicroBrick modules, including the RS-232 and RS-485 communications wiring and the DC power wiring, are made via removable terminal blocks.

Class 1 Division 2 Group A, B, C, and D Requirements

THIS EQUIPMENT IS SUITABLE FOR USE IN CLASS I, DIVISION 2, GROUPS A, B, C, D OR NON-HAZARDOUS LOCATIONS ONLY.

WARNING - EXPLOSION HAZARD – SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 2;

AVERTISSEMENT - RISQUE D'EXPLOSION – LA SUBSTITUTION DECOMPOSANTS PEUT RENDRE CE MATERIEL INACCEPTABLE POUR LES EMPLACEMENTS DE CLASSE I, DIVISION 2;

WARNING - EXPLOSION HAZARD - DO NOT DISCONNECT EQUIPMENT UNLESS POWER HAS BEEN SWITCHED OFF OR THE AREA IS KNOWN TO BE NON-HAZARDOUS;

AVERTISSEMENT - RISQUE D'EXPLOSION - AVANT DE DÉCONNECTER L'EQUIPEMENT, COUPER LE COURANT OU S'ASSURER QUE L'EMPLACEMENT EST DÉSIGNÉ NON DANGEREUX.

WARNING - EXPLOSION HAZARD – BATTERIES MUST ONLY BE CHANGED IN AN AREA KNOWN TO BE NON-HAZARDOUS.

AVERTISSEMENT- RISQUE D'EXPLOSION –AFIN D'ÉVITER TOUT RISQUE D'EXPLOSION, S'ASSURER QUE L'EMPLACEMENT EST DÉSIGNÉ NON DANGEREUX AVANT DE CHANGER LA BATTERIE.

NOTE: The terminal block screws must be tightened to 22 pound-inches (0.25 Nm).

NOTE: The terminal blocks are designed for high density wiring and have small screw heads. A 3/32" flat blade screwdriver is recommended, such as an Xcelite p/n R3323BK.

Diagrams in the following sections provide examples for analog and discrete I/O, communications and power wiring. The following wiring guidelines must be followed:

Stranded or solid conductors, from #14 to #28 AWG consisting of either copper or copper-clad aluminum is permitted.

Wires must be rated for 120V, 90°C and suitably current rated. Wire insulation must be a minimum of 0.9mm (0.031") thick if subjected to movement, flexing or handling during use or maintenance.

Wires shall be routed away from sharp edges, screw threads, burrs, fins, moving parts, drawers, and the like.

Clamps and guides, if used, shall be provided with smooth, well-rounded edges.

Wiring that is subject to flexing during servicing such as that from a stationary part to a part mounted on a hinged door shall be provided with additional insulation at any point where flexed.

Additional insulation, if used, shall be insulating tubing, or a wrapping of not less than two layers of insulating tape. All must be minimum of 90ºC and 120V.

All splices and connections must be mechanically secure and provide electrical continuity

Conductors are also not to be grouped.

CAUTION: Use supply wires suitable for 15ºC above surrounding ambient

ATTENTION: Utiliser des fils d'alimentation qui conviennent a une temperature de 15ºC au-dessus de la temperature ambiente.

Discrete Input Modules

MicroBrick Discrete Input modules are used to monitor the state of switches, relays contacts, motor starter auxiliary contacts and any other on/off type sensor signal. The inputs are optically isolated to avoid ground loop effects and prevent damage from transients and power surges on the input lines. There are a total of 32 discrete inputs built into the MicroBrick DI32 modules.

Signal Types and Levels

MicroBrick Discrete Input modules have a unique input design that accepts both AC and DC signals. The inputs are not sensitive to signal polarity, supporting DC sensors with either “sinking” or “sourcing” output configurations as well as switch contacts with AC or DC signals.

Currently, there are two models of MicroBrick Discrete Input Modules; one designed for low-voltage (12/24V) operation, the other for 120V operation.

In the low voltage model, an input level of 9 volts (AC/DC) or greater is considered to be an “ON”. Input levels of 6 volts (AC/DC) or less are considered OFF. The inputs can accept signal levels of up to 50 volts (AC/DC) and tolerate overloads of nearly twice that.

The 120V model responds to inputs of 75V or greater as an “ON”, 50V or less as an “OFF” and will tolerate a 100% overload.

Other input voltage ranges are available by special order. Please contact your ICL representative for additional information.

LED Input Status Indicators

Each discrete input has an LED indicator to show the current ON or OFF state of the input. Typically, the state of the LED indicator mimics the state of the input, unless the input is “forced” on or off. When the state of an input is forced, the LED shows the forced state that is communicated back to a Host Controller, regardless of the actual input state.

I/O Processor Functions

The discrete input modules have a microprocessor that performs processing that goes beyond monitoring the simple on or off state of inputs. These tasks include input noise filtering, pulse counting, runtime totalization, and pulse rate computation. These local functions help off-load the Host Controller and improve system performance.

Input Filtering

The discrete input modules have filtering that rejects spurious noise and limits the maximum counting rate to 40Hz with DC pulses, up to 10Hz with AC signals.

Pulse Totalization

MicroBrick Discrete Input modules count ON transitions for every input point, providing reliable pulse totalization that is not sensitive to communications rates and I/O scan time. This feature can be used for very accurate flow and wattage totalization.

The pulse totalizers are 32-bit counters, meaning that the totalizers count up to 4,294,836,225 ON transitions before they "roll over" to zero again. The counters are Modbus holding registers that can be reset to zero, or any preset value, at any time.

Runtime Totalization

MicroBrick Discrete Input modules monitor the runtime (ON time) for every input point, providing reliable "down-to-the-second" measurement of how long an input has been "ON". This information is useful for scheduling equipment maintenance and wear leveling. For example, to maximize pump life in a multi-pump system, runtime can be used to determine which pump should be used next based on which pump has seen the least usage to date.

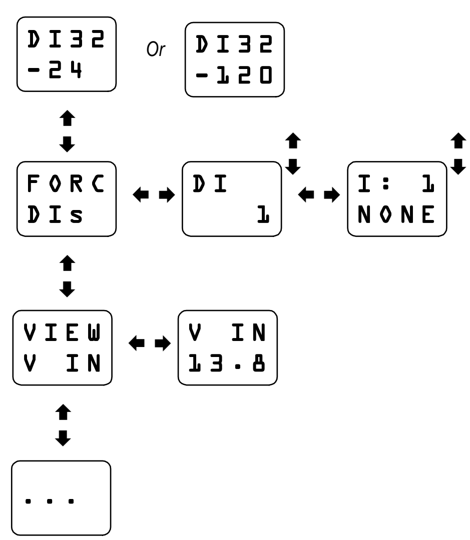
The runtime totalizers are 32-bit registers, meaning that the totalizers count seconds, up to 4,294,836,225 before they "roll over" to zero again. The runtime totalizers can be reset to zero or preset to a value at any time by simply writing to the appropriate holding register.

Pulse Rate Calculation

MicroBrick Discrete Input modules calculate the input pulse rate for every input. With the appropriate sensors, this can be used to show "real-time" flow, usage rates, and speeds. A software settable "gate" time determines the measurement interval over which the input pulses are counted. Longer gate time intervals provide greater measurement resolution, but the measured value is updated less frequently. The gate time is the measurement update interval. Once the gate time has expired, each totalized count is stored in a rate register for that discrete input, and a new set of rate totalization measurements are automatically started.

Operator Interface

In addition to module configuration functions, the operator interface of the MicroBrick Discrete Input Modules may be used to individually force the state of discrete inputs ON or OFF. This feature is especially useful at system startup, allowing control software to be tested in the field without waiting for I/O devices and field wiring to be installed. It is also invaluable for system maintenance, eliminating the need for dragging a laptop computer around to troubleshoot the system.



MicroBrick Discrete Input Module Operator Interface Menu Tree

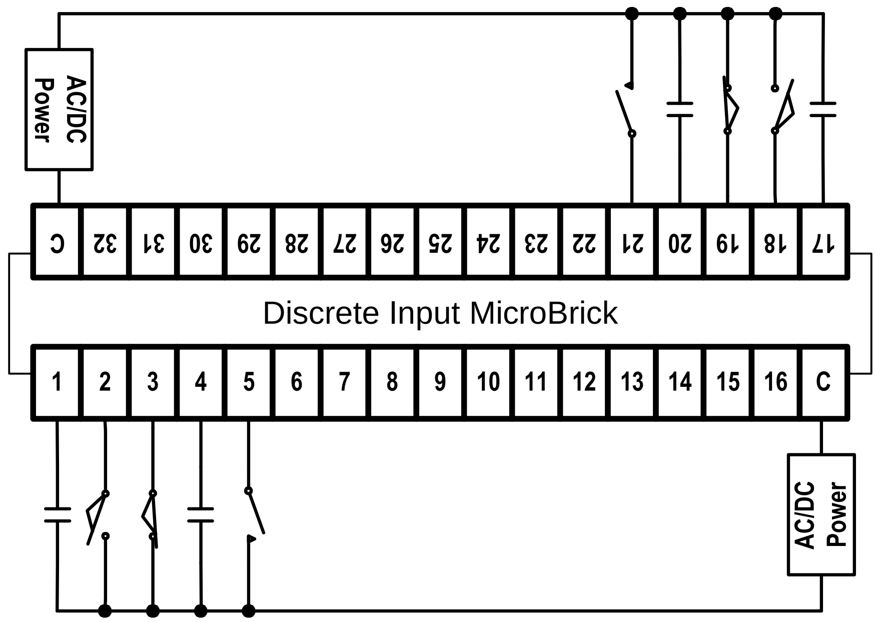
The general operation of the MicroBrick operator interface is described in a previous section. The diagram below shows the map of the specific menu tree for the MicroBrick Discrete Input Modules (both models).

Any Input can be forced “ON”, forced “OFF” or set to “NONE” (no forcing). When scrolling through the channel selection portion of the forcing menu, any channel that is currently forced ON or OFF displays an “F” to the left of the channel number.

Note that the 120V model has a “-120” in the lower line of the first screen instead of a “-24”.

Field Wiring

The Discrete Input connections from field sensors come into the MicroBrick on a pair of 17-position removable terminal blocks. Each block has 16 inputs plus a common that is shared by those 16 inputs but isolated from the other 16-input terminal block.



Discrete Input MicroBricks - Field Wiring Example

The discrete inputs are passive and require an active voltage to be switched between their common and the input signal connections. The inputs are isolated so that power source for the inputs can safely be the MicroBricks power supply without causing a ground loop. The inputs are not sensitive to polarity, so the power lead connected to the field sensors can be either the negative or positive side of a DC power source, or AC power can be used. The input current at 12Vdc is approximately 1mA, sufficient for contact “wetting”, but low enough for practical use in solar and battery-backed applications.

Register Map - Discrete Input MicroBricks

MicroBrick Discrete Input modules use the following Modbus register map:

STATUS (Read Only Input Bits - Modbus Type 10xxx)

Start	*End*	*Description*
001	032	Discrete Inputs 1 through 32 (w/forcing)
033	064	Raw Discrete Inputs 1 through 32 (no forcing)

COILS (Read/Write Output Bits - Modbus Type 00xxx)

none

INPUT REGISTERS (Read Only 16-bit - Modbus Type 30xxx)

Start	*End*	*Description*
001	032	Pulse Rate - Inputs 1 through 32

HOLDING REGISTERS (Read/Write 16-bit - Modbus Type 40xxx)

Start	*End*	*Description*
001	064	Pulse Totalizers - Inputs 1 through 32 (32-bit, 1st/Odd register is MSB)
065	128	Runtime Totalizers - Inputs 1 through 32 (32-bit, 1st/Odd register is MSB)
129	-	Rate Measurement “Gate” (sampling) Time

Specifications - Discrete Input MicroBricks

DISCRETE INPUT Module - Model# 22-0011 (DI32-24)

Number of Discrete Inputs	32
Input Type	Bipolar Optocoupler
Input Voltage, nominal	12/24 Vdc/ac
Input Voltage Range	0 to 60 Vdc/ac
Input Overvoltage Tolerance	85Vdc/Vac
Input Resistance, typical	10,000 ohms
Input Noise Filtering, AC/DC	20Hz / 100Hz
Counting Frequency, AC/DC	10Hz / 50Hz

DISCRETE INPUT Module - Model# 22-0012 (DI32-120)

Number of Discrete Inputs	32
Input Type	Bipolar Optocoupler
Input Voltage, nominal	120 Vdc/ac
Input Voltage Range	0 to 125 Vdc/ac
Input Overvoltage Tolerance	190Vdc/Vac
Input Resistance, typical	100,000 ohms
Input Noise Filtering, AC/DC	20Hz / 100Hz
Counting Frequency, AC/DC	10Hz / 50Hz

Discrete Output Modules

MicroBrick Discrete Output modules are used to control relays, lights, motor starters, enunciators or any other on/off type control device. There are two MicroBrick Discrete Output modules; one with 16 mechanical relay outputs, the second with 32 solid state FET (protected transistor) outputs.

16 Relay Output Module

For systems that require isolated “dry” relay contacts, the MicroBrick DO16-RLY module is the perfect fit. Each relay output will switch up to 1A and 120V and includes internal snubber protection against contact arcing. Fourteen of the relay outputs are Form A (normally open contacts), while two of the relay outputs are full Form C (normally open and normally closed) configurations.

32 FET (Protected Transistor) Output Module

For highest density and lowest power, the MicroBrick 32 FET output module is the best choice. Unlike mechanical relays, FET transistors are extremely efficient and consume very little power, ideal for solar and battery backed systems. When a “dry” relay contact is required, the FET outputs can drive interposing relays.

The FET outputs are isolated as well as overload, surge, and reverse polarity protected by a combination of self-resetting polymer fuses and “Transorb” transient limiters. Because of the built-in transient protection, a suppression diode is not typically required across relay coils or other inductive loads driven by the MicroBrick discrete outputs.

The FET outputs are designed to operate in 12 and 24 volt control systems, with control voltages of up to 28 volts DC. An external power source is NOT required to power the MicroBrick FET output circuitry, but IS required by the load devices. FET outputs ARE sensitive to signal polarity, driving DC control devices with a open drain output that switches to a common “ground”. When turned ON, the outputs have a very low (< 2Ω) resistance to the common. When turned OFF, the outputs exhibit very high resistance and low leakage that will not provide a false ON to sensitive controller inputs like other solid state outputs have in the past. If an output drives a low resistance or shorted load, it will be protected automatically, switching to a low current, high-resistance state. The output will continue to sink some current in this condition until the overload is removed. Once the fault condition is cleared, the output will automatically switch back to its normal low resistance, driving the full current required by the load.

LED Output Status Indicators

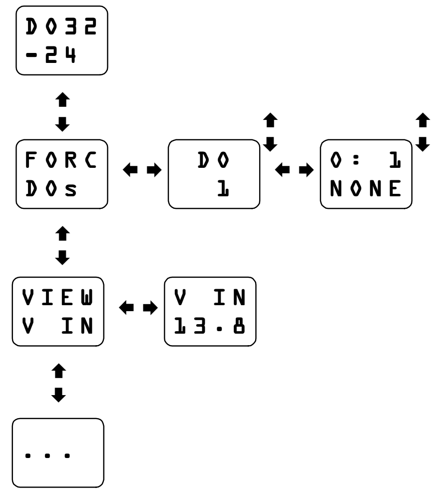
Each discrete output has an LED indicator to show the current ON or OFF state of the output. Typically, the state of the LED indicator mimics the state of the output commanded by a “Host” system, unless the output is “forced” on or off. When the state of an output is forced, the LED shows the forced state that is actually driving the field device, not what the Host is calling for.

I/O Processor Functions

MicroBrick Discrete Output Modules are sometimes used to flash alarm indicators remotely. Without help from the on-board microprocessor, variations in communications and I/O scan time can make the flashing look erratic. Each of the MicroBrick discrete outputs has a precise flashing capability that is independent of communications I/O speed or scan time. Two control bits are used per output; one to turn the output ON or OFF, the second to command the output to flash whenever it is turned ON by the first bit. A separate register sets the flashing rate.

Operator Interface

In addition to module configuration functions, the operator interface of the MicroBrick Discrete Output Modules may be used to individually force the state of discrete outputs ON or OFF. This feature is especially useful at system startup, allowing I/O devices and field wiring to be tested without a full working communications network and host software in place. It is also invaluable for system maintenance, eliminating the need for dragging a laptop computer around to troubleshoot the system.



MicroBrick Discrete Output Modules Operator Interface Menu Tree

The general operation of the MicroBrick operator interface is described in a previous section. The diagram below shows the map of the specific menu tree for the MicroBrick Discrete Output Modules (both models).

Any output can be forced "ON", forced "OFF" or set to "NONE" (no forcing). When scrolling through the channel selection portion of the forcing menu, any channel that is currently forced ON or OFF displays an "F" to the left of the channel number.

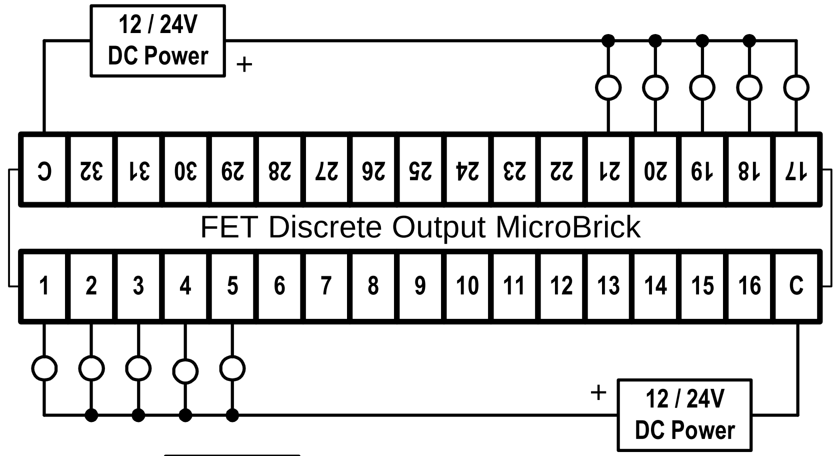
Note that the relay model of the Discrete Output MicroBrick displays a "DO16-RLY" at the top level menu screen.

Field Wiring

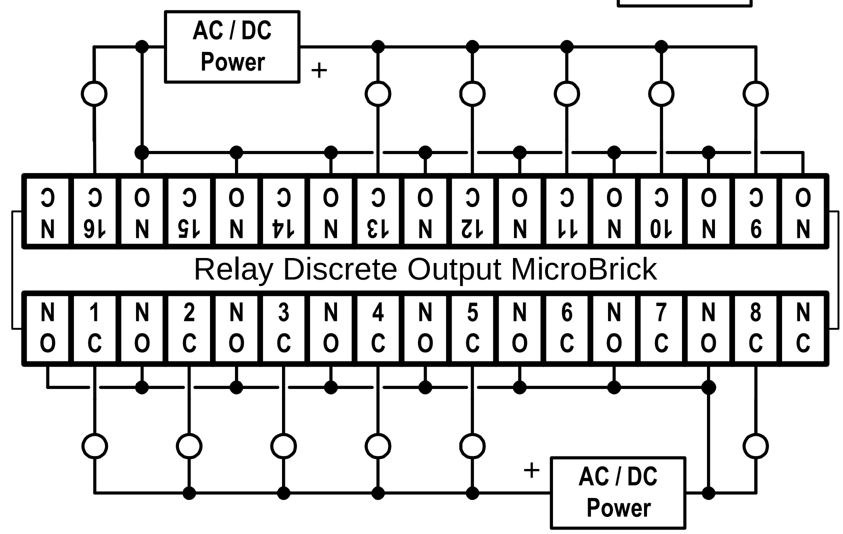
The MicroBrick Discrete Output modules connect to their field wiring via a pair of 17-position removable terminal blocks. The FET Output Module has 16 outputs on either side of the module, with a single common shared by those 16 outputs but isolated from the other 16 outputs. The outputs of the relay module are fully isolated with no shared commons.

Both the FET and Relay discrete output modules are passive and require an active positive supply voltage on one side of the load, while the output from the MicroBrick switches the other side of the load to the power return. For the FET outputs, the return must be the negative side of the power source. For the relay outputs, there are no polarity restrictions. Examples of field wiring for either output module are shown below. Note the "extra" normally closed outputs next to the "8C" and "16C" relay module output terminals.

FET Discrete Outputs - Field Wiring Example:



Relay Discrete Outputs - Field Wiring Example



Register Map - Discrete Output MicroBricks

STATUS (Read Only Input Bits - Modbus Type 10xxx)

none

COILS (Read/Write Output Bits - Modbus Type 00xxx)

DO16-RLY relay output module

Start	*End*	*Description*
001	016	Discrete Outputs 1 through 16
017	032	not used
033	048	Flash Enables 1 through 16
049	064	not used

DO32-24 FET output module

Start	*End*	*Description*
001	032	Discrete Outputs 1 through 32
033	064	Flash Enables 1 through 32

INPUT REGISTERS (Read Only 16-bit - Modbus Type 30xxx)

none

HOLDING REGISTERS (Read/Write 16-bit - Modbus Type 40xxx)

Start	*End*	*Description*
131	-	Output Flash Rate ON/OFF time (half duty cycle) in 10mS. increments

Specifications - Discrete Output MicroBricks

FET DISCRETE OUTPUT Module - Model# 22-0021 (DO32-24)

Number of Discrete Outputs	32
Output Type	FET Power Transistor
Output Configuration	Sinking to Common (open drain)
Output Voltage, nominal	12/24Vdc
Output Voltage Range	0 to 28Vdc
Output Switch Rating	0.5A @ 20ºC, derate linearly to 0.25A @ 80ºC 3.0A peak (0.5 second surge)
Overvoltage & Transient Protection	Transorb
Overload Protection	Self Reseting Polymer Fuse
Flash ON/OFF times & Resolution	0 to 655.35 seconds in 10mS increments
Power, Typical/Maximum	0.75 Watts / 1.5 Watts

RELAY DISCRETE OUTPUT Module - Model# 22-0022 (DO16-RLY)

Number of Discrete Outputs	16
Output Type	Mechanical Relay, dry contact outputs
Output Configuration	14 Form A (NO), 2 Form C (NO/NC)
Output Voltage, nominal	12/24Vdc, 120Vac
Output Voltage Range	0 to 30Vdc, 0 to 140Vac
Output Switch Current Rating	1.0A AC/DC
Output Transient Protection	R/C Snubber across output contacts
Flash ON/OFF times & Resolution	0 to 655.35 seconds in 10mS increments
Power, Typical/Maximum	0.75 Watts / 2.5 Watts

Analog Input Module

MicroBrick Analog Input modules accept signals from sensors that monitor levels, flows, temperatures, pressures, etc. Measurements are made with a high-accuracy 16-bit Analog-to-Digital (A/D) converter. The MicroBrick Analog Input module has a total of 16 analog inputs.

Signal Types and Levels

The MicroBrick Analog Inputs may be individually configured to accept standard 5V or 20mA process control signals. For each analog channel, the user configures the I/O module for the correct input mode (voltage or current). The configuration information is nonvolatile and need only be set once unless the system is changed. The MicroBrick module uses the configuration information to determine which calibration tables to use for processing analog input conversion and calibration data for each channel. When changing between modes on an input channel, the user must also set switches on the side of the Controller that enable precision current sense resistors that are required for 20mA operation but are not used for 5Vdc operation.

When configured for 5Vdc operation, the MicroBrick Analog Input module will accurately read signals up to 5.5Vdc (10% over-range). With standard calibration of the MicroBrick from the factory, inputs ranging from 0 to 5.5 volts will result in readings of 0 to 55000. When configured for 20mA operation, the MicroBrick will accurately read signals up to approximately 40mA (100% over-range). With factory calibration, a span of 0 to 40mA will result in corresponding readings of 0 to 40000 (20mA = 20,000). When an analog input is configured for 20mA operation, a precision 124Ω current sensing resistor is used to measure current flow. At 20mA, this resistor will reduce the available loop voltage (compliance) by approximately 2.5 volts.

Whenever an analog input is configured for voltage or current mode, a corresponding DIP switch next to the Analog Input terminal block must be set. The switches are numbered 1 through 8 corresponding to input channels 1 through 8 on one side, 9 through 16 on the other. For each channel, set the switch UP for current operation (20mA), DOWN for voltage operation (5Vdc).

Isolation and Input Protection

To help avoid ground loop effects, the MicroBrick Analog Inputs are optically isolated with shared commons in groups of 8 inputs. The inputs are also overload, surge, and reverse polarity protected by a combination of self-resetting polymer fuses and "Transorb" transient limiters. Input levels greater than 6Vdc or 50mA, or negative signal levels, will cause the transient protection circuitry to start limiting the input signal. Greater overloads will cause the polymer fuses to begin to increase in resistance protecting the internal input circuitry. During a full overload condition, the inputs will conduct some current, but that current is held at a safe level. When the fault is cleared, the input is restored back to normal operation automatically.

I/O Processor Functions

MicroBrick analog inputs are sometimes connected to the analog outputs of flow and wattage meters. In addition to indicating instantaneous flow or usage rates by the real-time analog reading, the microprocessor in the Analog Input MicroBrick will totalize the readings, accumulating samples of the analog inputs at periodic intervals. This provides a totalized flow or wattage usage over time. The sampling interval (or "gate time") is user configurable.

Calibration

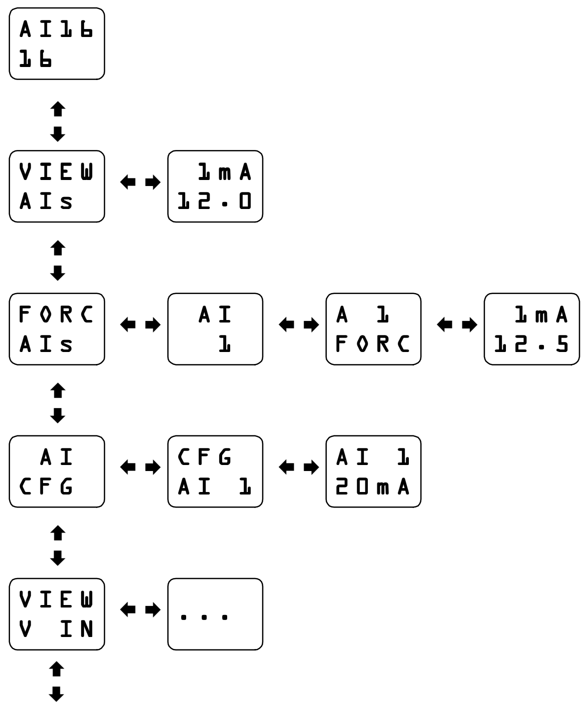
The Analog Input calibration is software controlled. Calibration tables for the analog inputs are stored in nonvolatile EEROM memory and calibration is performed by software techniques without opening the I/O module enclosure.

If you want to do your own calibration, contact ICL technical support for the recommended field calibration procedure.

Operator Interface

In addition to module configuration functions, the operator interface of the MicroBrick Analog Input Module may be used to display the analog levels and individually force the apparent readings of the individual Analog Inputs. This feature is especially useful before system start-up, allowing control software to be tested in the field with "simulated" sensor readings without waiting for I/O devices and field wiring to be installed. It is also invaluable for system maintenance, eliminating the need for dragging a laptop computer, analog simulator and meter around to troubleshoot the system.

Any channel's input level can be displayed or forced. When scrolling through the channel selection portion of the forcing menu, a channel that is forced displays an "F" to the left of the channel number. The operator interface may also be used to configure the input mode of individual analog inputs to: "RAW" (non calibrated A/D reading), Voltage or Current.



MicroBrick Analog Input Module - Operator Interface Menu Tree

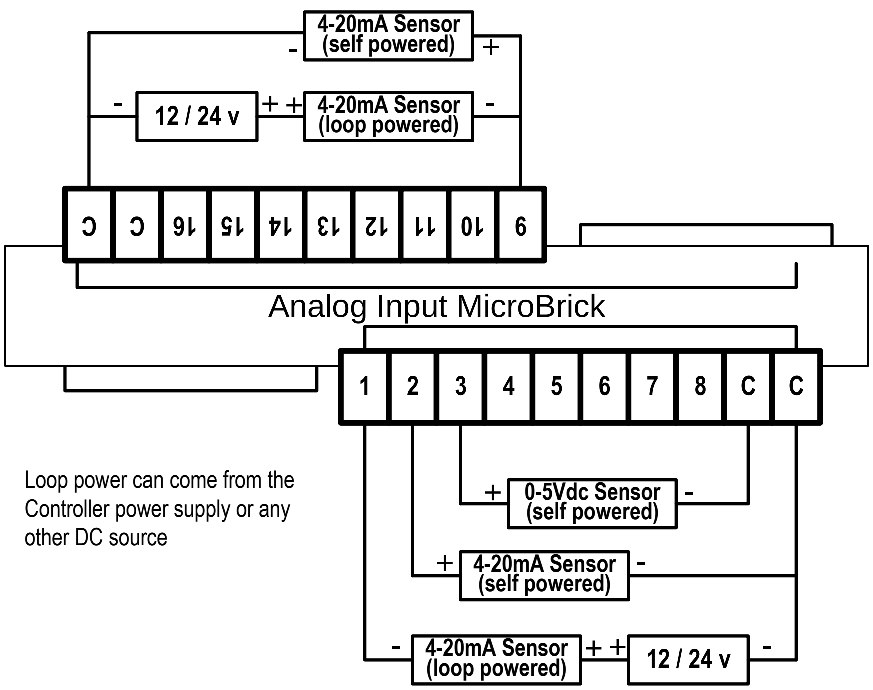
The general operation of the MicroBrick operator interface is described in a previous section. The diagram below shows the map of the specific menu tree for the MicroBrick Analog Input Module.

Field Wiring

The Analog Input connections come into the MicroBrick module on a pair of 16-position removable terminal blocks. There are 8 sensor input connections and 8 common connections, one per input channel, on each terminal block. The common connections on each block are electrically tied together within the MicroBrick. The commons on one terminal block are isolated from the other terminal block, as well as the MicroBricks microprocessor, communications and power supply circuitry.

The Analog Inputs are passive and require an active signal source. 20mA current loop devices must either have their own internal loop power supplies, or an external supply must be used. The Analog Inputs are isolated, so that the power source for the loop devices can safely be the Controller power supply without causing a ground loop. Voltage type sensors are typically self-powered. The user should ensure that self-powered devices are isolated from each other to avoid ground loops.

Typical Analog Input wiring is shown below:



Analog Input MicroBrick - Field Wiring Example

Register Map - Analog Input MicroBrick

MicroBrick Analog Input modules use the following Modbus register map:

STATUS (Input Bits - Modbus Type 10xxx)

none

COILS (Output Bits - Modbus Type 00xxx)

none

INPUT REGISTERS (Read Only 16-bit - Modbus Type 30xxx)

Start	*End*	*Description*
001	016	Analog Inputs 1 through 16
248	249	Reserved - ICL Test ONLY

HOLDING REGISTERS (Read/Write 16-bit - Modbus Type 40xxx)

Start	*End*	*Description*
001	032	Analog Input Totalizers - Inputs 1 through 16 (32-bit, 1st/Odd register is MSB)
132	-	Analog Totalizer Measurement Sampling Interval
133	148	Analog Input Mode - Inputs 1 through 16 (0 = “Raw”/uncalibrated, 1 = mA, 2 = 5V)

Specifications - Analog Input MicroBrick

Number of Analog Inputs	16
Input Type	Unipolar multiplexed inputs with shared Common
Input Levels, nominal	0 to 5Vdc, 0/4 to 20mA
Input Overload Tolerance	Input voltage limiting starts at 6Vdc Input current limited to 50mA
Overload/Transient Protection	Transorbs and self resetting polymer fuses
Conversion Rate	Approximately 2 samples per second at each point
Noise Rejection	-120dB @ 50/60Hz
Power, Typical/Maximum	0.75 Watts / 1.5 Watts

Universal Input Modules

The MicroBrick Universal Input modules accept signals from analog sensors that monitor levels, flows, temperatures, pressures, etc. as well as discrete contact closures. The Universal Input Modules are unique in that they include the signal conditioning circuits required for direct support of thermocouples, RTDs and thermistor temperature sensors, millivolt type sensors such as strain gages, as well as conventional 5V and 20mA devices. The inputs can also be used with discrete contact closures. Built-in signal conditioning eliminates the need for most external signal converters. With the addition of two external resistors, an input channel can accept high-level bipolar voltage inputs such as +/-5Vdc and +/-10Vdc. Measurements are made with high-accuracy 24-bit Analog-to-Digital (A/D) converters. There are two versions of Universal Input Modules: the UI8I and the UI12.

The UI8I input module has a total of 8 dual analog inputs; one “voltage” input and one “resistance” input. When a channel is configured to support a 3-wire RTD temperature sensor, both inputs are used together to accurately measure the sensor resistance, and therefore the temperature, while compensating for the resistance of the wires to the sensor head. For all other sensors that are 2-wire devices, the channels inputs may be configured separately, yielding a total of 16 analog inputs, 8 for voltage type sensors (5Vdc, 20mA, mV, and thermocouples) and 8 for resistance type sensors (thermistors, 1000 ohm 2-wire RTDs and potentiometers). Each pair of inputs is isolated from each of the other input channels as well as the MicroBricks microprocessor and communications circuits. Internal DC-DC converters are provided within the Universal Input module, so no external isolated power is required.

The UI12 input module does not support three wire RTDs but does support the rest of the sensor styles with a total of 12 inputs supporting all other sensor types. The UI12 has two “sides” that are isolated from communications and power, from side to side, but not between channels 1 through 6 or channels 7 through 12.

Input mode Configuration

The MicroBrick Universal inputs may be individually configured to accept process control signals and temperature sensors through the built-in operator interface, or by commands from any Modbus (or BrickNet) Master, or using the ICL ScadaFlex I/O Toolbox software.

The configuration of a MicroBrick Universal Input module can be read or changed at any time with simple register commands. The module configuration is retained in nonvolatile EEROM memory so that the settings are “remembered” even after the module is powered off. No batteries are used.

For current loop sensors, the user must also set switches next to the input terminal blocks that enable or disable precision current sense resistors required for handling 20mA sensors.

RAW Mode

Raw mode bypasses all scaling and calibration in the UIO module, providing “raw” 16-bit (truncated 24-bit) readings from the A/D converter. A full scale reading of 65535 represents an input of approximately 5Vdc. If the current configuration switches are enabled, the input current can be calculated as the voltage drop read across a precision 121ohm resistor, or just over 40mA for a full scale readings of 65,535. The calculation is:

A/D Reading = (65535 * mA * 121) /5

If the current sources are enabled (for resistance measurements), the RAW readings are the ratiometric values read across the input resistance in series (bottom portion of a voltage divider) with a precision 20,000 ohm 0.1% low-drift resistor connected to the A/D reference. The calculation is:

A/D Reading = 65535 * R / (R + 20,000)

where R is the input resistance being measured. For example, a 10,000 resistor will read approximately 21845 counts:

65535 * 10,000/(10,000 + 20,000) = 21845

5Vdc Mode

When configured for voltage measurements, the Universal Input module measures signals from 0 to 5.6 volts (5 volts plus 12% over-range) with a resolution of just over 16-bits. There's no loss of accuracy in this over-range area, so it's possible to accurately read the signal levels from slightly misadjusted sensors that run "a little hot". It's also possible to distinguish between a sensor output that is at full scale versus over-range. The Universal Input module scales and performs calibration correction on the readings, so that a full scale reading of 5.6Vdc is presented to the Host system as a value of 56000 (10,000 counts per volt). This provides readings that without further scaling, read out directly in 100uV increments (imagine a decimal point 4 places from the right to interpret the readings in volts).

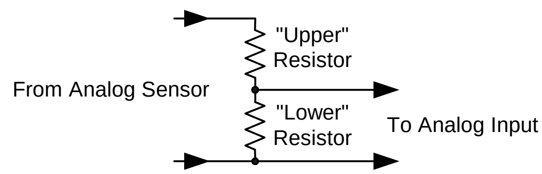
20mA Mode

When configured for milliampere measurements, the Universal Input module measures signals from 0 to just over 40mA (200% over-range for "standard" 20mA signals). The module scales and performs calibration correction on the readings, so that a full scale reading of 40mA is presented to the main CPU as a value of 40000 (1,000 counts per milliampere). The milliampere mode is typically used to measure the output of 4 to 20mA sensors. The readings from these sensors will come back to the Host system as 4000 for 4mA and 20,000 for 20mA. Current is measured by reading the voltage drop across a 121 ohm precision resistor. Besides setting the input mode in the module, current loops require that the current sense resistors be enabled by setting a DIP switch (labeled 20mA) next to their respective input connector. There is a separate switch for each input.

Millivolt Mode

The MicroBrick Universal Input module can accurately measure very small signal levels like those from "bridge" type pressure transducers and low power devices such a solar radiation sensors. In the millivolt mode, the module has a full scale measurement range of +/-300mV. The microprocessor in the Universal Input module scales and performs calibration correction on the low-level readings, so that a full-scale reading of +/- 300mV is presented back to the Host system as a value of +/- 30,000 (10,000 counts per 100mV). Besides reading the output of low-level sensors, this mode is useful for creating custom input voltage ranges using an external resistor voltage divider.

Typical custom ranges and their corresponding divider values are listed below. The resistor values shown provide approximately a 150% over range capacity (+/-200mV signal for the listed To Analog Input full-scale values) The values were also chosen to provide a 10K ohm or higher resistance on the input signal.

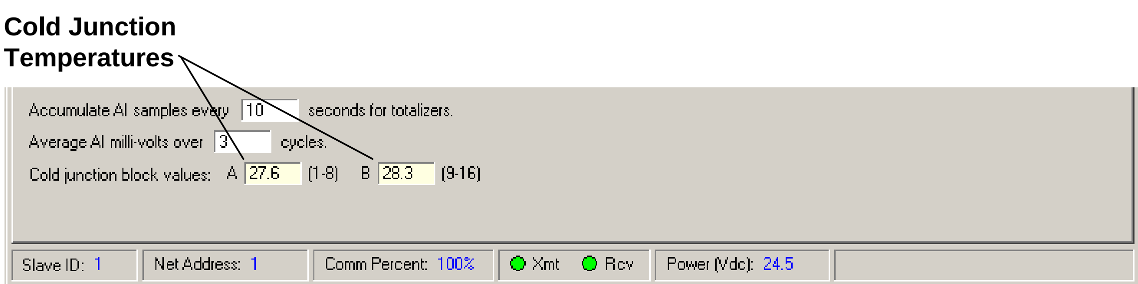


Range	"Upper" resistor	"Lower" resistor
+/-1Vdc	8.06K ohm 1%	2.0K ohm 1%
+/-5Vdc	12.1K ohm 1%	499 ohm 1%
+/-10Vdc	24.3K ohm 1%	499 ohm 1%

Thermocouple Modes

The MicroBrick Universal Input module supports temperature measurements using thermocouple sensors. No external signal conditioners are needed for any combination of type J, K, T, E, R, S, B and N thermocouples.

Thermocouple signals require linearization and cold-junction compensation. In the MicroBrick Universal Input module, the cold junction (terminal block) temperature is measured by a pair of solid-state temperature sensors, one located in close proximity to each I/O terminal block. The temperature readings from these sensors are available in a pair of Modbus registers that can also be viewed near the bottom of the Analog Inputs window in the ScadaFlex I/O toolbox software as shown below.



The microprocessor in the MicroBrick Universal Input module automatically performs the required compensation and linearization calculations so that an accurate scaled and calibrated temperature reading in degrees C or degrees F is provided back to the Host system. The inputs have upscale burnout protection, forcing a maximum temperature reading for an open thermocouple sensor. The supported temperature ranges and corresponding readings for each of the thermocouple types are listed below:

Thermocouple	Temperature Range	From UI Module

Type J - Deg C	-240.7ºC to 1199.0ºC	-2407 to 11990
Type J - Deg F	-401.2ºF to 2190.2ºF	-4012 to 21902
Type K - Deg C	-261.2ºC to 1369.5ºC	-2612 to 13695
Type K - Deg F	-438.1ºF to 2497.1ºF	-4381 to 24971
Type T - Deg C	-263.2ºC to 398.8ºC	-2632 to 3988
Type T - Deg F	-441.7ºF to 749.8ºF	-4417 to 7498
Type E - Deg C	-267.4ºC to 999.0ºC	-2674 to 9990
Type E - Deg F	-449.3ºF to 1830.2ºF	-4493 to 18302
Type R - Deg C	-43.1ºC to 1759.8ºC	-431 to 17598
Type R- Deg F	-45.5ºF to 3199.6ºF	-455 to 31996
Type S- Deg C	-41.3ºC to 1759.1ºC	-413 to 17591
Type S - Deg F	-42.3ºF to 3198.3ºF	-423 to 31983

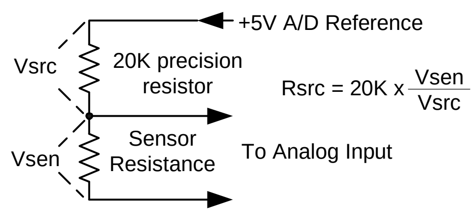
Resistance Type Sensor Modes

Resistance measurements and resistive type sensors such as thermistors, RTDs and potentiometers require a current source. In the MicroBrick Universal Input module, one of each of the pair of inputs for an input channel is a current sourced input. For 2-wire devices, the sensor is simply connected between the “Resistance” and the channels common terminal. For 3-wire RTDs (UI8I only), all three terminals are used, two for measuring sensor resistance, and the third to measure the lead resistance and compensate the final precision temperature reading accordingly.

Resistance Mode (2-wire)

MicroBrick Universal Input modules can measure resistance from 0 to 65,535 ohms. The resolution is 1 ohm below 20,000 ohms and several ohms towards the top of the range. The resistance mode is typically used to read the resistance of potentiometer sensors that indicate position or rotation.

Resistance is measured by sourcing current through a precision 10,000 ohm reference resistor that is in series with the sensor. The microprocessor in the Universal Input module measures the voltage drop at the junction of the reference resistor and the sensor and compares it to the reference voltage. The microprocessor is then able to ratiometrically calculate the sensor resistance.



Thermistor Modes

Thermistors are temperature sensors that are popular for use in HVAC, building monitoring and mobile vehicle applications. The resistance of a thermistor varies non-linearly with temperature, so the Universal Input module automatically corrects for the non-linearity and provides a calibrated reading in degrees C or F back to the host system.

The MicroBrick Universal Input module supports two common types of thermistors; 10K ohm, Type II and III (resistance is 10,000 ohms at 25°C/77°F). The only difference between them is the “shape” of their temperature to resistance curves. The supported temperature ranges and corresponding readings from the Universal Input module are:

Sensor Mode	Temperature	From UI Module

Type II - Deg C	-40.1ºC to 203.4ºC	-401 to 2034
Type II - Deg F	-40.1ºF to 398.1ºF	-400 to 3981
Type III - Deg C	-40.1ºC to 201.1ºC	-401 to 2011
Type III - Deg F	-40.1ºF to 393.9ºF	-400 to 3939

The table below shows the temperature to resistance relationship for the 10,000 ohm thermistors supported by the Universal Input module.

Deg C	Deg F	10K Type II - ohms	10K Type III - ohms
-40	-40	335,671	239,831
-35	-31	242,195	179,280
-30	-22	176,683	135,233
-25	-13	130,243	102,890
-20	-4	96,974	78,930
-15	5	72,895	61,030
-10	14	55,298	47,549
-5	23	42,314	37,316
0	32	32,650	29,490
5	41	25,395	23,462
10	50	19,903	18,787
15	59	15,714	15,136
20	68	12,493	12,268
25	77	10,000	10,000
30	86	8,056	8,197
35	95	6,530	6,754
40	104	5,324	5,594
45	113	4,366	4,656
50	122	3,601	3,893
55	131	2,985	3,271
60	140	2,487	2,760
65	149	2,082	2,339
70	158	1,751	1,990
75	167	1,480	1,700
80	176	1,256	1,458
85	185	1,070	1,255
90	194	916	1,084
150	302	185	238

RTD Modes

RTDs are another form of resistance temperature sensor. They are frequently used in HVAC and refrigeration applications. Although RTDs are considerably more linear than thermistors, the microprocessor in the Universal Input module must still linearize the readings to provide accurate values back to a Host system.

The MicroBrick Universal Input module supports both 100 3-wire RTDs (both standard curves: TCR - 0.00385 and 0.00392—UI8I only), and 1000 ohm 2-wire RTDs. Although 100 ohm RTDs can be used in a 2-wire configuration, their accuracy will be much greater using a 3-wire configuration since the lead resistance effects are significant for 100 ohm sensors and these effects are compensated for in a 3-wire configuration. The measurement range of RTDs with the Universal Input module is:

Sensor Mode	Temperature	From UI module
100/1000 ohm RTD - Deg C	-198.9ºC to 869.4ºC	-1989 to 8694
100/1000 ohm RTD - Deg F	-326.0ºF to 1596.9ºF	-3260 to 15969

The relationship between temperature and RTD resistance is:

Deg C	Deg F	100 ohm - .385	100 ohm - .392	1000 ohm - .385
-40	-40	84.27	83.99	843
-30	-22	88.22	88.01	882

-20	-4	92.16	92.02	922
-10	14	96.09	96.02	961
0	32	100.0	100.0	1000
10	50	103.90	103.97	1039
20	68	107.79	107.93	1078
30	86	111.67	111.88	1117
40	104	115.54	115.82	1155
50	122	119.40	119.75	1194
60	140	123.24	123.66	1232
70	158	127.08	127.56	1271
80	176	130.90	131.45	1309
90	194	134.71	135.33	1347
100	212	138.51	139.20	1385
110	230	142.29	143.06	1423
120	248	146.07	146.90	1461
130	266	149.83	150.73	1498
140	284	153.58	154.55	1536
150	302	157.33	158.36	1573
160	320	161.05	162.16	1610
170	338	164.77	165.94	1648
180	356	168.48	169.71	1685
190	374	172.17	173.48	1722
200	392	175.86	177.23	1759
210	410	179.53	180.96	1795
220	428	183.19	184.69	1832
230	446	186.84	188.41	1868
240	464	190.47	192.11	1905
250	482	194.10	195.80	1941

Contact Closure and Logic Level Discrete Inputs

In addition to analog type sensors, the MicroBrick Universal Input module can accept simple discrete input signals in the form of contact closures and low-level logic signals. Unlike the discrete inputs in other I/O modules, the universal inputs can use the built-in current sources available for resistance measurements so that no external “wetting” current is required for contact closure type sensors (switches, relay contacts, etc.). The inputs are also more sensitive so they are capable of accepting TTL and CMOS logic levels which typically run between 3 and 5Vdc.

Do NOT apply any voltage in excess of 5.5Vdc to a Universal Input, otherwise the overload protection circuitry will take over and clamp the input at approximately 6Vdc.

The microprocessor in the Universal Input module actually processes a discrete sensor on a Universal Input like any other analog sensor, so the inputs are heavily filtered and respond much more slowly than the conventional discrete inputs. Do not use these inputs if you require response times faster than 1/4 second!

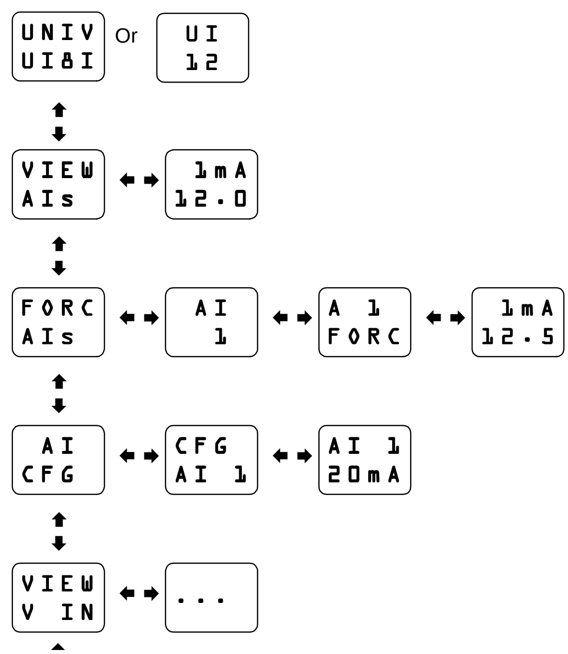
The Universal Input signals are read from the Universal input module as DI1 through DI8 on the UI8I and DI1 through DI12 on the UI12. The UI12 is required to be in resistance mode to use this feature; the UI8I does not.

If the voltage level on an input is HIGH (a voltage of 2.50Vdc or greater), it is considered OFF. A LOW (any voltage level below 2.50Vdc) is considered to be ON. Be sure to connect the contacts to the RESISTANCE inputs of the module.

Operator Interface

In addition to module configuration functions, the operator interface of the MicroBrick Universal Input Module may be used to display signal levels and individually force the apparent readings of the individual inputs. This feature is especially useful before system start-up, allowing control software to be tested in the field with “simulated” sensor readings without waiting for I/O devices and field wiring to be installed. It is also invaluable for system maintenance, eliminating the need for dragging a laptop computer, analog simulator and meter around to troubleshoot the system.

Any channel’s input level can be displayed or forced. When scrolling through the channel selection portion of the forcing menu, a channel that is forced displays an “F” to the left of the channel number. The operator interface may also be used to configure the input mode of individual analog inputs.



MicroBrick Universal Input Module Operator Interface Menu Tree

The general operation of the MicroBrick operator interface is described in a previous section. The diagram below shows the map of the specific menu tree for the MicroBrick Universal Input Modules.

Field Wiring

The Universal Input connections come into the MicroBrick module on a pair of 12-position removable terminal blocks.

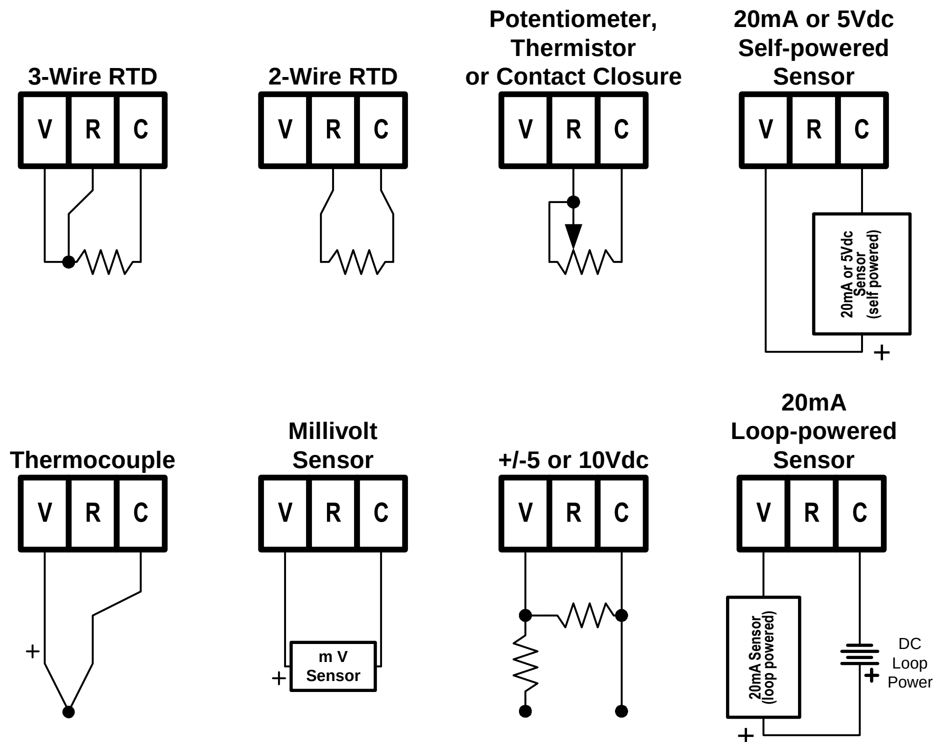
On the UI8I, there are 8 channels; each channel with a “voltage/current” input (V) and a “resistance” input (R), along with a common for both inputs (C). Each channel (input pair) is electrically isolated from the other channels and the rest of the MicroBrick electronics.

On the UI12, there are 12 channels with only one input and a common for each. Inputs 1 through 6 share a common and inputs 7 through 12 share a common.

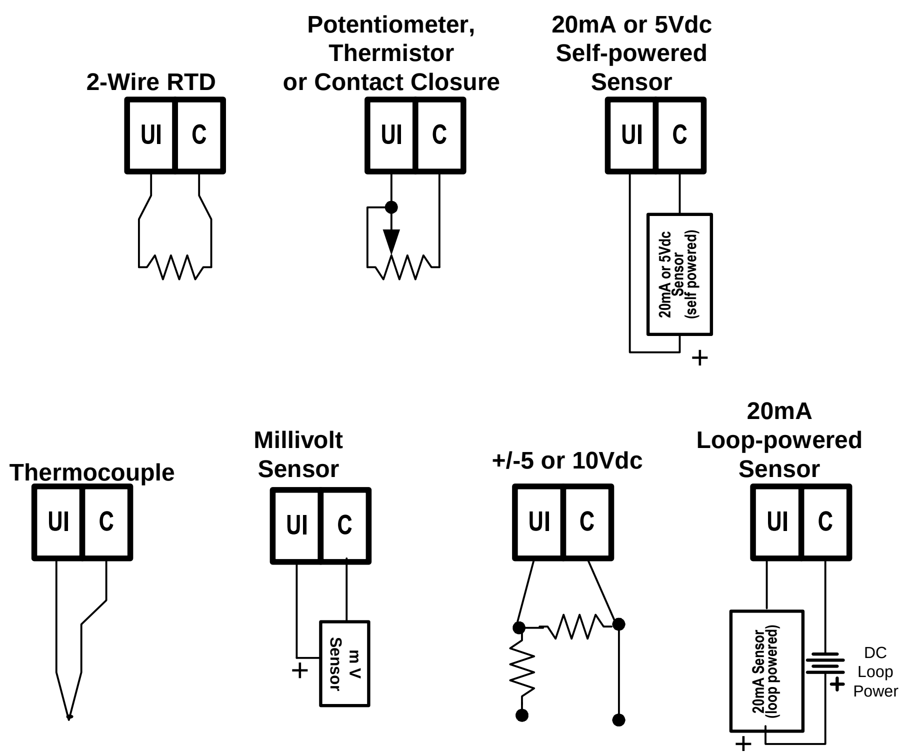
The voltage/current inputs are passive and require an active signal source. 20mA current loop devices must either have their own internal loop power supplies, or an external supply must be used. 5V and millivolt sensors are typically self-powered. Other voltage type sensors such as thermocouples are naturally self powered. Resistance and contact closure type sensors require a current source which is built into the RESISTANCE inputs. The source provides less than 1mA to avoid self-heating of resistance temperature sensors with low thermal mass. In order to use the contact closure feature on the UI12, you must put the appropriate channel in resistance mode.

On the UI8I module, if a 3-wire RTD sensor is being used, a voltage/current sensor and a resistance type sensor may share a channel and be used simultaneously. The UI8I has two set of mode settings and analog reading registers for this purpose. Typical wiring of a Universal Input with various sensors is shown below:

UI8I MicroBrick - Field Wiring Examples :



UI12 MicroBrick - Field Wiring Examples:



Register Map - Universal Input UI8I And UI12

STATUS (Read Only Input Bits - Modbus Type 10xxx) UI8I

Start	*End*	*Description*
001	008	Discrete Inputs 1 through 8

STATUS (Read Only Input Bits - Modbus Type 10xxx) UI12

Start	*End*	*Description*
001	012	Discrete Inputs 1 through 12 (resistance mode must be set for the channel).

INPUT REGISTERS (Read Only 16-bit - Modbus Type 30xxx) UI8I

Start	*End*	*Description*
001	008	Universal Inputs 1 through 8 - “A” Readings,
009	016	Universal Inputs 1 through 8 - “B” Readings
017	018	Cold Junction Temperatures, inputs 1 - 4 and 5 - 8 (deg C x 10)

INPUT REGISTERS (Read Only 16-bit - Modbus Type 30xxx) UI12

Start	*End*	*Description*
001	012	Universal Inputs 1 through 12
013	014	Cold Junction Temperatures, inputs 1 - 6 and 7 - 12 (deg C x 10)

HOLDING REGISTERS (Read/Write 16-bit - Modbus Type 40xxx) UI8I

Start	*End*	*Description*
001	016	Analog Input Totalizers - Inputs 1 through 8 (Voltage/Current, 32-bit, 1st/Odd register is MSB)
130	-	AI Millivolt Averaging Modes 1 - 8
132	-	Analog Totalizer Measurement Sampling Interval
133	148	Analog Input Modes - 1-8 “A” (primary “A” readings), 1-8 ”B” (alternate “B” readings) (see UNIVERSAL INPUT MODES below)
150	157	Voltage calibration, inputs 1 through 8
158	165	MV calibration (numerator), inputs 1 through 8
166	173	MV calibration (offset), inputs 1 through 8
174	181	Current calibration, inputs 1 through 8
182	189	Resistance calibration, inputs 1 through 8

HOLDING REGISTERS (Read/Write 16-bit - Modbus Type 40xxx) UI12

Start	*End*	*Description*
001	024	Analog Input Totalizers - Inputs 1 through 12 (Voltage/Current, 32-bit, 1st/Odd register is MSB)
130	-	AI Millivolt Averaging Modes 1 - 8
131	-	Analog Filter 50/60Hz Bitmap
132	-	Analog Totalizer Measurement Sampling Interval
133	145	Analog Input Mode - Inputs 1 -12 (see UNIVERSAL INPUT MODES below)
149	-	Input Power (voltage) and Sensor Power calibration numerators (denominator = 65,535)
150	161	Current calibration, inputs 1 through 12
162	163	Voltage calibration (numerators), inputs 1 through 6 and inputs 7 through 12 respectively
164	165	Millivolt calibration (numerators), inputs 1 through 6 and inputs 7 through 12 respectively
166	167	Millivolt calibration (offset), inputs 1 through 6 and 7 though 12 respectively
168	179	Resistance calibration, inputs 1 through 12

UNIVERSAL INPUT MODES

0 = Raw (A/D readings with no calibration or scaling)

1 = Current (20,000 = 20.000mA)   2 = Voltage (50,000 = 5.0000Vdc)

3 = Millivolts (+/-30000 = +/-300.00mV)
4 = Resistance (0 to 65535 ohms)
5 (ºC), 6 (ºF) = J Thermocouple
7 (ºC), 8 (ºF) = K Thermocouple
9 (ºC), 10 (ºF) = T Thermocouple
11 (ºC), 12 (ºF) = E Thermocouple
13 (ºC), 14 (ºF) = R Thermocouple
15 (ºC), 16 (ºF) = S Thermocouple
17 (ºC), 18 (ºF) = B Thermocouple
19 (ºC), 20 (ºF) = N Thermocouple
21 (ºC), 22 (ºF) = RTD, 100 ohms, 0.385
22 (ºC), 23 (ºF) = RTD, 100 ohms, 0.392
24 (ºC), 25 (ºF) = RTD, 1000 ohms, 0.385
26 (ºC), 27 (ºF) = 10K Thermistor Type II
28 (ºC), 29 (ºF) = 10K Thermistor Type III

Specifications - Universal Input MicroBrick

Number of Inputs UI8I	8 dual channels (8 voltage/current, 8 resistance)
Number of Inputs UI12	12 single channels
A/D Converter Resolution/Type	24 bits, Delta-Sigma Maximum Reading
Resolution	16 bits (1 part in 65,536)
Converter Type	Delta-Sigma
Input Resistance	
Voltage & Thermocouple	>1 Million Ohms
Current	121 ohms
Resistance & Contacts	10,000 ohms
Analog Input Signal Range	
Current	20mA (0mA to 46mA) - Limited at 60mA
Voltage	5Vdc (0Vdc to 5.625Vdc) - Limited at 6Vdc
Millivolts	+/-300mV (-300mV to +300mV)
Resistance	65,000 ohms (0 to 65,535 ohms)
Thermocouples :	
Type J (-240.7ºC to 1199.0ºC)	Type K (-261.2ºC to 1369.5ºC)
Type T (-263.2ºC to 398.8ºC)	Type E (-267.4ºC to 999.0ºC)
Type R (-43.1ºC to 1759.8ºC)	Type S (-41.3ºC to 1759.1ºC)
Type B (-253.4ºC to 1792.1ºC)	Type N (-255.4ºC to 1296.8ºC)
Thermistors 10Kohm - II (-401ºC to 173.9ºC)	10Kohm - III (-401ºC to 188.0ºC)
RTDs: 100 ohm - 385 (-198.9ºC to 869.4ºC)	100 ohm - 392 (-200.0ºC to 629.7ºC)
	1K ohm - 385 (-198.9ºC to 869.4ºC)
Accuracy @ 25ºC (% Full Scale)	
Current , Voltage, millivolts	+/- 0.01% of Full Scale
Resistance	+/- 0.01% (<25Kohm), +/- 0.3% (>25Kohm)
Thermistors & RTDs	+/- 0.5ºC
Thermocouples	+/- 0.5ºC +/- 1ºC Cold Junction Tolerance
Temperature Coefficient	
Voltage & Thermocouples	+/- 5ppm/ºC maximum
Current, Thermistor, RTD & ohms	+/- 30ppm/ºC maximum
Input Overload Clamping	Inputs limited to 50mA and 6Vdc
Overload / Transient Protection	Transorb/Self Resetting Polyfuse

Discrete I/O Modules

MicroBrick Discrete I/O modules provide a mix of discrete inputs, and discrete outputs. They are an economical alternative to using separate modules when smaller quantities of I/O are needed. Because of their mix of I/O, Discrete I/O MicroBricks are frequently used as low-cost Modbus Remote Terminal Units (RTUs).

Discrete I/O MicroBricks have 16 Discrete Inputs (12/24V or 120V models), and 16 discrete (FET) outputs. The functionality of each section is identical to their equivalent MicroBrick modules

Discrete I/O Module Discrete Input Section

Discrete I/O module Discrete Inputs are used to monitor the state of switches, relays contacts, motor starter auxiliary contacts and any other on/off type sensor signal. The inputs are optically isolated to avoid ground loop effects and damage from transients and power surges. There are a total of 16 discrete inputs with a shared common.

Signal Types and Levels

The Discrete I/O module Discrete Inputs have a unique input design that accepts both AC and DC signals. The inputs are not sensitive to signal polarity, supporting DC sensors with either “sinking” or “sourcing” output configurations as well as switch contacts with AC or DC signals.

Currently, there are two models of Discrete I/O Modules; one designed for low-voltage (12/24V) discrete inputs, the other for 120V discrete inputs. In the low voltage model, an input level of 9 volts (AC/DC) or greater is considered to be an “ON”. Input levels of 6 volts (AC/DC) or less are considered OFF. The inputs can accept signal levels of up to 50 volts (AC/DC) and tolerate overloads of nearly twice that. The 120V model responds to inputs of 75V or greater as an “ON”, 50V or less as an “OFF” and will tolerate a 100% overload.

LED Input Status Indicators

Each discrete input has an LED indicator to show the current ON or OFF state of the input.

I/O Processor Functions

The discrete inputs are supported by a microprocessor that performs input noise filtering, pulse totalization and pulse rate computation, helping to off-load the Host Controller and improve system performance.

Input Filtering

The discrete inputs have filtering that rejects spurious noise and limits the maximum counting rate to 40Hz with DC pulses, up to 10Hz with AC signals.

Pulse Totalization

Discrete I/O module Discrete Inputs count ON transitions for every input point, providing reliable pulse totalization that is not sensitive to communications rates and I/O scan time. This feature can be used for very accurate flow and wattage totalization.

The pulse totalizers are 32-bit counters, meaning that the totalizers count up to 4,294,836,225 ON transitions before they “roll over” to zero again. The counters can be reset or preset to any value at any time.

Runtime Totalization

MicroBrick Discrete I/O module Discrete Inputs monitor the runtime (ON time) for every input, providing reliable “down-to-the-second” information on how long an input has been “ON”. This information is useful for equipment maintenance and wear leveling. An example is the use of runtime to determine which pump should be used based on which pump has seen the least usage.

The runtime totalizers are 32-bit registers, meaning that the totalizers count seconds, up to 4,294,836,225 before they “roll over” to zero again. The runtime totalizers can be reset to zero or preset to a value at any time by simply writing to the appropriate register.

Pulse Rate Calculation

MicroBrick module Discrete Inputs calculate the input pulse rate for every input. With the appropriate sensors, this can be used to show “real-time” flow, usage rates, and speeds. A software settable “gate” time determines the measurement interval over which the input pulses are counted. Longer gate time intervals provide greater measurement resolution, but the measured value is updated less frequently. The gate time is the measurement update interval. Once the gate time has expired, each totalized count is stored in a Modbus register for that discrete input, and a new set of rate totalization measurements are started.

Discrete I/O Module Discrete Output Section

The Discrete I/O module Discrete Outputs are used to control relays, motor starters, lights, annunciators and any other on/off type control device. The Discrete I/O modules provide 16 solid state FET (protected transistor) outputs. FET transistors are extremely efficient and consume very little power, ideal for solar and battery backed systems. If a “dry” relay contact is required, a FET output can drive an interposing relay.

The FET outputs are isolated as well as overload, surge, and reverse polarity protected by self-resetting polymer fuses and “Transorb” transient limiters. Because of the built-in transient protection, a suppression diode is typically not required across relay coils or other inductive loads.

The FET outputs are designed to operate in 12 and 24 volt control systems, with control voltages of up to 28 volts DC. An external power source is NOT required to power the MicroBrick FET output circuitry, but IS required by the load devices. FET outputs ARE sensitive to signal polarity, driving DC control devices with an open drain output that switches to a common “ground”. When turned ON, the outputs have a very low (< 2Ω) resistance to the common. When turned OFF, the outputs exhibit very high resistance and low leakage that will not provide a false ON to sensitive controller inputs like other solid state outputs have in the past. If an output drives a low resistance or shorted load, it will be protected automatically by switching to a low current state high resistance state. The output will continue to sink some current in this condition until the overload is removed. Once the fault condition is cleared, the output will automatically switch back to its normal low resistance, driving the full current required by the load.

LED Output Status Indicators

Each discrete output has an LED indicator to show the current ON or OFF state of the output.

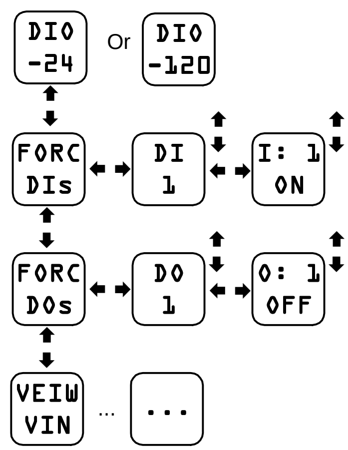
I/O Processor Functions - Discrete Outputs

MicroBricks are sometimes used to flash alarm indicators remotely, but without help from the on-board microprocessor, variations in communications and I/O scan time can make the flashing look erratic. All of the MicroBrick Discrete I/O Module discrete outputs have a precise flashing capability that is independent of communications I/O speed or scan time. 2 control bits are used per output; one to turn the output ON or OFF, the second to command the output to flash whenever it is turned ON by the first bit. A separate Modbus register sets the flashing rate.

Operator Interface

In addition to module configuration functions, the operator interface of the MicroBrick Discrete I/O module may force the readings of the individual Discrete Inputs. This feature is especially useful at system startup, allowing I/O devices and field wiring to be tested without a full working communications network and host software in place, or to assist in testing the system software by simulating sensor readings. It is also invaluable for system maintenance, eliminating the need for dragging a laptop computer and meter around to troubleshoot the system.

The general operation of the MicroBrick operator interface is described in a previous section. The diagram here shows the map of the specific menu tree for the MicroBrick Discrete I/O Module. The common communication configuration interface is shown earlier in this document.



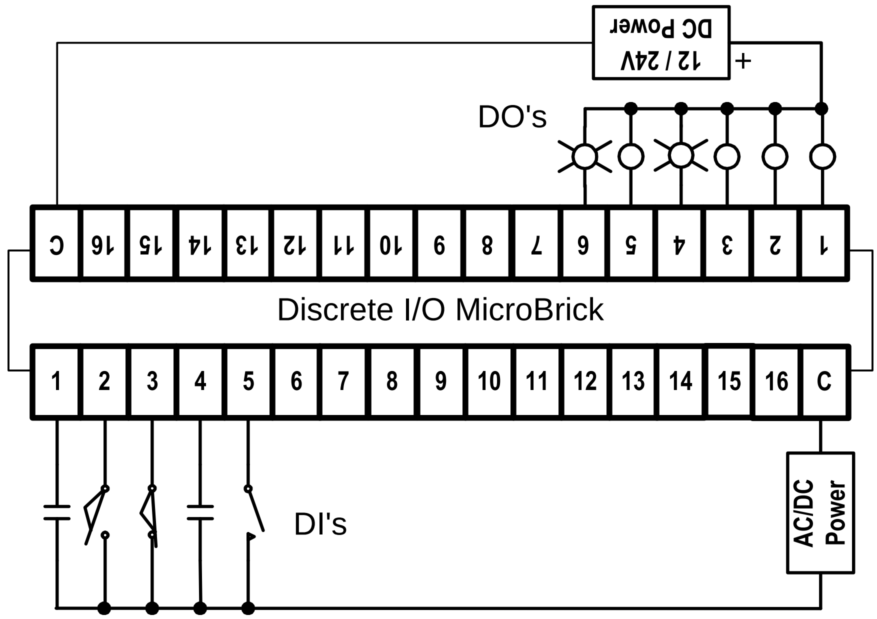
MicroBrick Discrete I/O Module Operator Interface Menu Tree

Any Discrete I/O can be forced. When scrolling through the channel selection portion of any of the forcing menus, a channel that is currently forced displays an “F” to the left of the channel number.

Discrete I/O Module Field Wiring

Discrete I/O Module discrete I/O field wiring terminates at two 17-position removable terminal blocks with one isolated common on each terminal.

The Discrete Outputs are “open-drain” FET transistors that require a positive supply voltage on one side of the loads, while the outputs switch the other side of the loads to the power return. The power return must be connected to the negative side of the power source.



DIO MicroBrick - Field Wiring Examples :

The Discrete Inputs require an active voltage to be switched between their common and the input signal connections. The inputs are isolated, so the power source for the inputs can be the MicroBricks power supply without causing a ground loop. The discrete inputs are not sensitive to polarity. The input current at 12Vdc is approximately 1mA, sufficient for contact “wetting”, but low enough for use in solar and battery-backed applications.

Modbus Register Map

STATUS (Read Only Input Bits - Modbus Type 10xxx)

Start	*End*	*Description*
001	016	Discrete Inputs 1 through 16

COILS (Read/Write Output Bits - Modbus Type 00xxx)

Start	*End*	*Description*
001	016	Discrete Outputs 1 through 6
033	064	Flash Enables 1 through 6

INPUT REGISTERS (Read Only 16-bit - Modbus Type 30xxx)

Start	*End*	*Description*
001	016	Pulse Rate - Inputs 1 through 16

HOLDING REGISTERS (Read/Write 16-bit - Modbus Type 40xxx)

Star	*End*	*Description*
001	032	Pulse Totalizers - Inputs 1 through 16 (32-bit, 1st/Odd register is MSB)
033	064	Runtime Totalizers - Inputs 1 through 16 (32-bit, 1st/Odd register is MSB)
129	-	Rate Measurement “Gate” (sampling) Time
131	-	Output Flash Rate ON/OFF time (half duty cycle) in 10mS. increments

Specifications - Discrete Input PicoBricks

DISCRETE INPUTS Module -	22-0055 (DIO16/16-24)	22-0056 (DIO6/6-120)
Number of Discrete Inputs	16	16
Input Type	Bipolar Optocoupler	Bipolar Optocoupler
Input Voltage, nominal	12/24 Vdc/ac	120 Vdc/ac
Input Voltage Range	0 to 60 Vdc/ac	0 to 125 Vdc/ac
Input Overvoltage Tolerance	85Vdc/Vac	190Vdc/Vac
Input Resistance, typical	10,000 ohms	100,000 ohms
Input Noise Filtering, AC/DC	20Hz / 100Hz	20Hz / 100Hz
Counting Frequency, AC/DC	10Hz / 50Hz	10Hz / 50Hz

FET DISCRETE OUTPUTS All DIO16/16 Modules

Number of Discrete Outputs	16
Output Type	FET Power Transistor
Output Configuration	Sinking to Common (open drain)
Output Voltage, nominal	12/24Vdc
Output Voltage Range	0 to 28Vdc
Output Switch Rating	0.5A @ 20oC, derate linearly to 0.25A @ 80oC 3.0A peak (0.5 second surge)
Overvoltage & Transient Protection	Transorb
Overload Protection	Self Resetting Polymer Fuse
Flash ON/OFF times & Resolution	0 to 655.35 seconds in 10mS increments

Analog I/O Module

MicroBrick Analog I/O Modules provide a mix of analog inputs and analog outputs. They are an economical alternative to using separate modules when smaller quantities of I/O are needed. Because of their mix of I/O, Analog I/O MicroBricks are frequently used as low-cost Modbus Remote Terminal Units (RTUs).

Analog I/O MicroBricks have 8 16-bit Analog Inputs (0-20mA, 0-5VDC and +/-300mV) and 8 isolated Analog Outputs.

Analog I/O Module Analog Input Section

MicroBrick Analog I/O module Analog Inputs accept signals from sensors that monitor levels, flows, temperatures, pressures, etc. Measurements are made with a high-accuracy 16-bit Analog-to-Digital (A/D) converter. The Analog I/O Modules have a total of 8 analog inputs.

Signal Types and Levels

MicroBrick Analog I/O Module analog inputs may be individually configured to accept standard 5V, +/-300mV or 20mA process control signals. For each analog channel, the user configures the I/O module for the correct input mode (voltage or current). The configuration information is nonvolatile and need only be set once unless the system is changed. The Module uses the configuration information to determine which calibration tables to use for processing analog input conversion and calibration data for each channel. The user must also set switches on the side of the Module that enable precision current sense resistors required for 20mA operation but are not used for 5Vdc operation.

When configured for 5Vdc operation, the MicroBrick Combo Module analog inputs will accurately read signals up to 5.5Vdc (10% over-range). With standard calibration from the factory, inputs ranging from 0 to 5.5 volts will result in readings of 0 to 55000. When configured for 20mA operation, the Module will accurately read signals up to approximately 40mA (100% over-range). With factory calibration, a span of 0 to 40mA will result in corresponding readings of 0 to 40000 (20mA = 20,000). When an analog input is configured for 20mA operation, a precision 124Ω current sensing resistor is used to measure current flow. At 20mA, this resistor will reduce the available loop voltage by approximately 2.5 volts.

Whenever an analog input is configured for voltage or current mode, a corresponding DIP switch next to the Analog Input terminal block must be set. The switches are numbered 1 through 8 corresponding to input channel numbering. For each channel, set the switch UP (or ON) for current operation (20mA), DOWN for voltage operation (5Vdc or +/- 300mV)

Isolation and Input Protection

To help avoid ground loop effects, the MicroBrick Analog I/O module Analog Inputs are optically isolated from communications and Analog Outputs but with a shared common. The inputs are also overload, surge, and reverse polarity protected by a combination of self-resetting polymer fuses and “Transorb” transient limiters. Input levels greater than 6Vdc or 50mA, or negative signal levels, will cause the transient protection circuitry to start limiting the input signal. Greater overloads will cause the polymer fuses to begin to increase in resistance protecting the internal input circuitry. During a full overload condition, the inputs will conduct some current, but that current is held at a safe level. When the fault is cleared, the input is restored back to normal operation.

I/O Processor Functions

MicroBrick Analog I/O module Analog Inputs are supported by an intelligent I/O microprocessor. The analog inputs are sometimes connected to the analog outputs of flow, level and wattage meters. In addition to indicating instantaneous flow or usage rates by the real-time analog reading, the microprocessor in the Analog I/O MicroBrick will totalize the readings, accumulating samples of the analog inputs at periodic intervals. This provides a totalized flow or wattage usage over time. The sampling interval (or "gate time") is user configurable.

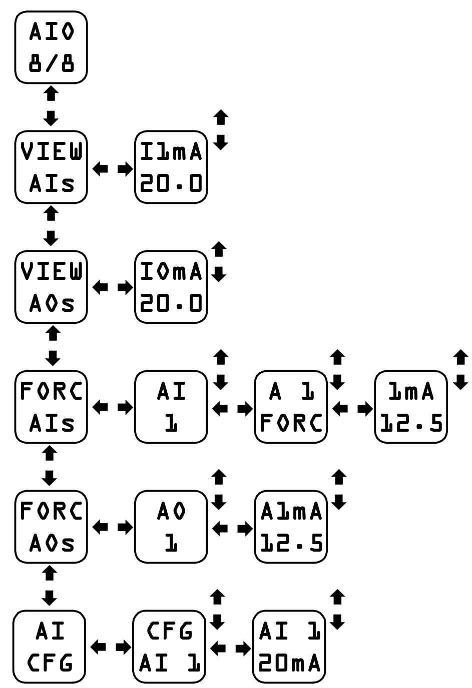
Analog Input Calibration

The Analog Input calibration is software controlled. Calibration tables for the analog inputs are stored in nonvolatile EEROM memory and calibration is performed by software techniques without opening the I/O module enclosure. If you want to do your own calibration, contact ICL technical support for the recommended field calibration procedure.

Operator Interface

In addition to module configuration functions, the operator interface of the MicroBrick Analog I/O module may be used to display analog levels, force the readings of the individual Analog Inputs. This feature is especially useful at system startup, allowing I/O devices and field wiring to be tested without a full working communications network and host software in place, or to assist in testing the system software by simulating sensor readings. It is also invaluable for system maintenance, eliminating the need for dragging a laptop computer, analog simulator and meter around to troubleshoot the system.

The general operation of the MicroBrick operator interface is described in a previous section. The diagram here shows the map of the specific menu tree for the MicroBrick Analog I/O Module. The common communication configuration interface is shown earlier in this document.



MicroBrick Analog I/O Module Operator Interface Menu Tree

Any Analog I/O can be forced. When scrolling through the channel selection portion of any of the forcing menus, a channel that is currently forced displays an "F" to the left of the channel number.

In addition to viewing Analog Inputs or forcing I/O, the operator interface may also be used to configure the input mode of individual analog inputs to: “RAW” (non calibrated A/D reading) Voltage or Current.

Analog I/O Module Analog Output Section

The Analog I/O Analog Output section operates control devices such as variable speed drives and positioners as well as display and operator interface devices such as panel meters and chart recorders.

Signal Types and Levels

The Analog I/O Analog Output section has 8 4 to 20mA analog outputs. Each output is individually isolated and powered by the loop that it controls. With factory calibration, the Host system controls each output by setting the output channel’s register to a value between 4000 (4mA) and 20,000 (20mA). The analog outputs reduce the available loop voltage (compliance) by about 5V.

Isolation and Output Protection

To help avoid ground loop effects, the MicroBrick Analog Outputs are optically isolated, between the field connections and the internal logic, and from analog output channel to analog output channel. The outputs are also transient and surge protected by a combination of self-resetting polymer fuses and “Transorb” transient limiters. Loop voltages or transients that might exceed the modules ratings will cause the transient protection circuitry to start limiting the output signal. Greater overloads will cause the polymer fuses to increase in resistance protecting the internal output circuitry. During a full overload condition, the outputs will conduct some current, but that current is held at a safe level. When the fault is cleared, the output is restored back to normal operation automatically.

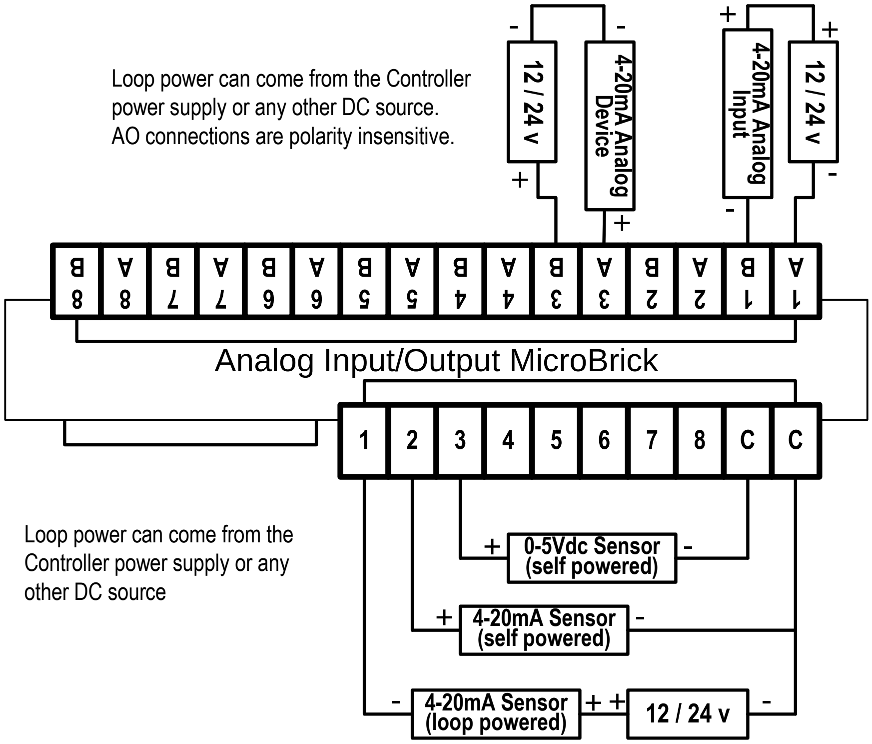
Calibration

The calibration of the Analog Output section is software controlled. Calibration tables for the analog outputs are stored in nonvolatile EEROM memory and calibration is performed by software techniques without opening the I/O module enclosure. If you want to do your own calibration, contact ICL technical support for the recommended field calibration procedures and software.

Field Wiring

The Analog Inputs require an active signal source. 20mA current loop devices must either have their own internal loop power supplies, or an external supply must be used. The Analog Inputs are isolated, so that power source for the loop devices can be the MicroBricks power supply without causing a ground loop. Voltage type sensors are typically self-powered. The user should ensure that self-powered devices are isolated to avoid ground loops through individual sensors.

The Analog output connections are on a 16-position removable terminal block. There are 8 pairs of output connections, one pair per output channel. The outputs are not polarity sensitive. Being isolated and polarity insensitive means that the outputs may be inserted into any point in the control loop.



Loop power can come from the Controller power supply or any other DC source

Analog I/O Microbrick - Field Wiring Example

Modbus Register Map

STATUS (Input Bits - Modbus Type 10xxx)
none

COILS (Output Bits - Modbus Type 00xxx)
none

INPUT REGISTERS (Read Only 16-bit - Modbus Type 30xxx)

Star	*End*	*Description*
001	008	Analog Inputs 1 thru 8
248	249	Reserved - ICL Test ONLY
250	-	Input Voltage (power) x 10 (143 = 14.3 volts)

HOLDING REGISTERS (Read/Write 16-bit - Modbus Type 40xxx)

Start	*End*	*Description*
001	008	Analog Outputs - 1 through 8 (4000 to 20000 = 4mA to 20mA)
017	032	Analog Input Totalizers - Inputs 1 through 8 (32-bit, 1st/Odd register is MSB)
132	-	Analog Totalizer Measurement Sampling Interval
133	140	Analog Input Mode - Inputs 1 through 8 (0 = “Raw”/uncalibrated, 1 = mA, 2 = 5V)
161	166	Analog Outputs 1 through 6 - calibration numerators (denominator = 65,535)
186	191	Analog Outputs 1 through 6 - calibration offsets

Specifications - Analog I/O MicroBrick

ANALOG INPUTS

Number of Analog Inputs	8
Input Type	Unipolar multiplexed inputs with shared Common
Input Levels, nominal	0 to 5Vdc, +-300mV, 0/4 to 20mA
Input Overload Tolerance	Input voltage limiting starts at 6Vdc Input current limited to 50mA
Overload/Transient Protection	Transorbs and self resetting polymer fuses
Conversion Rate	Approximately 2 samples per second at each point
Noise Rejection	-120dB @ 50/60Hz
Power, Typical/Maximum	0.75 Watts / 1.5 Watts

ANALOG OUTPUTS

Number of Analog Outputs	8
Output Type	Loop Powered Current Loop
Output Levels, nominal	4 to 20mA
Resolution	12-bits (1 part in 4096)
Overload/Transient Protection	Transorbs and self resetting polymer fuses
Conversion Rate	Approx. 100 conversions per second, each output

Combo I/O Modules

MicroBrick "Combo" I/O modules provide a mix of discrete inputs, discrete outputs and analog inputs. They are an economical alternative to using separate modules when smaller quantities of I/O are needed. Because of their mix of I/O, combo MicroBricks are frequently used as low-cost Modbus Remote Terminal Units (RTUs).

Combo MicroBricks have 6 16-bit Analog Inputs, 10 Discrete Inputs (12/24V or 120V models), and 4 discrete (FET) outputs. The functionality of each section is identical to their equivalent MicroBrick module. In addition, the Discrete Input section has programmable filtering on 2 of the 10 inputs. When the filters are switched OFF, these two discrete inputs support high-speed counting rates of up to 5Khz (5,000 pulses per second).

Combo Module Discrete Input Section

MicroBrick Combo module Discrete Inputs are used to monitor the state of switches, relays contacts, motor starter auxiliary contacts and any other on/off type sensor signal. The inputs are optically isolated to avoid ground loop effects and damage from transients and power surges. There are a total of 10 discrete inputs grouped as 8 and 2 inputs with separate commons.

Signal Types and Levels

MicroBrick Combo module Discrete Inputs have a unique input design that accepts both AC and DC signals. The inputs are not sensitive to signal polarity, supporting DC sensors with either "sinking" or "sourcing" output configurations as well as switch contacts with AC or DC signals.

Currently, there are two models of MicroBrick Combo Modules; one with discrete inputs designed for low-voltage (12/24V) operation, the other for 120V operation. In the low voltage model, an input level of 9 volts (AC/DC) or greater is considered to be an "ON". Input levels of 6 volts (AC/DC) or less are considered OFF. The inputs can accept signal levels of up to 50 volts (AC/DC) and tolerate overloads of nearly twice that. The 120V model responds to inputs of 75V or greater as an "ON", 50V or less as an "OFF" and will tolerate a 100% overload.

LED Input Status Indicators

Each discrete input has an LED indicator to show the current ON or OFF state of the input. Typically, the state of the LED indicator mimics the state of the input, unless the input is "forced" on or off. When the state of an input is forced, the LED shows the forced state that is communicated back to a Host Controller, regardless of the actual input state.

I/O Processor Functions

The modules discrete inputs are supported by a microprocessor that performs input noise filtering, pulse totalization and pulse rate computation, helping to off-load the Host Controller and improve system performance.

Input Filtering

The discrete inputs have filtering that rejects spurious noise and limits the maximum counting rate to 40Hz with DC pulses, up to 10Hz with AC signals.

Pulse Totalization

MicroBrick Combo module Discrete Inputs count ON transitions for every input point, providing reliable pulse totalization that is not sensitive to communications rates and I/O scan time. This feature can be used for very accurate flow and wattage totalization. The 9th and 10th inputs have software controlled filtering, allowing the input filters to be individually disabled for high-speed counting up to 5KHz. When the filters are enabled, their response is identical to the other discrete inputs. These two inputs have their own separate common.

The pulse totalizers are 32-bit counters, meaning that the totalizers count up to 4,294,836,225 ON transitions before they "roll over" to zero again. The counters can be reset or preset to any value at any time.

Runtime Totalization

MicroBrick Combo Module discrete inputs monitor the runtime (ON time) for every input, providing reliable "down-to-the-second" information on how long an input has been "ON". This information is useful for equipment maintenance and wear leveling. An example is the use of runtime to determine which pump should be used based on which pump has seen the least usage.

The runtime totalizers are 32-bit registers, meaning that the totalizers count seconds, up to 4,294,836,225 before they "roll over" to zero again. The runtime totalizers can be reset to zero or preset to a value at any time by simply writing to the appropriate holding register.

Pulse Rate Calculation

The MicroBrick Combo Module discrete inputs calculate the input pulse rate for every input. With the appropriate sensors, this can be used to show "real-time" flow, usage rates, and speeds. A software settable "gate" time determines the measurement interval over which the input pulses are counted. Longer gate time intervals provide greater measurement resolution, but the measured value is updated less frequently. The gate time is the measurement update interval. Once the gate time has expired, each totalized count is stored in a rate register for that discrete input, and a new set of rate totalization measurements are started.

Combo Module Discrete Output Section

MicroBrick Combo Module discrete outputs are used to control relays, motor starters, lights, annunciators and any other on/off type control device. The Combo modules provide 4 solid state FET (protected transistor) outputs. FET transistors are extremely efficient and consume very little power, ideal for solar and battery backed systems. If a "dry" relay contact is required, a FET output can drive an interposing relay.

The FET outputs are isolated as well as overload, surge, and reverse polarity protected by self-resetting polymer fuses and "Transorb" transient limiters. Because of the built-in transient protection, a suppression diode is not typically required across relay coils or other inductive loads.

The FET outputs are designed to operate in 12 and 24 volt control systems, with control voltages of up to 28 volts DC. An external power source is NOT required to power the MicroBrick FET output circuitry, but IS required by the load devices. FET outputs ARE sensitive to signal polarity, driving DC control devices with a open drain output that switches to a common “ground”. When turned ON, the outputs have a very low (< 2Ω) resistance to the common. When turned OFF, the outputs exhibit very high resistance and low leakage that will not provide a false ON to sensitive controller inputs like other solid state outputs have in the past. If an output drives a low resistance or shorted load, it will be protected automatically by switching to a low current, high resistance state. The output will continue to sink some current in this condition until the overload is removed. Once the fault condition is cleared, the output will automatically switch back to its normal low resistance, driving the full current required by the load.

LED Output Status Indicators

Each discrete output has an LED indicator to show the current ON or OFF state of the output. Typically, the state of the LED indicator mimics the state of the output commanded by a Host, unless the output is “forced” on or off. When the state of an output is forced, the LED shows the forced state that is actually driving the field device, not what the Host is calling for.

I/O Processor Functions

MicroBrick Combo modules are sometimes used to flash alarm indicators remotely, but without help from the on-board microprocessor, variations in communications and I/O scan time can make the flashing look erratic. Each of the MicroBrick Combo Module discrete outputs has a precise flashing capability that is independent of communications I/O speed or scan time. Two control bits are used per output; one to turn the output ON or OFF, the second to command the output to flash whenever it is turned ON by the first bit. A separate Modbus holding register sets the flashing rate.

Combo Module Analog Input Section

MicroBrick Combo module Analog Inputs accept signals from sensors that monitor levels, flows, temperatures, pressures, etc. Measurements are made with a high-accuracy 16-bit Analog-to-Digital (A/D) converter. The Combo modules have a total of 6 analog inputs.

Signal Types and Levels

MicroBrick Combo Module analog inputs may be individually configured to accept standard 5V or 20mA process control signals. For each analog channel, the user configures the I/O module for the correct input mode (voltage or current). The configuration information is nonvolatile and need only be set once unless the system is changed. The Module uses the configuration information to determine which calibration tables to use for processing analog input conversion and calibration data for each channel. The user must also set switches on the side of the Module that enable precision current sense resistors required for 20mA operation but are not used for 5Vdc operation.

When configured for 5Vdc operation, the MicroBrick Combo Module analog inputs will accurately read signals up to 5.5Vdc (10% over-range). With standard calibration from the factory, inputs ranging from 0 to 5.5 volts will result in readings of 0 to 55000. When configured for 20mA operation, the Module will accurately read signals up to approximately 40mA (100% over-range). With factory calibration, a span of 0 to 40mA will result in corresponding readings of 0 to 40000 (20mA = 20,000). When an analog input is configured for 20mA operation, a precision 124Ω current sensing resistor is used to measure current flow. At 20mA, this resistor will reduce the available loop voltage by approximately 2.5 volts.

Whenever an analog input is configured for voltage or current mode, a corresponding DIP switch next to the Analog Input terminal block must be set. The switches are numbered 1 through 6 corresponding to input channel numbering. For each channel, set the switch UP for current operation (20mA), DOWN for voltage operation (5Vdc)

Isolation and Input Protection

To help avoid ground loop effects, the MicroBrick Combo module Analog Inputs are optically isolated with a shared common. The inputs are also overload, surge, and reverse polarity protected by a combination of self-resetting polymer fuses and "Transorb" transient limiters. Input levels greater than 6Vdc or 50mA, or negative signal levels, will cause the transient protection circuitry to start limiting the input signal. Greater overloads will cause the polymer fuses to begin to increase in resistance protecting the internal input circuitry. During a full overload condition, the inputs will conduct some current, but that current is held at a safe level. When the fault is cleared, the input is restored back to normal operation.

I/O Processor Functions

MicroBrick Combo module Analog Inputs are supported by an intelligent I/O microprocessor. The analog inputs are sometimes connected to the analog outputs of flow and wattage meters. In addition to indicating instantaneous flow or usage rates by the real-time analog reading, the microprocessor in the Combo MicroBrick will totalize the readings, accumulating samples of the analog inputs at periodic intervals. This provides a totalized flow or wattage usage over time. The sampling interval (or "gate time") is user configurable.

Analog Input Calibration

The Analog Input calibration is software controlled. Calibration tables for the analog inputs are stored in nonvolatile EEROM memory and calibration is performed by software techniques without opening the I/O module enclosure.

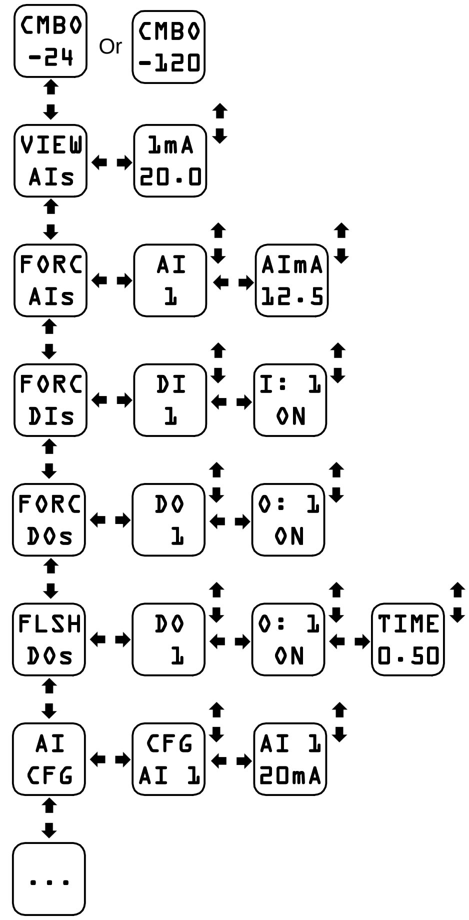
If you want to do your own calibration, contact ICL technical support for the recommended field calibration procedure.

Operator Interface

In addition to module configuration functions, the operator interface of the MicroBrick Combo module may be used to display analog levels, force the readings of the individual Analog Inputs, as well as individually force the state of Discrete Input and Outputs. This feature is especially useful at system startup, allowing I/O devices and field wiring to be tested without a full working communications network and Host software in place, or to assist in testing the system software by simulating sensor readings. It is also invaluable for system maintenance, eliminating the need for dragging a laptop computer, analog simulator and meter around to troubleshoot the system.

The general operation of the MicroBrick operator interface is described in a previous section. The diagram on the next page shows the map of the specific menu tree for the MicroBrick Combo I/O Module.

Any Discrete I/O or Analog Input can be forced. When scrolling through the channel selection portion of any of the forcing menus, a channel that is currently forced displays an "F" to the left of the channel number.



MicroBrick Combo I/O Module Operator Interface Menu Tree

In addition to viewing Analog Inputs or forcing I/O, the operator interface may also be used to configure the input mode of individual analog inputs to: "RAW" (non calibrated A/D reading, Voltage or Current.

Combo Module Field Wiring

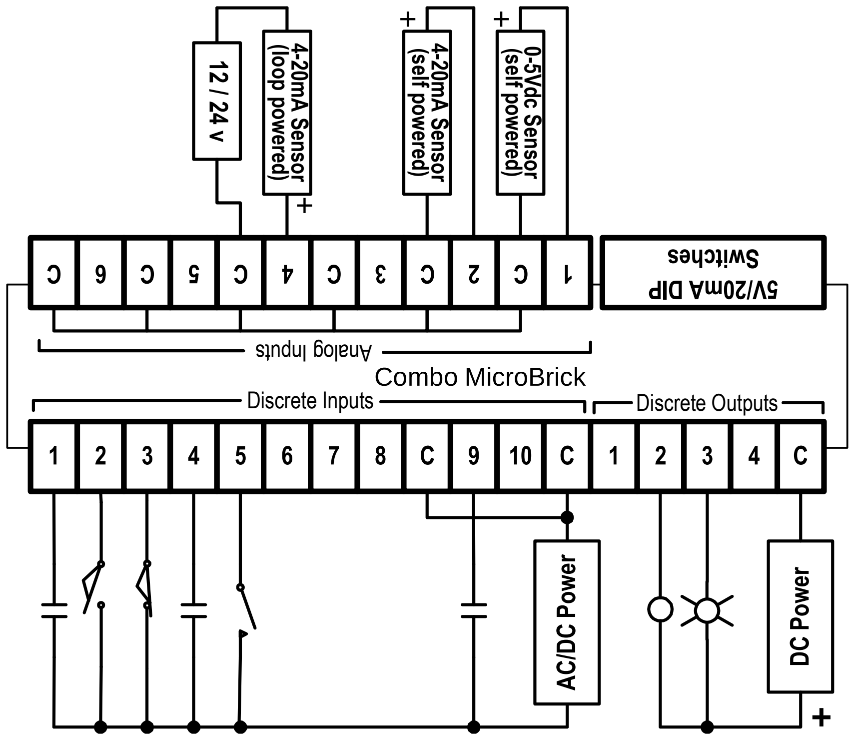
Discrete Input and Output field wiring terminates at a 17-position removable terminal block. The Inputs are divided into groups of 8 and 2 inputs with isolated commons. The Discrete Outputs have their own isolated common terminal. The Analog Inputs come into a 12 position terminal block; 6 sensor input connections and 6 commons, one per input channel.

The Discrete Inputs require an active voltage to be switched between their common and the input signal connections. The inputs are isolated, so the power source for the inputs can be the MicroBricks power supply without causing a ground loop. The Discrete Inputs are not sensitive to polarity. The input current at 12Vdc is approximately 1mA, sufficient for contact "wetting", but low enough for use in solar and battery-backed applications.

The Discrete Outputs are "open-drain" FET transistors that require a positive supply voltage on one side of the loads, while the output switches the other side of the load to the power return. The power return must be connected to the negative side of the power source.

The Analog Inputs require an active signal source. 20mA current loop devices must either have their own internal loop power supplies, or an external supply must be used. The Analog Inputs are isolated, so that power source for the loop devices can be the MicroBricks power supply without causing a ground loop. Voltage type sensors are typically self-powered. The user should ensure that self-powered devices are isolated to avoid ground loops through individual sensors.

Loop power can come from the Controller power supply or any other DC source



Register Map - Combo I/O MicroBricks

STATUS (Input Bits - Modbus Type 10xxx)

Start	*End*	*Description*
001	010	Discrete Inputs 1 through 10 (w/forcing)
033	042	Raw Discrete inputs 1 through 10 (no forcing)

COILS (Output Bits - Modbus Type 00xxx)

Star	*En*	*Description*
001	004	Discrete Outputs 1 through 4
033	036	Flash Enables 1 through 4

INPUT REGISTERS (Read Only 16-bit - Modbus Type 30xxx)

Start	*End*	*Description*
001	006	Analog Inputs 1 through 6
007	018	Pulse Rate - Discrete Inputs 1 through 10

HOLDING REGISTERS (Read/Write 16-bit - Modbus Type 40xxx)

Start	*End*	*Description*
001	020	Pulse Totalizers - Inputs 1 through 10 (32-bit, 1st/Odd register is MSB)
021	040	Runtime Totalizers - Inputs 1 through 10 (32-bit, 1st/Odd register is MSB)
041	052	Analog Input Totalizers - Inputs 1 through 6 (32-bit, 1st/Odd register is MSB)
129	-	Rate Measurement “Gate” (sampling) Time
130	-	Discrete Inputs 9 and 10 - Filter Select (0001h = DI 9 - fast, 0002h = DI10 - fast)
131	-	Discrete Outputs Flash Rate ON/OFF time (half duty cycle) in 10mS. increments
132	-	Analog Totalizer Measurement Sampling Interval
133	138	Analog Input Mode - Inputs 1 through 6 (0 = “Raw”/uncalibrated, 1 = mA, 2 = 5V)
150	-	Analog Inputs 1 through 6 Voltage Mode calibration numerator (denominator = 65,535)
151	156	Analog Inputs 1 through 6 Current Mode calibration numerator (denominator = 65,535)

Specifications - Combo I/O MicroBricks

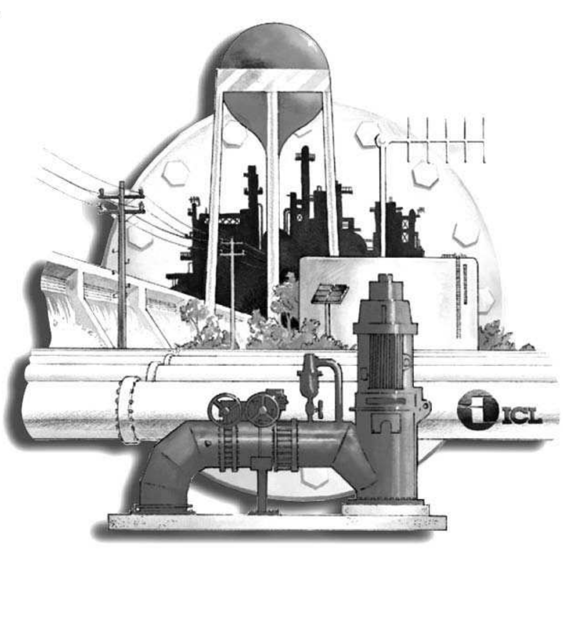
MICROBRICK DISCRETE INPUTS	(12/24V #22-0051)	(120V #22-0052)
Number of Discrete Inputs	10	10
Input Type	Bipolar Optocoupler	Bipolar Optocoupler
Input Voltage, nominal	12/24 Vdc/ac	120 Vdc/ac
Input Voltage Range	0 to 60 Vdc/ac	0 to 125 Vdc/ac
Input Overvoltage	Tolerance 85Vdc/Vac	190Vdc/Vac
Input Resistance, typical	10,000 ohms	190Vdc/Vac
Input Noise Filtering, AC/DC	20Hz / 100Hz	20Hz / 100Hz
Counting Frequency, AC/DC	10Hz / 50Hz	10Hz / 50Hz

COMBO MICROBRICK FET DISCRETE OUTPUTS (both models)

Number of Discrete Outputs	4
Output Type	FET Power Transistor
Output Configuration	Sinking to Common (open drain)
Output Voltage, nominal	12/24Vdc
Output Voltage Range	0 to 28Vdc
Output Switch Rating	0.5A @ 20ºC, derate linearly to 0.25A @ 80ºC 3.0A peak (0.5 second surge)
Overvoltage & Transient Protection	Transorb
Overload Protection	Self Resetting Polymer Fuse
Flash ON/OFF times & Resolution	0 to 655.35 seconds in 10mS increments

COMBO MICROBRICK ANALOG INPUTS (both models)

Number of Analog Inputs	6
Input Type	Unipolar multiplexed inputs with shared Common
Input Levels, nominal	0 to 5Vdc, 0/4 to 20mA
Input Overload Tolerance	Input voltage limiting starts at 6Vdc Input current limited to 50mA
Overload/Transient Protection	Transorbs and self resetting polymer fuses
Conversion Rate	Approximately 2 samples per second at each point
Noise Rejection -	120dB @ 50/60Hz



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