mBC082
Bus Converter

Document No. 10910, Revision -

February 2007

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Revision Notes

First Release – February 15, 2007

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1. Overview

The mBC082 Bus Converter is an industrial device mounted in a low cost plastic enclosure. The device is used to connect up to 32 1-Wire® bus sensors to a Modbus 485 RTU compatible PLC or computer system.

Automatic bus tuning is employed to allow a wide variation in network topology and cabling systems. The sensor bus can extend up to 300 meters (1000 feet). The sensor field bus includes a failsafe current limited sensor power supply.

Communication to the host system is via an RS485 multi-drop network using Modbus RTU protocol. The device looks like a simple PLC to the host system. Sensor values and status are continuously available to the host system. Sensor network polling and maintenance are handled automatically in the background. Sensor bus fault detection and recovery are also automatic.

A simple flashing lamp diagnostic is included to aid field service. This diagnostic identifies open and shorted sensor bus cables. Up to 6 sensor bus and hardware faults are annunciated.

The 1-Wire® sensor bus uses a unique serial number provided with each sensor for polling. The converter will automatically capture the serial numbers of sensors present on the bus and store them in ascending order. Included in the sensors serial number is also a device code. The device code tells the converter what type of sensor is present and how to process the sensors data. The sensor data is presented to the host system a single 16 bit word in 2's complement form.

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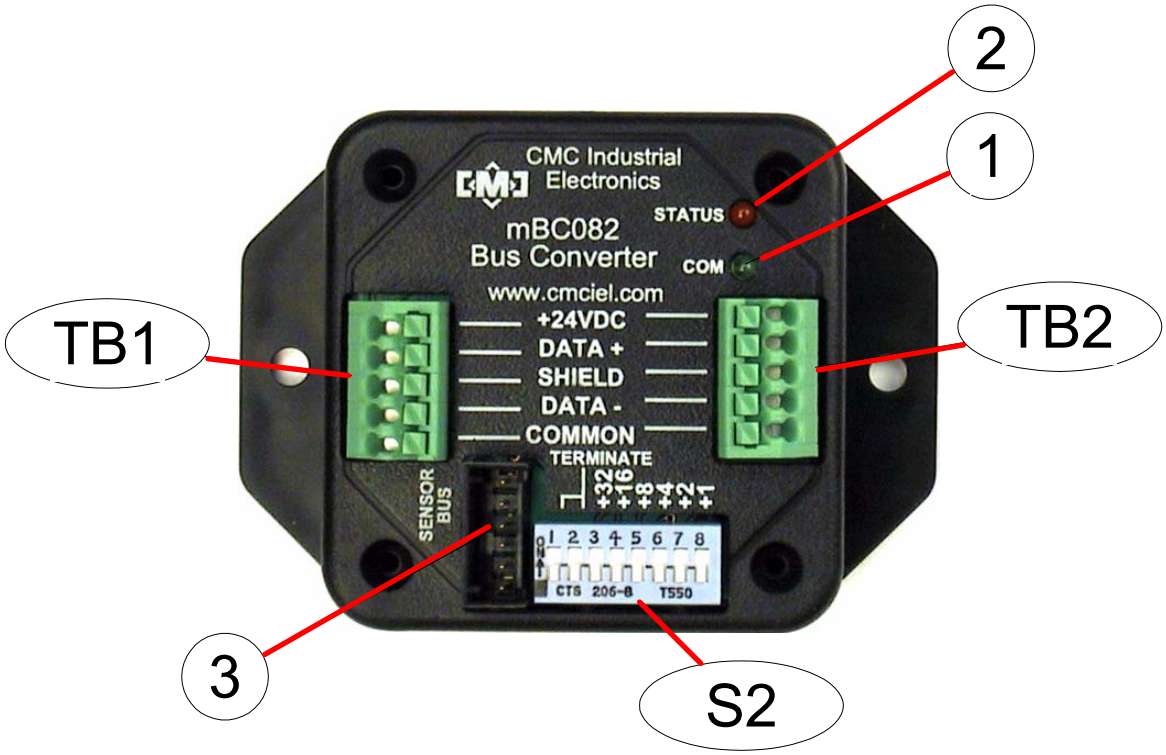
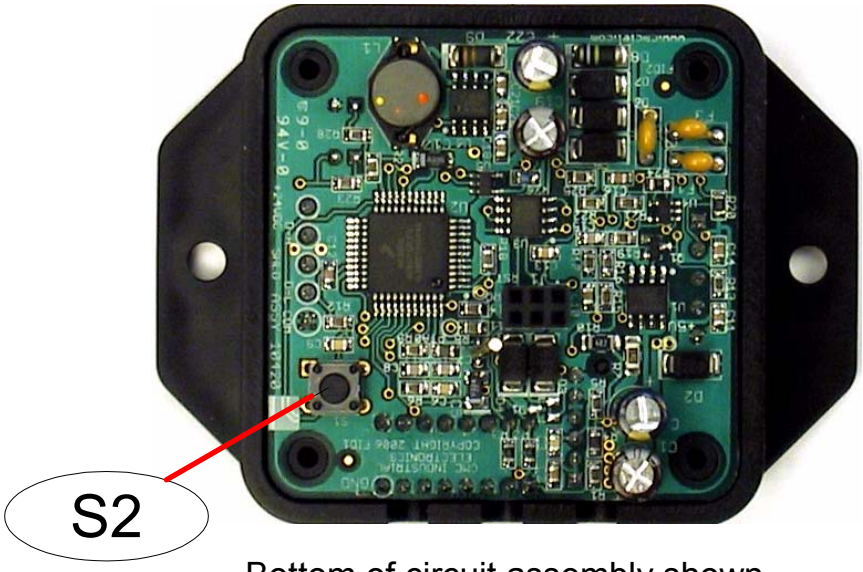
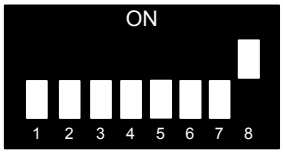
2. Description of Connectors, Operators and Indicators





Bottom of circuit assembly shown
with cover removed

Figure 1 - Connectors, Operators and Indicators

ID	Label	Description
TB1	RS485 Network and Supervisory Power Terminals	Communications and power connections. See drawing 10386 and 10416 in the Appendices for connection details.
TB2	RS485 Network and Supervisory Power Terminals	Communications and power connections. See drawing 10386 and 10416 in the Appendices for connection details.
1	Communications lamp (green)	Flashes for each valid packet received and replied to. May light continuously, depending on the poll rate.
2	Status lamp (red)	Normal operation, flashing 1 second on / 1 second off; Diagnostics, a series of short flashes followed by 1 second off; Flashes — Description 1 — 5VDC supply wire shorted to common wire 2 — No sensors detected on the bus 3 — Data wire shorted to common wire 4 — Data wire shorted to 5VDC wire 5 — Excessive bus communications errors during an acquire serial number operation 6 — Power on test hardware fault or Flash memory write fault
3	Sensor bus cable connector	Attach the supplied 6 conductor sensor cable to this connector
S1	Setup	Press and hold during power-up to reload factory default values.
S2	Address / Termination Switch	 To set an address turn on the switches that add up to the address required. Switch is shown set for address 1. For address 5, switches marked +1 and +4 would be turned on. The switch marked T is used to terminate the RS485 bus at the last converter on the network. Only the last device (only one communications cable connected) can have the T switches on.

3. External Wiring

The sensor bus consists of CAT5 cable interconnected sing field wiring interconnects. The complete wiring system is specified. The sensors connect to the 1-Wire® bus using RJ-11 connectors supplied with the sensors.

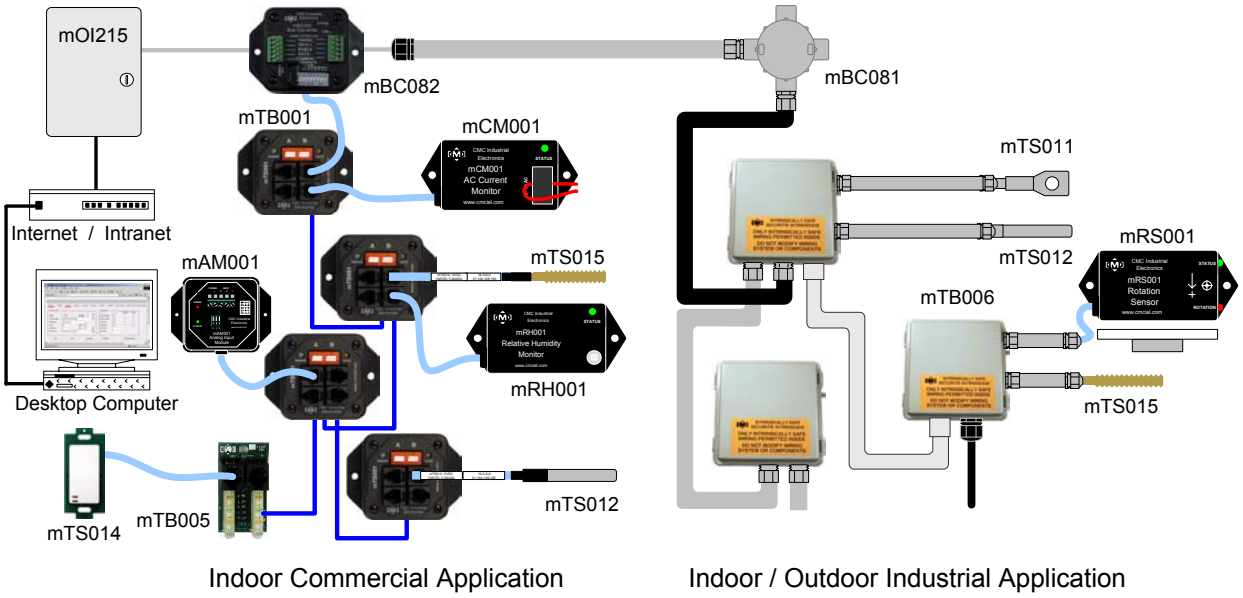


Figure 1 – Typical Field Wiring Detail

3.1 Wiring the Sensor Bus Network

The mBC082 supports up to 32 1-Wire® Bus devices. The 1-Wire® Bus uses a single conductor for data communications. Included with the bus is 5VDC to power the sensors.

Only CAT5 cable is permitted for the sensor bus. This cable is available in standard, plenum, direct burial and Teck90/ACIC jacket configurations. The only difference between cables is the jacket. Where the cable needs mechanical protection, we recommend direct burial cable or cables with a Teck90/ACIC jacket. Direct burial cable has a semi-rigid, tough outer jacket with good protection for most areas. Direct burial cable should be purchased with the available integral aluminum shield. Superior Essex Type BBDN, Part No. 04-001-34 is an example of direct burial cable.

The sensor bus allows for taps and tees in the network topology. The converter has an automatic adaptive sensor bus system that adjusts for changes in the cabling topology. This system is dynamic and requires no adjustments. Sensors can be installed anywhere on the cable. Branch lines of any length can be used, but the entire CAT5 network, including branches, must not exceed 305m or 1000'.

The cabling system should also be shielded from severe electrical noise. Cable installation should prevent mechanical damage to both the main bus cable and the individual sensor cables.

3.2 Wiring the mTB006 Field Wiring Interconnects

The Field Wiring Interconnect provides the transition between the CAT5 cable and the cables provided with each sensor and the mBC082 Bus Converter. Each of the field devices comes complete with 2 meters of cable and an attached RJ11 plug. The Field Wiring Interconnects have two, four or six RJ11 sockets to accept the field devices. Do not modify the cable attached to the mBC082 or the cables attached to the sensors. Connect these cables directly to the RJ11 sockets on the mTB006.

The backbone of the system is CAT5 cable, which punches down to the 110 punch-down blocks on the front of the Field Wiring Interconnect. Any form of CAT5 cable including unshielded, shielded and direct burial can be used. The mTB006 Field Wiring Interconnect includes a NEMA4X plastic enclosure and all required internal mounting hardware for installation outdoors or in industrial environments.

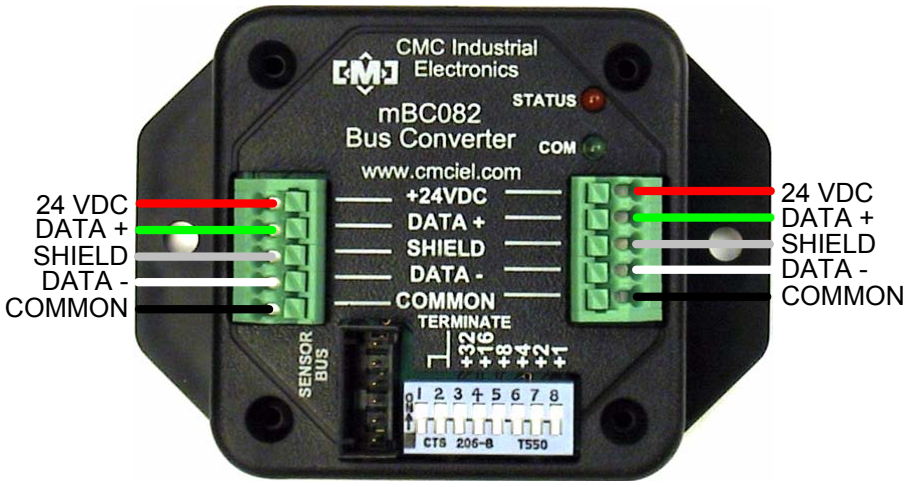
There are two or three, 110 punch-down blocks on the front of each Field Wiring Interconnect. The center block of the three block units is for the incoming cable. This is the cable that will be supplying power and data from an mBC082 or previous network branch. The one or two outgoing blocks are to continue the network. Punch the cables down using an approved 110 tool. The required cable color codes are printed next to the punch-down blocks. Use the supplied wire clamps to secure the cable if required. The shield on shielded CAT5 cable must be connected using the cable clamps or wire nuts if used. When using the mTB006 and shielded CAT5 cabling, connect the conduit ground strap to the grounding terminal in the mTB006 connected directly to the mBC082. Do not connect the grounding strap to the grounding terminal at any other mTB006.

There are 2 switches and 2 indicator lights on the mTB001 and mTB006. The Branch A switch controls the network segment attached to the Network A punch-down block and Branch B switch controls the network segment attached to the Network B punch-down block. The power lamp indicates that 5 VDC control power is present. The Data lamp indicates that data packets are present on the bus.

When first powering up the network, have all switches off. Add each network segment, observing the lamps. If a lamp go out, when a network segment is added, verify the wiring for that segment. This method can also be used to troubleshoot the network in the future.

3.3 Wiring the Power and Communications Network

The mBC082 is equipped with 2 terminal strips for the RS485 communications network. The second terminal strip allows for the continuation of the network. Either terminal strip may be used for the incoming or outgoing cable. The RS485 network does not allow taps or tees in the cabling topology. Always bring both incoming and outgoing network cables directly to the mBC082. At the end of the cabling system the unused terminal strip is left unconnected.



Modbus RS-485 network with 5VDC Power
Wire colors shown are typical

Figure 2 - Typical Data/Power Connections

The communication network backbone cable should be a two pair individually shielded cable. Low capacitance twisted pair cable is recommended. The cable should be sized to ensure voltage drop on the supervisory power conductors does not exceed the input voltage specifications. The mBC082 uses efficient switching regulator technology. The input current required by the controller will increase proportionally as the input voltage is reduced.

The mBC082 is a full load RS485 device allowing a maximum of 31 controllers from a single RS485 host transceiver. Do not connect more than 32 devices, including the host, to a network segment. The RS485 data signals are referenced to the 24VDC common terminal. The Data + line is the non-inverted RS485 data line and the Data - line is the inverted RS485 data line. The data lines of the mBC082 can be connected directly to an RS485 host or to an RS232 host using a suitable converter.

3.4 Setting the Converter's Modbus Address

To set the converter's address turn on the switches that add up to the address required. The address switch is shown set for address 1. For address 5, switches marked +1 and +4 would be turned on.

The switches marked T is used to terminate the RS485 bus at the last converter on the network. Only the last device (only one communications cable connected) can have the T switches on.

Switch	Description
8	Adds 1 to address
7	Adds 2 to address
6	Adds 4 to address
5	Adds 8 to address
4	Adds 16 to address
3	Adds 32 to address
2	On to terminate network (Adds 64 to address before V1.05)
1	On to terminate network

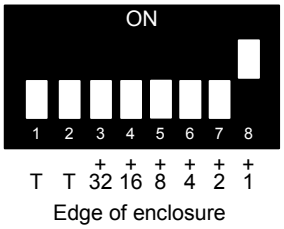


Figure 3 – Address Switch Details

The address switch is read during the power on sequence. Changes made to the address while the controller is running will not take effect until the next power on cycle or soft reset.

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4. 1-Wire® Sensor Bus Operation

The converter communicates with the field sensors over a 1-Wire® communications bus. The bus voltage levels are 5VDC and the data bus is at 5VDC (high) when idle. The method of signaling is Master-Slave. The Master initiates communication by sending a command sequence. The slave device responds by controlling the bus during pre-defined read time slots. All slave devices are wired AND devices and can only leave the bus high, or pull it low during pre-defined time slots.

Each slave device (sensor) has a unique serial number assigned by the manufacturer. Slave devices are selected by polling the bus with the slave's serial number. The serial numbers to be polled are stored in a table within the controller. Only devices specifically designed for use with the converter can be attached to the bus. A list of supported devices and sensors is included in the Appendix 1 of this manual.

Polling of the sensors is automatic and continuous. The entire network of 32 sensors is polled approximately each second. Empty entries in the serial number table are skipped. The new values obtained from the sensors are placed in the sensor value table. The status of each sensor, either on of off line, is maintained in the sensor status registers.

The health of the sensor data bus is reported in the converter's status register. Physical faults with the sensor bus are automatically reported. Status bits indicate the cause of sensor bus faults. Controller hardware and parameter tables' faults are also indicated.

The sensor bus power supply is current limited and controlled. If a short circuit is detected on the 5 VDC wire, the current is limited and then the power source is turned off. The power source will be returned in 10 seconds. If the power bus is still shorted, the cycle repeats every 10 seconds. No damage will occur to either the data or power portions of the sensor bus due to shorts or open conditions. Do not apply external voltage sources of any kind to the sensor bus.

The sensor serial number consists of eight, single byte (8-bit) numbers. The converter has a 32 entry table for the serial numbers. Sensors are polled from this table, starting from table entry 1. The converter stores the serial number table in flash memory. The serial numbers can be read from the table over the Modbus Network using a group of scratch pad registers. The serial number consists of:

Byte	Description
1	Sensor device code
2	MSB of serial number
3	Byte 5 of serial number
4	Byte 4 of serial number
5	Byte 3 of serial number
6	Byte 2 of serial number
7	LSB of serial number
8	Checksum of serial number

The converter has a command register that allows operations to be controlled over the Modbus Network. One of these commands allows the setting of sensor serial number table entries from

the values stored in the scratchpad registers. See **Section 5. Modbus 485 RTU Communications** for details.

A second command can automatically obtain the serial numbers of the sensors connected to the bus. A special sequence is initiated, which uses a high-speed algorithm to obtain the serial numbers. A third command allows the clearing of the serial number table. See **Section 5. Modbus 485 RTU Communications** for details on initiating the serial number search and clear commands.

If the serial number table is clear when the acquire serial number command is executed, the serial numbers located will be placed in the table in ascending order. If the table contains previously located serial numbers, the controller will follow this sequence to store the new serial numbers;

1) All of the serial numbers currently attached to the sensor bus will be located and stored in a temporary table;
2) The temporary table will be verified against the existing table and any serial numbers from the existing table not found in the temporary table will be deleted from the existing table;
3) Any new serial numbers from the temporary table not founding in the existing table will be placed in the existing table in ascending order starting with the first empty space;

This method of operation allows replacement sensors to be located and added to the table without disturbing the table positions of the pre-existing sensors. The serial number table may not be in true ascending order after completion of an acquire command with a previously populated sensor serial number table.

5. Modbus RS485 RTU Communications

The controller communicates with a host computer or PLC over an RS-485 network using the Modbus RTU protocol. The default settings for the communications network are 19200 Baud, no parity and 1 stop bit. The memory of the controller has been configured to simulate a PLC with 45, 16 bit registers. These registers are allocated as follows:

Register	Typ	Description
40001	R/W	Sensor number Setting this register causes the serial number for the selected sensor to be loaded immediately into registers 40002 – 9. The sensor number is also used for the write sensor serial number command. The values in registers 40002 – 9 will be written to the location specified by this register upon execution of a write serial number command. The range of sensor numbers is 1 – 32.
40002 - 9	R/W	Sensor serial number The values entered in these register are the sensor's serial number selected by register 40001. Each 16 bit register contains 1 byte (8 bits, right justified) of the serial number. The serial number is represented as follows: 40002 - The device code 40003 – The most significant byte of the serial number 40004 – Byte 5 of the serial number 40005 – Byte 4 of the serial number 40006 – Byte 3 of the serial number 40007 – Byte 2 of the serial number 40008 – The least significant byte of the serial number 40009 – The checksum of the serial number The range of each serial number byte is from 0 – 255. If all bytes are set to 0, the entry is not polled during communications.

40010	R/W	Command register The command register contains a series of bits that initiate operations within the controller. To initiate an operation, set the associated bit. The controller automatically clears the bits when the operations are initiated. A list of the bits and their functions follows: 0 Soft reset — Reset the controller, equivalent to a power on reset. 1 Write serial no from scratch — Write the serial number from registers 40002 – 9 to the table entry indicated in register 40001. 2 Acquire serial numbers — Automatically acquire the sensor serial numbers for all sensors connected to the bus. If the table was cleared before performing this operation, the serial numbers will be retrieved and stored in ascending order, with the lowest order serial number in register 40014. If the sensor serial number table was already populated, sensors that existed in the table would remain in their previous locations. Sensors that were in the table, but not detected during this operation would be deleted. Any new sensors detected would be added to the blank spaces in the table in ascending order. The new table may now not be in ascending order. This method of operation allows the controller to acquire replacement sensors without disturbing the remaining sensors table positions. 3 Clear serial no's — Clear the serial number table of all existing entries. The table will be filled with 0 and no sensors will be polled on the bus. 8 Channel select 0 — On multi-channel sensor devices, select channel 0 for all sensors. 9 Channel select 1 — On multi-channel sensor devices, select channel 1 for all sensors. 10 Channel select 2 — On multi-channel sensor devices, select channel 2 for all sensors.

		11	Channel select 3	On multi-channel sensor devices, select channel 3 for all sensors.
40011	R	Status Register This register indicates the internal status of the converter and the sensor bus. A set bit indicates a fault. The fault assigned to each bit is as follows:		
		0	Bus data shorted low	The data wire is shorted to the common wire.
		1	Bus data shorted high	The data wire is shorted to the 5VDC wire.
		2	No Sensors present	No sensors are present on the sensor bus, or the sensor bus data wire is open.
		3	Bus power overload	The 5VDC wire is shorted to the common wire.
		4	Excessive bus errors	During an acquire serial number operation, the converter detected excessive bus errors. This condition would indicate faulty sensor bus cabling, or excessive electrical interference on the sensor data bus.
		8	Sensor bus fault	A sensor bus fault is present as indicated by bits 0 – 4.
		9	Sensor table overflow	More than 32 sensors were detected during a sensor serial number acquire operation.
		10	Unsupported Sensor detected	A sensor was detected on the sensor bus that is not supported by this converter.
		11	In acquire	An acquire sensor serial numbers operation is in progress.
		13	RAM fault	The converters RAM did not pass the power on test.
		14	Parameter table fault	The parameter table checksum is invalid or a write to the parameter table Flash memory has failed.
		15	Firmware fault	The converters Flash memory firmware failed the power on CRC test.

400012 - 13	R	Sensor status Each bit of these registers represents a single sensor. If the bit is set the sensor is faulted and not available. If the bit is clear is sensor is online. Bit 0 of register 400012 represents sensor 1. Bit 31 of register 40013 represents sensor 32.
40014 - 45	R	Sensor values Each of these registers represents a sensors raw 2's complement value. The value is right justified, with the MSB representing the sign. Sensors that are offline have a forced value of +4095. Appendix 1 details the sensor value returned from each type of sensor.
40046	R	Watchdog counter, increments every second and rolls over at 32767
40047	R	Channel 0 - Software Version Channel 1 - Address switch setting

6. Restoring Factory Default Values

Pressing and holding the SETUP push button during a power-up sequence will restore the factory default values. The STATUS indicator will flash at a 10 per second rate when the parameters have been reloaded. Release the button to resume normal operation. The Factory Default Values will be in effect immediately after this operation.

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7. Specifications

Description	Characteristic
Sensor bus Voltage Current Communications	5 VDC 0.125A, electronically limited 1-Wire® Bus
DC Power Supply Voltage Current	22 to 28 VDC 80mA @ 24VDC maximum
Communication Standard Distance Input Load Termination	RS485 differential 500m (1640ft.) 12kΩ, standard 120Ω balanced line
Environment Temperature Relative Humidity	-40 to 70C (-40 to 158°F) 0 to 95% non-condensing
Dimensions Hieght Width Depth	65mm (2.5in) 90mm (3.5in) 40mm (1.5in)

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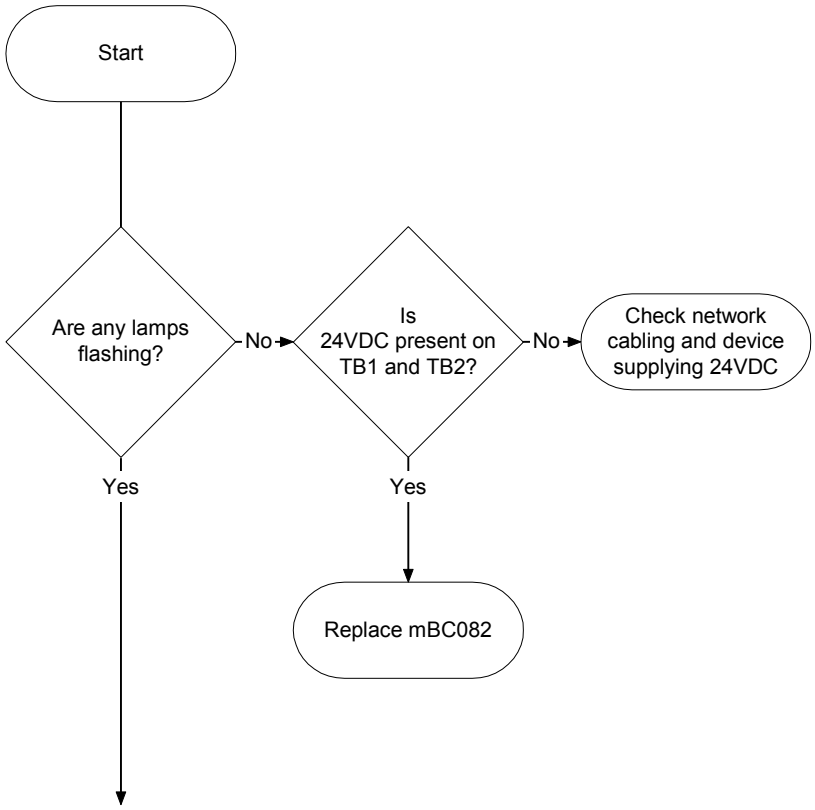
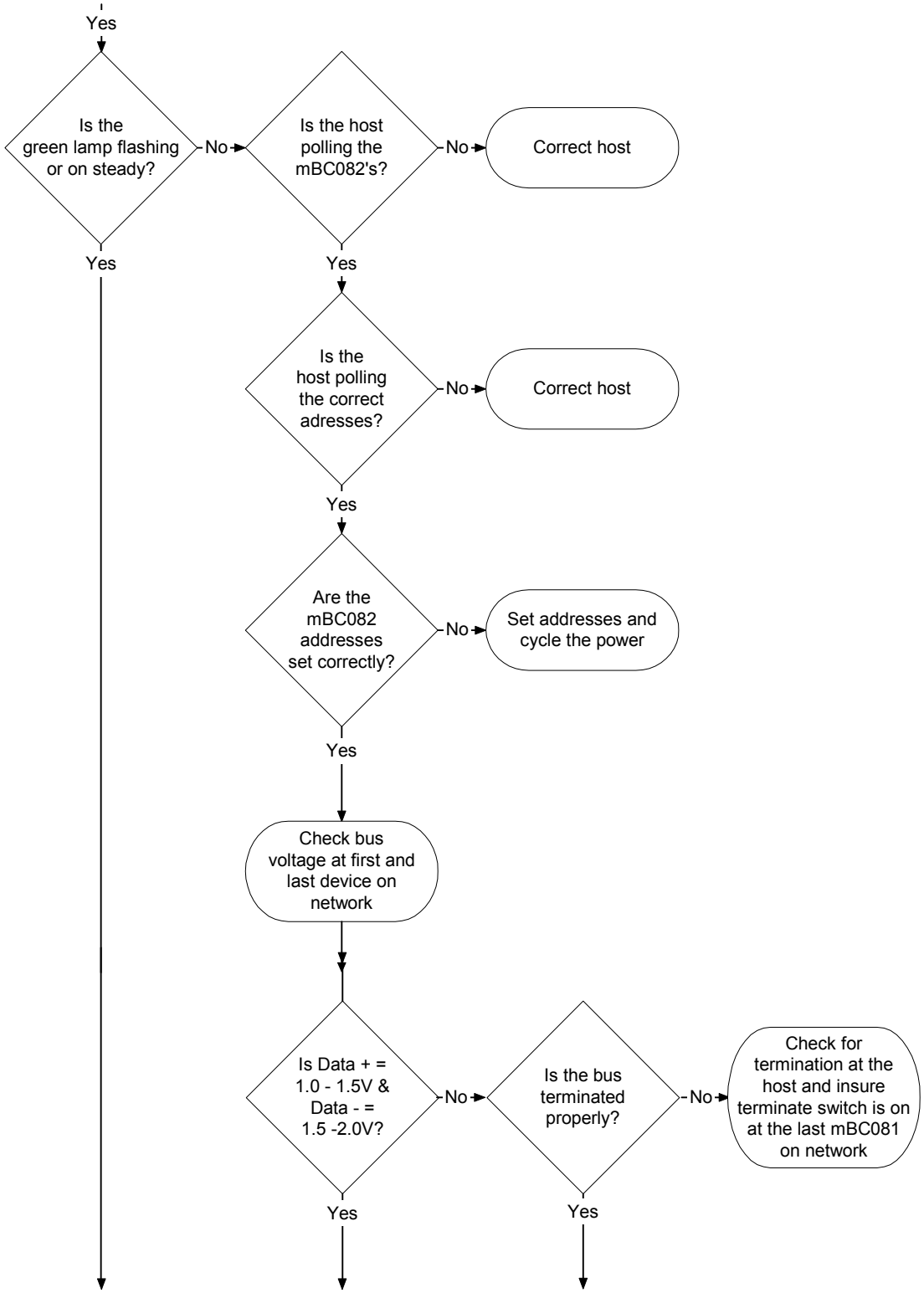
8. Troubleshooting Guide

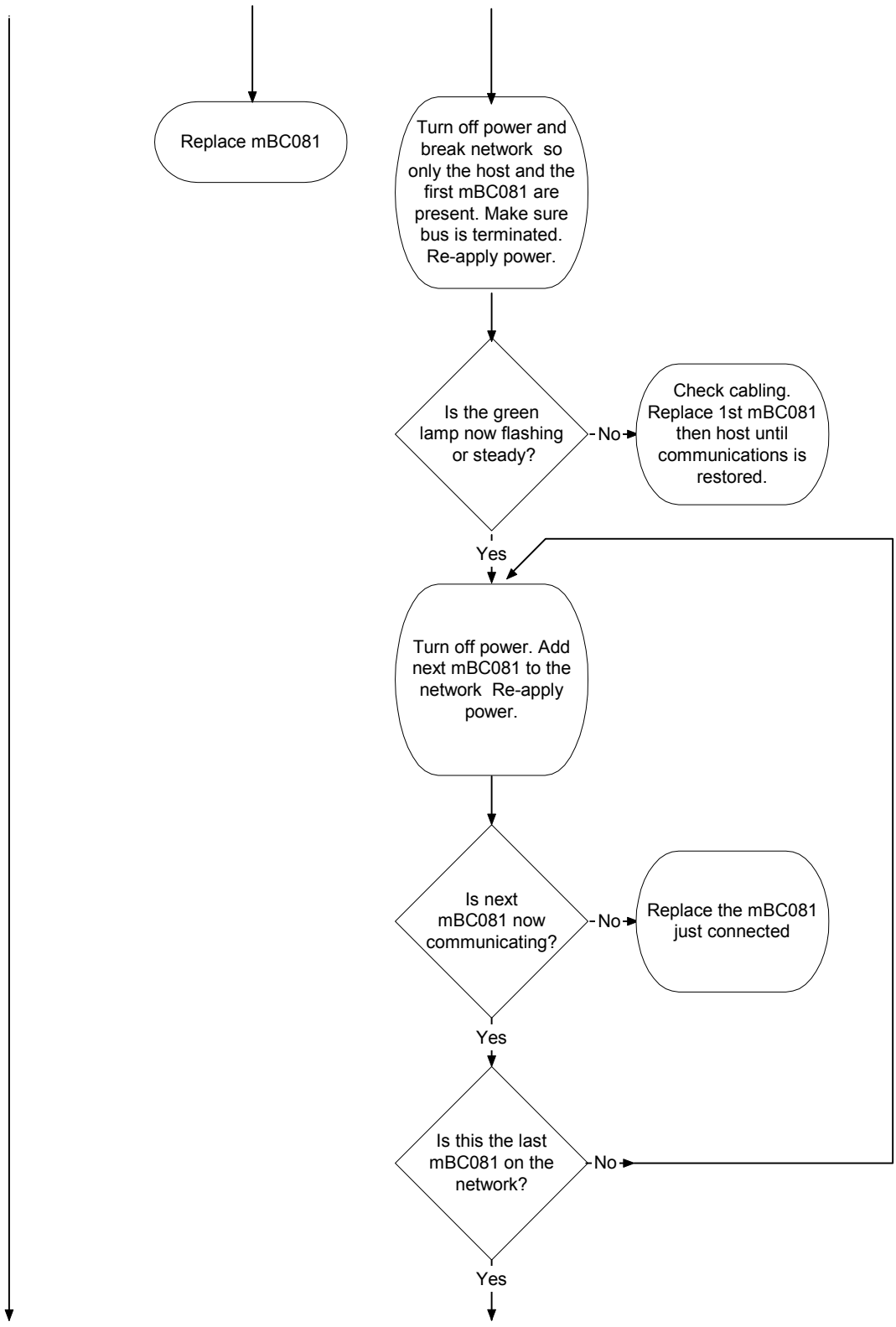
Before attempting troubleshooting, familiarize yourself with the indicator lamps and address switch settings detailed in **2. Description of Connectors, Operators and Indicators.**

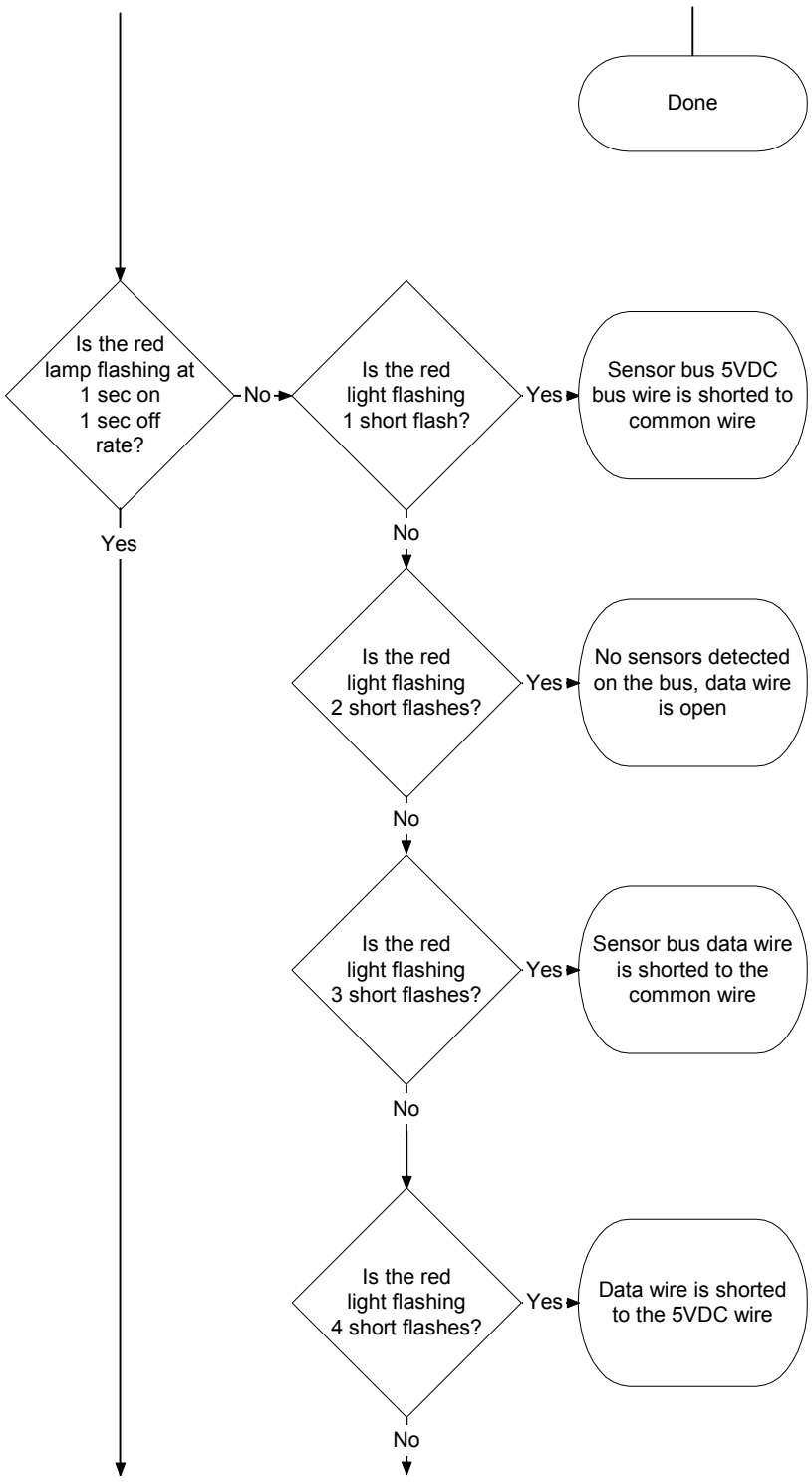
There are 2 basic systems operating within the mBC082. The first is the Modbus RTU RS485 communications network. This network connects multiple mBC082's to a single Host or Master device. It is the host that polls for data from the mBC082. Before starting this guide, insure that the host is running and polling the mBC082's.

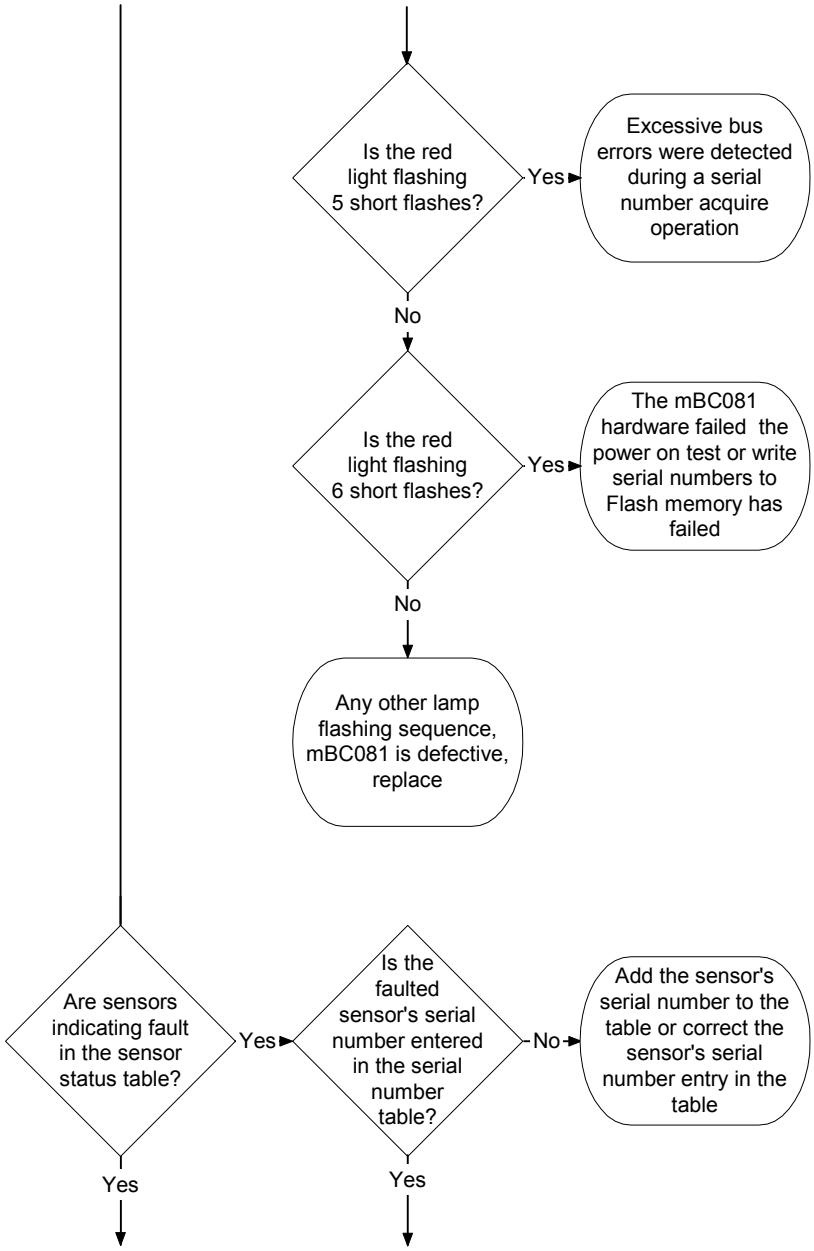
The second system is the sensor bus network. The mBC082 manages the sensor bus and continually polls for sensors in its serial number table. Before starting this guide verify that the sensor serial number table in the mBC082's are correct. The status lamp on each mBC082 provides information as to the state of the sensor bus. The Field Wiring Interconnect status lamps and switches can be used to isolate network segments during troubleshooting. To isolate a defective cable or sensor, start at the Field Wiring Interconnect closest to the mBC082 and disable outgoing network segments using the switches. Observe the lamps on the Field Wiring Interconnect as you switch in additional segments. If a segment has a shorted cable or sensor, the lamps will go out when that segment is added. Note if the power conductor is shorted, the mBC082 will turn off the 5VDC supply. Wait for at least 10 seconds to see if power is restored.

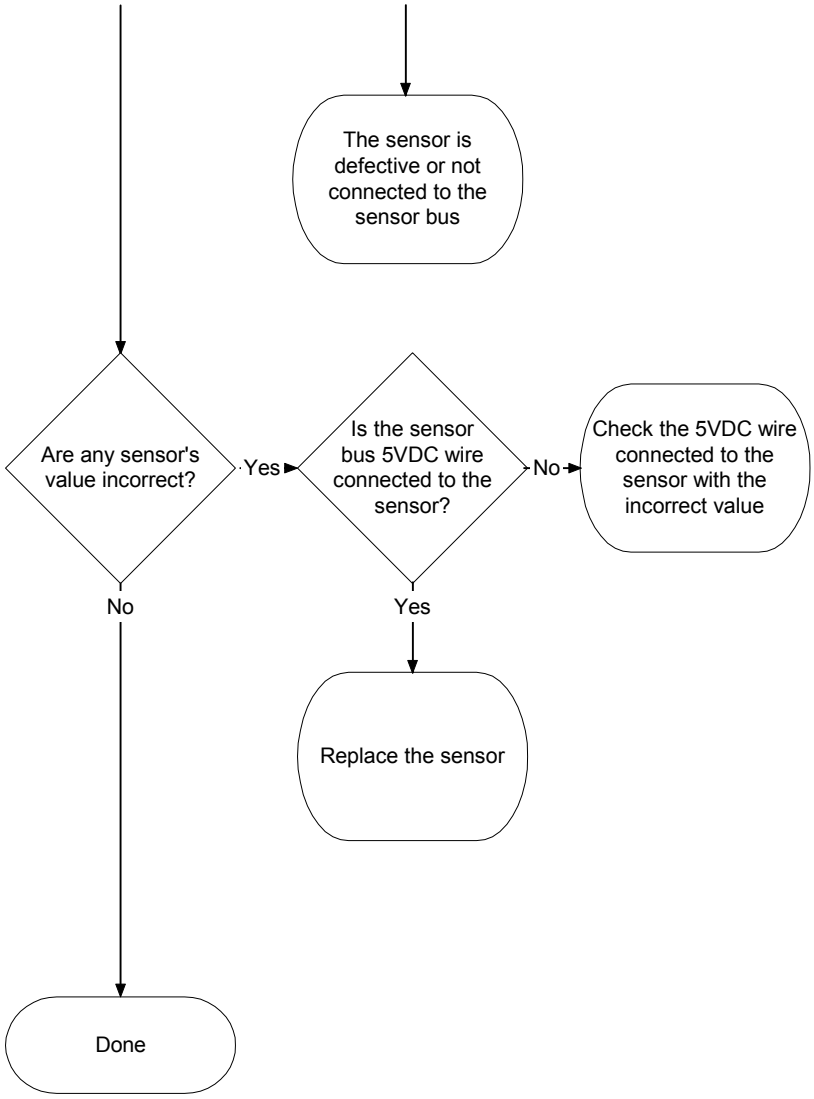



Yes
Is the green lamp flashing or on steady?
No
Is the host polling the mBC082's?
No
Correct host
Yes
Yes
Is the host polling the correct adresses?
No
Correct host
Yes
Are the mBC082 addresses set correctly?
No
Set addresses and cycle the power
Yes
Check bus voltage at first and last device on network
Is Data + = 1.0 - 1.5V & Data - = 1.5 -2.0V?
No
Is the bus terminated properly?
No
Check for termination at the host and insure terminate switch is on at the last mBC081 on network
Yes
Yes


Replace mBC081
Turn off power and break network so only the host and the first mBC081 are present. Make sure bus is terminated. Re-apply power.
Is the green lamp now flashing or steady?
No
Check cabling. Replace 1st mBC081 then host until communications is restored.
Yes
Turn off power. Add next mBC081 to the network Re-apply power.
Is next mBC081 now communicating?
No
Replace the mBC081 just connected
Yes
Is this the last mBC081 on the network?
No
Yes


Done
Is the red lamp flashing at 1 sec on 1 sec off rate?
No
Is the red light flashing 1 short flash?
Yes
Sensor bus 5VDC bus wire is shorted to common wire
Yes
No
Is the red light flashing 2 short flashes?
Yes
No sensors detected on the bus, data wire is open
No
Is the red light flashing 3 short flashes?
Yes
Sensor bus data wire is shorted to the common wire
No
Is the red light flashing 4 short flashes?
Yes
Data wire is shorted to the 5VDC wire
No


Is the red light flashing 5 short flashes?
Yes
Excessive bus errors were detected during a serial number acquire operation
No
Is the red light flashing 6 short flashes?
Yes
The mBC081 hardware failed the power on test or write serial numbers to Flash memory has failed
No
Any other lamp flashing sequence, mBC081 is defective, replace
Are sensors indicating fault in the sensor status table?
Yes
Is the faulted sensor's serial number entered in the serial number table?
No
Add the sensor's serial number to the table or correct the sensor's serial number entry in the table
Yes
Yes


The sensor is defective or not connected to the sensor bus
Are any sensor's value incorrect?
Yes
Is the sensor bus 5VDC wire connected to the sensor?
No
Check the 5VDC wire connected to the sensor with the incorrect value
No
Yes
Replace the sensor
Done

Appendix 1 – Supported Sensors

Only sensors supplied and approved by CMC Industrial are permitted. A wide variety of sensors are available. Contact the factory or our web site www.cmciel.com for a list of available sensors for this system.

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