13.0 COMMUNICATIONS MODULE FOR MODBUS RTU

13.1 MODBUS Description

MODBUS is a widely used digital communications protocol created in 1979 by Modicon. The MODBUS communication protocol is now under the jurisdiction of The MODBUS Organization at www.modbus.org.

MODBUS RTU (**R**emote **T**erminal **U**nit) devices communicate using a master-slave arrangement. There can be up to 247 slaves but only one master. Slaves do not transmit data without a request from the master and do not communicate with other slaves on the network. Each slave has its own address on the network (usually a RS-232 or a RS-485 network). The master is not addressed. The slave is given instructions by the master (often a PLC or SCADA) to read or write a value. The slave responds by sending the requested data to the master. If a slave is unable to process the request (because of a processing or communication error), it will not send a response. The master's request will time out and the master will generate an error. Depending upon the master, one or more retries may be sent. The response time-out must be long enough for any slave on the network to process the request and return the response.

There are several versions of MODBUS, such as MODBUS RTU, MODBUS ASCII, MODBUS PLUS and MODBUS TCP. MODBUS PLUS and MODBUS TCP are completely different protocols. PLUS is based on Fieldbus, TCP uses an IP address and runs on an Ethernet network. This Delphian module uses MODBUS RTU.

13.2 COMO (Communications Module) Description

13.2.1 Description

The COMO is packaged in an explosion proof enclosure which is secured with 4 bolts. It is designed for use in Class I, Div 1, Groups C,D environments. The COMO has three 3/4 inch NPT threaded openings. Internal to the enclosure, located on the PC board, are two 8-pin dip switches used to set Baud Rate, Data Format and Address. There are also two 5-pin terminal blocks which are intended to match exactly the pins coming out of the Detector Head, SLAM and the Extension Module. The COMO uses a microprocessor to interpret the analog 4-20 mA signals from the Detector Head and transmit them via the MODBUS Data-Highway upon request by the Master using the digital MODBUS RTU protocol. The COMO is connected to the MODBUS Data Highway using a 2-pin Network Terminal Block. A multi-color LED changes color to show operation and status. The maximum number of COMOs to be connected to a GazTell is one.

13.2.2 Module LED Operation

	LED Color	Module Operation
1.	Solid Green	Powered and ready for operation
2.	Pulsed Green	Receiving and sending
3.	Pulsed Yellow	Slave is not communicating sucessfully with the master.

13.2.3 Dip switches in the COMO

Two 8-position DIP switches are used to select the module's interface to the master.

1. DIP Switch 1: Positions 1-8 are used to set the module's address: 1 to 247 (address 0 is reserved for broadcasts by the master to all of the slaves and is not supported)

Note: The address dip switch uses eight positions to represent the address in binary. For instance, address 1 is 00000001 and address 247 is 11110111.

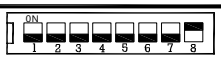
A space on the PC Board is provided to write the address as a standard numerical value.

2. DIP Switch 2:

- Positions 1-4: Set the baud rate: 19.2kbps (19200), 9600, 4800 and 2400
- Positions 5-8: Set the data format: 8E1, 8O1, 8N2

The default setting is 19.2 Kbps, 8E1, address 1.

Baud Rate	Switch 1 2 3 4	Position
19200	1 0 0 0	
9600	0 1 0 0	
4800	0 0 1 0	
2400	0 0 0 1	

Address	Switch 1 2 3 4 5 6 7 8	Position
1	0 0 0 0 0 0 0 1	

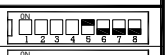
Data Bits	Parity	Stop Bit(s)	Format	Switch 5 6 7 8	Position
8	Even	1	8E1	1 0 0 0	
8	Odd	1	8O1	0 1 0 0	
8	None	2	8N2	0 0 1 0	

Figure 16: COMO Dip Switches

COMMUNICATION MODULE ADDRESS DIP SWITCH POSITION CHART

Dec	Binary	Dec	Binary	Dec	Binary	Dec	Binary	Dec	Binary	Dec	Binary
1	00000001	42	00101010	83	01010011	124	01111100	165	10100101	206	11001110
2	00000010	43	00101011	84	01010100	125	01111101	166	10100110	207	11001111
3	00000011	44	00101100	85	01010101	126	01111110	167	10100111	208	11010000
4	00000100	45	00101101	86	01010110	127	01111111	168	10101000	209	11010001
5	00000101	46	00101110	87	01010111	128	10000000	169	10101001	210	11010010
6	00000110	47	00101111	88	01011000	129	10000001	170	10101010	211	11010011
7	00000111	48	00110000	89	01011001	130	10000010	171	10101011	212	11010100
8	00001000	49	00110001	90	01011010	131	10000011	172	10101100	213	11010101
9	00001001	50	00110010	91	01011011	132	10000100	173	10101101	214	11010110
10	00001010	51	00110011	92	01011100	133	10000101	174	10101110	215	11010111
11	00001011	52	00110100	93	01011101	134	10000110	175	10101111	216	11011000
12	00001100	53	00110101	94	01011110	135	10000111	176	10110000	217	11011001
13	00001101	54	00110110	95	01011111	136	10001000	177	10110001	218	11011010
14	00001110	55	00110111	96	01100000	137	10001001	178	10110010	219	11011011
15	00001111	56	00111000	97	01100001	138	10001010	179	10110011	220	11011100
16	00010000	57	00111001	98	01100010	139	10001011	180	10110100	221	11011101
17	00010001	58	00111010	99	01100011	140	10001100	181	10110101	222	11011110
18	00010010	59	00111011	100	01100100	141	10001101	182	10110110	223	11011111
19	00010011	60	00111100	101	01100101	142	10001110	183	10110111	224	11100000
20	00010100	61	00111101	102	01100110	143	10001111	184	10111000	225	11100001
21	00010101	62	00111110	103	01100111	144	10010000	185	10111001	226	11100010
22	00010110	63	00111111	104	01101000	145	10010001	186	10111010	227	11100011
23	00010111	64	01000000	105	01101001	146	10010010	187	10111011	228	11100100
24	00011000	65	01000001	106	01101010	147	10010011	188	10111100	229	11100101
25	00011001	66	01000010	107	01101011	148	10010100	189	10111101	230	11100110
26	00011010	67	01000011	108	01101100	149	10010101	190	10111110	231	11100111
27	00011011	68	01000100	109	01101101	150	10010110	191	10111111	232	11101000
28	00011100	69	01000101	110	01101110	151	10010111	192	11000000	233	11101001
29	00011101	70	01000110	111	01101111	152	10011000	193	11000001	234	11101010
30	00011110	71	01000111	112	01110000	153	10011001	194	11000010	235	11101011
31	00011111	72	01001000	113	01110001	154	10011010	195	11000011	236	11101100
32	00100000	73	01001001	114	01110010	155	10011011	196	11000100	237	11101101
33	00100001	74	01001010	115	01110011	156	10011100	197	11000101	238	11101110
34	00100010	75	01001011	116	01110100	157	10011101	198	11000110	239	11101111
35	00100011	76	01001100	117	01110101	158	10011110	199	11000111	240	11110000
36	00100100	77	01001101	118	01110110	159	10011111	200	11001000	241	11110001
37	00100101	78	01001110	119	01110111	160	10100000	201	11001001	242	11110010
38	00100110	79	01001111	120	01111000	161	10100001	202	11001010	243	11110011
39	00100111	80	01010000	121	01111001	162	10100010	203	11001011	244	11110100
40	00101000	81	01010001	122	01111010	163	10100011	204	11001100	245	11110101
41	00101001	82	01010010	123	01111011	164	10100100	205	11001101	246	11110110
										247	11110111

Table 10: COMO Dip Switch Position Chart

13.3 Delphian's MODBUS Interface

13.3.1 General Description

Delphian uses the MODBUS RTU protocol transmitted on a 485 serial line, in compliance with The MODBUS Organization's "MODBUS over Serial Line, Specification and Implementation Guide V1.02." For a complete description of the MODBUS protocol V1.02 or MODBUS specification v1.1b see www.modbus.org/specs.php.

The interface board in the COMO translates the GazTell Detector Head's 0-21.9mA information into a 12-bit unsigned integer which is transmitted over a RS-485 multi-drop network (MODBUS Data-Highway).

13.3.2 Scaling

The master scaling should be 0-4095 decimal which corresponds to the slave's 0-21.9 mA.
Note: See section 9.3 of the GazTell Operations Manual for the GazTell mA outputs.

13.3.3 Command Register Location

Parameter	Function	Type	Scale	Access	Register Address	Master I/O Address
Analog	0-22 mA Current Output	Value	12-Bit	Read	0000	40001

Table 11: COMO Command Register Location

13.3.4 Read Request Message

The message is used to read the contents of registers in a slave. The request must specify the starting register address and the number of registers. In MODBUS registers are addresses starting at zero. Therefore registers number 1-16 are addressed as 0-15.
Note: Delphian uses only one register, which is addressed as zero "0."

Byte	MODBUS Message	Range	COMO
1st	Slave Address	1-247 (Decimal)	COMO Address (set by dip switch)
2nd	Function Code	03	Read Holding Registers
3rd	Starting Address Hi	00	Not Used by Delphian
4th	Starting Address Lo	00	Holding Register Address
5th	Number of Hi Registers	00	Not Used by Delphian
6th	Number of Lo Registers	01 (Hex)	Registers Used by Delphian
7th	CRC Lo	00-FF (Hex)	CRC Lo Byte
8th	CRC Hi	00-FF (Hex)	CRC Hi Byte

Table 12: COMO Read Request Messages

13.3.5 Read Response Message

The register data in the response message are packed as two bytes per register, with the binary contents right justified within each byte. For each register, the first byte contains the high order bits and the second contains the low order bits.

Byte	MODBUS Message	Range	COMO
1st	Slave Address	1-247 (Decimal)	COMO Address (set by dip switch)
2nd	Function Code	03	Read Holding Registers
3rd	Byte Count	02	Number of Data Bytes
4th	Data Hi	00-FF (Hex)	Hi Byte Status Data
5th	Data Lo	00-FF (Hex)	Lo Byte Status Data
6th	CRC Lo	00-FF (Hex)	CRC Lo Byte
7th	CRC Hi	00-FF (Hex)	CRC Hi Byte

Table 13: COMO Read Response Messages

*** Note**: CRC (Cyclical Redundancy Checking) is MODBUS error-checking. The CRC field checks the contents of the entire message.

13.3.6 Error Responses

If the COMO (slave) receives a communication from the master, one of the following will happen:

1. If the request arrives without a communications error, the slave will normally handle the request within the master's allowable timeout.

Note: The Delphian COMO has a normal response time of 100 milliseconds. Typically the master's response time-out is set from 1 second to several seconds at 9600 bps.

2. If the request is not received by the slave, no response will be returned by the slave, and the master will time out.
3. If the slave receives the request but can not understand the request (due to a communication error), no response will be returned by the slave and the master will time out.
4. If the slave receives an error free request but can not process the response quickly enough for the master, the master may time out before the response is received.
5. If the slave receives a request without a communications error, but can not process it due to a reading error, the slave will return an error response in the data field. The error codes supported are:

Byte	MODBUS Message	Range	COMO
1st	Slave Address	1-247 (Decimal)	ID Address
2nd	Function Code	83 (Hex)	MSB set with Function Code
3rd	Exception Code	01 - 03 (Hex)	Appropriate exception code (see table below)
4th	CRC Lo	00-FF (Hex)	CRC Lo Byte
5th	CRC Hi	00-FF (Hex)	CRC Hi Byte

Table 14: COMO Error Response Message

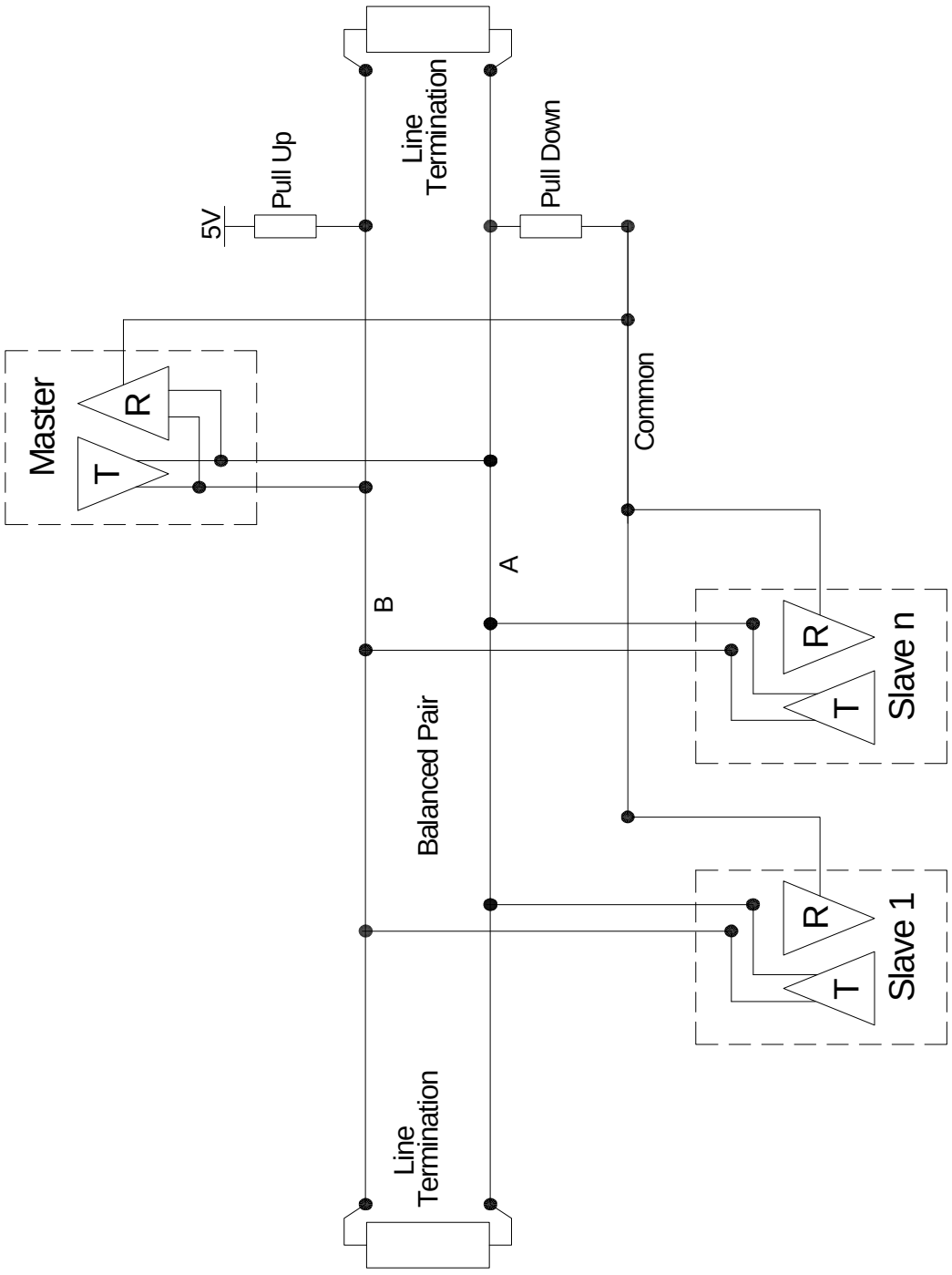


Figure 17: COMO: General 2-wire topography

Code	Name	Description
01	Illegal Function	The function code received is not an allowable action for the slave. This could indicate the master is not configured properly.
02	Illegal Data Address	The data address received is not an allowable address for the slave. This may indicate the master is asking for data from the wrong register
03	Illegal Data Value	A value in the request field is not an allowable value for the slave. This may indicate a fault in the structure of the request.

Table 15: COMO Error Codes

13.3.7 Data Rates, Cables, and Terminations

Although RS-485 is capable of network lengths up to 4,000 feet, the maximum length of the trunk cable (bus) without using a repeater depends on the baud rate, the cable (gage & impedance) and the number of loads on the cable. For instance, at a 9600 Baud rate and a gage of 26, the maximum cable length is 3,000 feet. Slaves which are not connected directly to the cable (daisy chaining) should be as close as possible. Active or Passive Taps (stubs) should not be more than 65 feet from the cable.

Note: Cables with more than 32 slaves may need a repeater, especially if the stubs are long.
Note: As the data rate decreases, the transmission length increases.

Twisted pair is the cable of choice for RS-485 networks. Twisted pair cables tend to pick up noise and other electromagnetically induced voltages as common mode signals, which are effectively rejected by the differential receivers. The Serial Line Cable must be shielded. At one end of each cable, its shield must be connected to protective ground.

Note: Delphian's COMO is intended to be used in a "two-wire bus configuration." On a two-wire bus, only one driver at a time has the right of transmitting. In addition on a two-wire bus, all devices on the bus must connect to a common circuit (power and Signal.) The COM must be connected directly to protective ground, preferably at one point only for the entire bus. Generally this point is on the master device or on its Tap.

Note: Line polarization is not needed and is not supported.

13.3.8 Termination Resistors

The twisted pairs must be balanced. Proper termination is imperative. Termination resistors are needed if transmission of data is corrupted or intermittent. Termination resistors are used to absorb the transmission-line signal so that it won't reflect (echo) off the end of the line and then combine with subsequent data signals.

For the balanced pairs used in a RS-485 system, the main cable must be terminated at both ends. Typically a 120/125 ohm resistor is used for terminations.

Note: Jumper select J5 on each of the GazTell modules provides an on-board termination resistor.

Caution: Do not place any line terminations on a stub. Do not place more than two line terminations on one balanced pair. The line termination resistor must be added in parallel with the data lines, so the line terminations are interconnected. See Drawing: General 2-wire topography.

13.4.0 Installing the COMO (Communications Module)

13.4.1 Wiring

The COMO has two 5-position Terminal Blocks and one 2-position Terminal Block.

• The 5-position Terminal blocks mate with 5-Pin Wiring Plugs. The first two pins are for power (+24 & COM) used to supply DC power to the COMO. The third pin is for the signal line wire which connects to the 4-20mA output from the sensor. **The last two pins are the RS-485 digital communication between with the GazTell modules only**.
• The 2-position Terminal Block connects the COMO to the MODBUS Data-Highway.

5-Pin Terminal Block Connections and typical wire colors

- +24VDC Red
- COM (common) -24VDC Black or Grey
- SIG (Signal) White
- RS-485 B Yellow
- RS-485 A Green

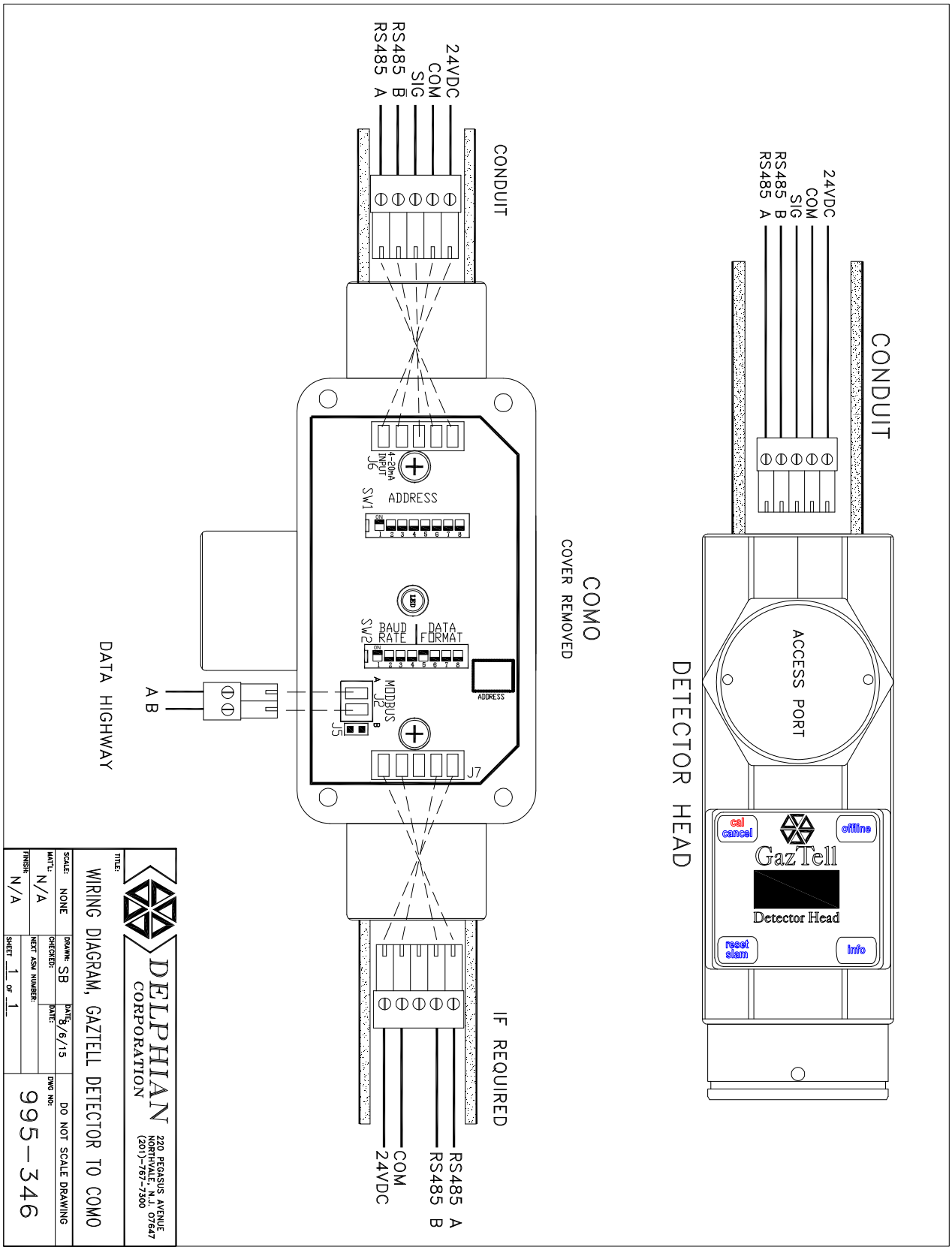


Figure 18: Wiring Diagram: GazTell Detector to COMO (Drawing # 995346)

2-Pin MODBUS Data-Highway Terminal Block Connections and typical wire colors

- RS-485 B Yellow
- RS-485 A Brown

Note: Whenever practical, use 20 AWG twisted pair for the MODBUS Data-Highway. We do not recommend using a wire gage larger than 16.

13.4.2 COMO Installation Steps

1. The COMO can be connected directly to a 3/4 inch NPT thread conduit. It can be used with the Detector Head alone or in series with the EXMO or SLAM. One end of the COMO should be connected by conduit to the Detector Head directly (or indirectly through the EXMO or SLAM). The other end should be connected by conduit to the 24 VDC power source. The 2-Pin Terminal Block is used to connect the COMO to the MODBUS Data-Highway.

CAUTION: The maximum impedance between the Detector Head's signal output "SIG" and the -24V "COM" should not be greater than 300 ohms. The maximum distance between any of the GazTell modules should not be more than 400 feet.

2. ENSURE THAT THE AREA IS DECLASSIFIED AND THAT THE AREA'S CLASSIFICATION DOES NOT EXCEED THE MODULE'S APPROVAL RATINGS.

3. **RECOMMENDED:** REMOVE POWER FROM THE DETECTOR HEAD BEFORE INSTALLING OR REMOVING THE OPTIONAL MODULES.

4. Connecting the COMO to Conduit.

A. Unscrew the 4 bolts holding the top and remove the top

B. Remove the plug on the hub closest to the Detector Head or EXMO, pull all five wires into the COMO and connect the conduit.

C. Connect all 5 wires (**sig**nal, power, RS-485) to the 5-pin Wiring Plug as shown on the Wiring Diagram (Drawing 995346).

D. If the COMO is placed between the Detector Head and one of the other GazTell modules (EXMO or SLAM), remove the plug on the other end of the Module, connect it to conduit in the same way and connect the 5 wires to the other 5-pin wiring plug.

E. Remove the plug on the side of the COMO, pull the wires into the Module, connect the conduit and connect the two Data Highway wires to 2-pin wiring plug, so that the RS-485 A and B terminals are correct.

F. Use the dip switches to set the correct Baud Rate, Data Protocol and Address. Write the binary address in standard digits in the space provided below the address dip switch.

G. Tighten the screw connections securely.

H. Tighten the COMO to the conduit. Tighten all threaded connections.

I. Reconnect power, the LED should show solid green.

J. Check to make sure that the COMO is communicating correctly with the master. The LED should blink Green for send and receive.

K. Check to make sure the master is receiving good information from the COMO. If the master is receiving unreadable information, the COMO's address is probably incorrect and two or more communication modules may be responding to requests.

L. Record the COMO's address and location. In the event of any mis-addressing, this record can be helpful in trouble-shooting.

Note: If the COMO is used with the Detector Head only:

- Locate it near the Detector Head
- There is no need to connect the RS-485 to the Detector Head, only power and SIG are needed.
- Connect the COMO to Power (+24VDC & COM)
- Connect the COMO to the MODBUS Data-Highway.

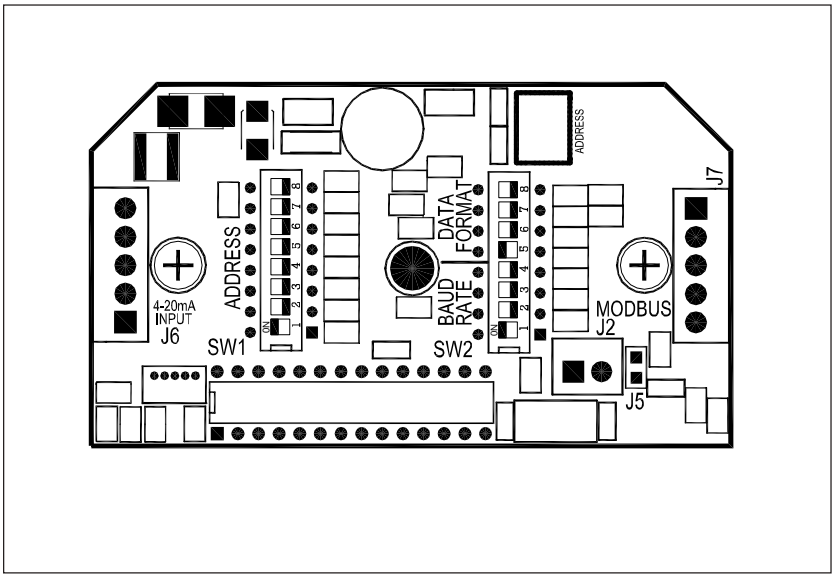


Figure 19: COMO PC Board

13.5.0 Troubleshooting the COMO

13.5.1 Faults, Likely Causes and Remedies

LED Operation	Problem	Remedy
LED is blinking yellow	Module is not communicating successfully with the master.	Check data highway Check to be sure the data highway is connected correctly to the A&B terminals Check data speed & format. If no errors, replace module
LED is not lit	COMO is not communicating with the master	Connect 24VDC power. If this does not solve the problem, replace COMO.
LED is blinking green	Master is receiving unreadable messages	Two or more COMOs may have the same address, see remedy discussion below.
LED is blinking green	Master is not receiving a response to requests and times out.	The COMO cannot process the command in time; increase the master's timeout setting.
LED is steady green	Master is not receiving a response to requests and times out	The COMO is waiting for a command from the master. Check to see if the master is operating properly or if it is correctly connected to the MODBUS data highway.

Table 16: COMO Troubleshooting

13.5.2 Two COMOs with the Same Address

If two or more COMOs have the same address, the master will receive unreadable information as the slaves will respond to the request, making the response unreadable to the master. To solve the mis-addressing:

- See which COMOs the master is showing in fail and check their address. If one or more of them have the same address, re-address as appropriate.
- If this has just started, it is likely that the last module installed is mis-addressed.
- If on bringing up the system, several modules are responding to requests from the master, it is likely the default address of “1” has not been changed.

13.5.3 Replacing a COMO

To swap out a COMO, declassify the area, remove power, duplicate the dip switch configuration of the old module. Connect and re-power the new COMO. Check the COMO and the master to make sure the slave is responding correctly.