MAIT Industries

Cable Replacement Series
CR-X
Bidirectional Switch

Specifications

Revision 2

12/12/2017

Revision History

Revision 2 – 12/12/2017

1. Added documentation for additional functionality introduced in CR-X firmware version 23.

   Functionality of DIP switch 1 changed. Former functionality was:

OFF	Do not perform any retransmission of input switch states
ON	Perform retransmissions every two minutes if no response

   New functionality is:

OFF	Perform retransmissions every two minutes if no response
ON	Always transmit every two minutes if one or both inputs are on

   Introduced functionality for DIP switch 4:

OFF	Normal output operation
ON	Outputs automatically turn off if no transmission is received for five minutes

   The purpose of these changes is to provide an option that ensures the outputs turn off in the event of a failure in communications (e.g. power or propagation issues). To enable this functionality, DIP switch 1 should be turned on at the transmitter end and DIP switch 4 should be turned on at the receiver end.

   In practice, with these settings, the transmitter will transmit an ON condition every two minutes. If two consecutive transmissions are missed then the outputs will turn off.

   Being bi-directional, this functionality may also be enabled in the reverse direction.

2. Added documentation relating to 9352 boards with electronic fuses.

Introduction

The CR-X Bidirectional Switch is a member of the MAIT Industries CR series of cable replacement units. A single CR-X unit forms one end of a wireless bi-directional switch. When paired with a similar unit, two digital channels (ON/OFF states) can be transmitted in both directions over distances of several kilometers line-of-sight. Repeaters (type CR-V) may be used to extend this distance if required.

The CR-X units are ideal for remote control of pumps and valves where laying cable is expensive, not feasible or simply not desired. They are also useful for remote monitoring of switch states (e.g. pressure and flow switches).

Each CR-X has two digital inputs and two digital outputs. The outputs can be configured to control two independent 12VDC relays or a single 12VDC latching solenoid. (Optional cards are available that allow two latching solenoids to be controlled from the one CR-X unit.)

Pairing Options

In addition to pairing two CR-X units, one CR-X may also be paired with an Analog Transmitter (CR-T) or an Analog Receiver (CR-R). However, transmission will only occur in one direction (from CR-T to CR-X and from CR-X to CR-R).

The CR-R Analog Receivers do not support auto-off functionality.

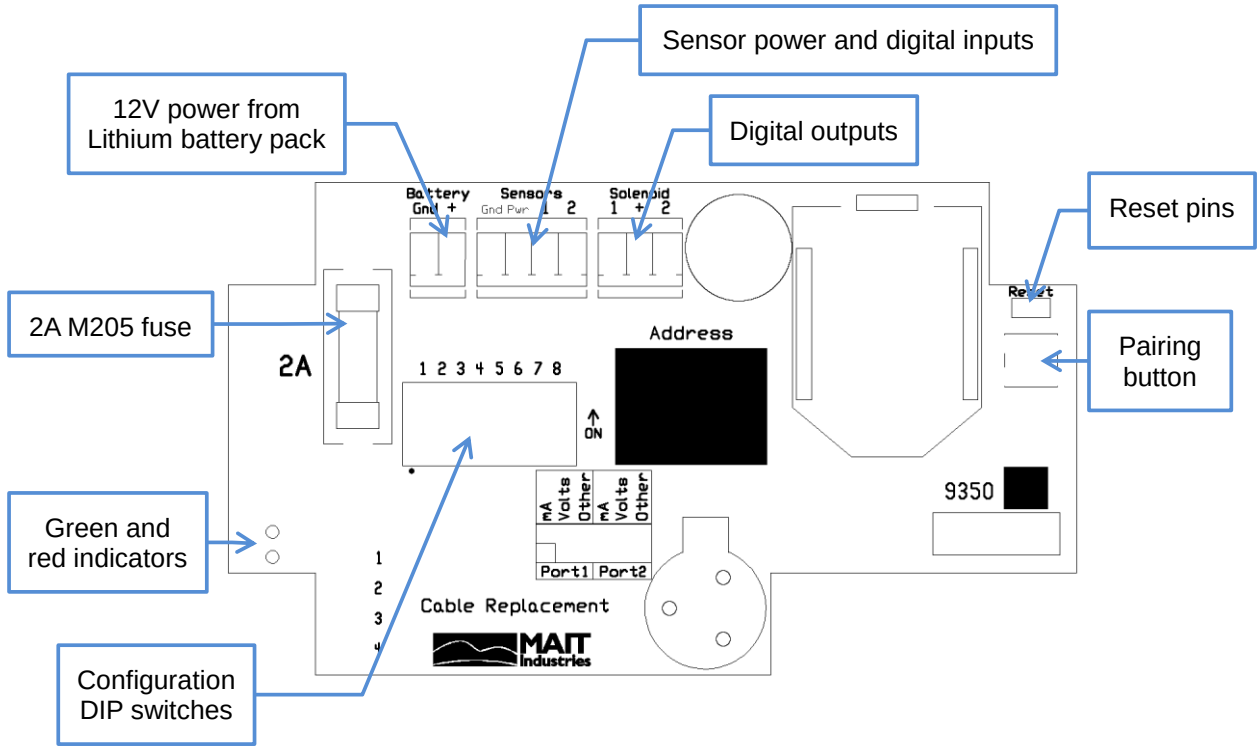
The CR-T Analog Transmitters continuously transmit their data at least once per minute so auto-off functionality is still available if a CR-X (version 23+) is used as the receiving unit.

Transmission in both directions.
Auto-off functionality available in CR-X v23 and above.

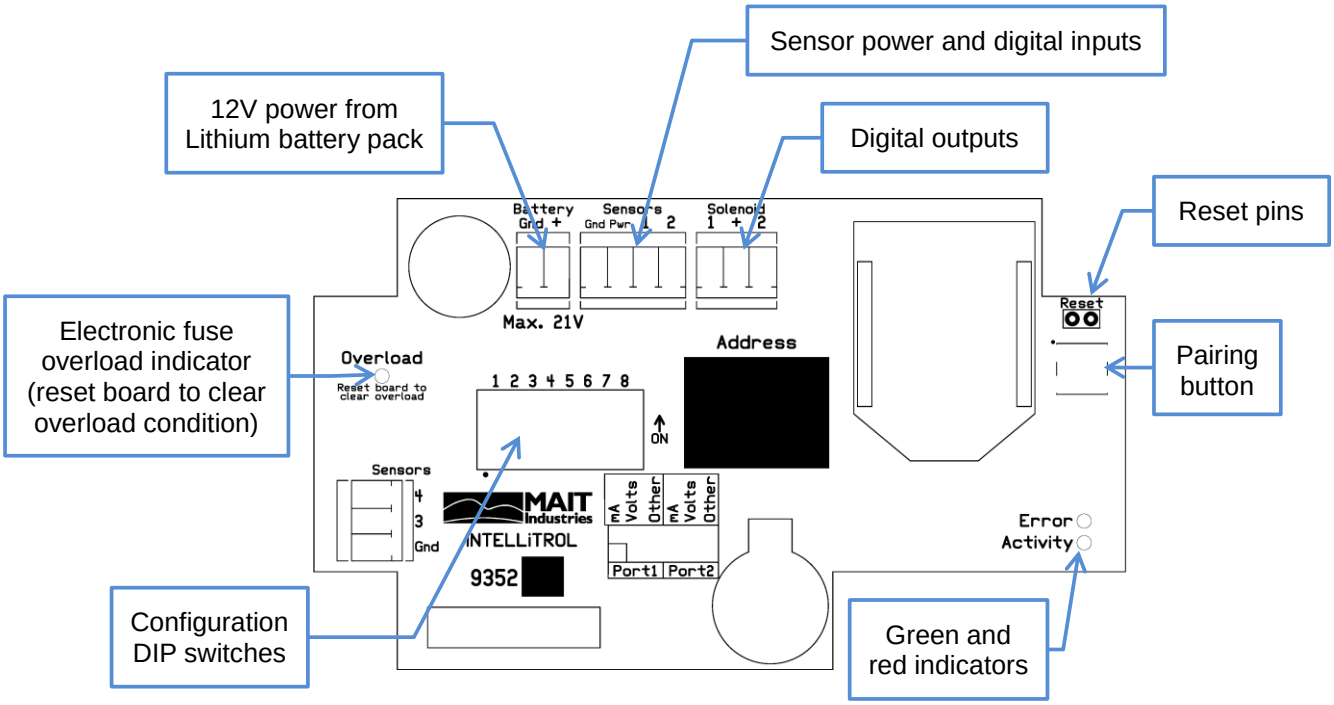
Transmission from CR-X to CR-R only.
Auto-off functionality not available.

Transmission from CR-T to CR-X only.
Auto-off functionality available in CR-X v23 and above.

Board Layout 9350/9351 (Standard Fuse)



Board Layout 9352 (Electronic Fuse)



Power Supply

The CR-X is powered from a nominal 12VDC power source. Typically this would be the standard in-built, 3AH, rechargeable Lithium battery pack. This pack is generally kept charged via a 15VDC 1A regulated plug pack. Where mains power is not available a 12V solar panel (5 or 10W) may be used but care must be taken to ensure the panel is able to supply sufficient charge to maintain the power requirement of the load.

Note: The voltage from the Lithium pack can vary between 9.5 and 12.5V DC. Caution must be exercised when selecting relays and solenoids to ensure they operate reliably over this range.

For higher power applications a 12V 7AH Sealed Lead Acid battery may be used, also charged from a suitable source.

The board may be powered directly from a **12VDC** plug pack if mains power is reliable and battery backup is not required. The Ampere rating of the plug-pack must be sufficient to handle the maximum load, including the CR-X and any attached output devices.

If the attached output devices continuously draw significant current (greater than a few hundred mA) then an external power source, rather than the lithium battery pack, is recommended.

Theory of Operation

The CR-X has two digital inputs and two digital outputs. The inputs on one unit will be replicated on the outputs of the other unit. These units operate in both directions.

Note: When the unit is paired with an Analog Transmitter (CR-T) or an Analog Receiver (CR-R) then the units will only operate in one direction (from the CR-T to the CR-X or from the CR-X to the CR-R).

DIP switches are used to select the type of output (e.g. latching solenoid, relays, etc.)

Note: If the output on a unit is configured for latching solenoid operation (or other complex function) then both outputs ports will be required to drive the attached device. Thus, only one channel is available in that direction. This equates to Sensor Switch 1 on the other end unit (i.e. Sensor Switch 2 has no effect).

Note: Optional boards may be purchased to allow the CR-X to drive one latching solenoid per port. This expands its capabilities to allow two latching solenoids per unit.

Sampling

Each sensor input is sampled once per second. A sensor input must remain in a given state for two successive samples for that state to be recognized. I.e. if the input changes state for one sample and then returns to its original state, the change is ignored. If the input changes state and maintains the new state for at least two samples then the change-of-state is transmitted to the remote unit.

The change-of-state transmission will be repeated up to ten times, each time waiting for a response from the remote CR-X. If no response is received from the remote unit then the unit will wait for two minutes (or until another change of state occurs, whichever is sooner) and then attempt a further ten transmissions. It will continue this sequence every two minutes until a response is received (or ad infinitum if a response is not received).

Note: If an input changes state during the middle of a transmission cycle then the current cycle is terminated and the new state will be transmitted up to ten times.

As of v23, if DIP switch 1 is ON then, if either of the inputs is ON, the unit will transmit every two minutes even if a response is received. This allows the auto-off functionality at the receive end to function correctly.

Resetting the Unit

A unit may be reset by shorting the reset pins with a metal object. Whenever a unit is reset it will immediately transmit the current values to the paired unit.

Resetting a unit will also force the outputs into a high impedance state. This will have the following effects:

Relay Outputs – The relays will be de-energised (turn OFF).

2W and 3W solenoids – The solenoids will remain in their current state.

Pump Start – The pump will shut off.

Flood Gates – The current operation (if any) will abort, leaving the flood gate in its current position.

Indicator Lights

The green light provides an indication that the CR-X is “awake”. When idle, the light will flash briefly once per second. The green light will also flash erratically whenever radio communications is occurring and will be permanently on during data transmission and whenever the pairing button is pressed.

When attempting to pair, the red and green lights will flash alternately. Once pairing is achieved, they will flash simultaneously for a period of five seconds before reverting to normal operation.

Except when pairing, the red indicator should be extinguished. If the red light flashes once per second (with or without the green light) it indicates a fault condition.

Fault conditions include:

- Not paired
- No response (or error response) from paired unit
- Various abnormal reset conditions
- Blown fuse

In the case of a blown fuse, the green light will be extinguished and the red light will flash every second for a longer duration (½ second).

For boards with a **physical fuse** (9350/9351), replace the fuse with the same type and rating:

2A M205 (20mm x 5mm) glass.

For boards with an **electronic fuse** (9352) an “Overload” indicator will also illuminate to indicate the overload condition. Reset the board (by shorting the two reset pins with a metal object) to clear the overload condition.

In the case of an abnormal reset (brown-out reset or watch-dog reset), resetting the unit (shorting the reset pins with a metal object) will clear the error condition.

After a reset, if the red light re-appears immediately then it is most likely the unit is not paired. If the red light appears after the first transmission then it is most likely that the paired unit is not responding.

DIP Switch Settings

There are eight DIP switches that allow the user to define the operation of the CR-X. These switches are defined in Table 1.

DIP switches are enabled (turned on) by pushing the switch "up" as indicated on the board. In the following table, for clarity, the OFF position is indicated by a small dot · and the ON position indicated by a large dot ●.

Switch	Function
1 · ● · ●	**Retransmission** v21 - Don't perform retransmissions if no response v21 - Retransmit every two minutes if no response v23 - Retransmit every two minutes if no response v23 - Retransmit every two minutes if one or both inputs are ON even if a response is received (allows auto-off functionality at the receive end) *Note: For v23 and above, turning this switch OFF for two seconds and then ON for a few seconds will force the CR-X to retransmit its input states. This is a useful method to force the re-transmission of the input states without having to turn an input on or off. When finished, the DIP switch may be left ON or OFF according to the desired operation.*
2 · ●	**12V Sensor Power** 12V sensor power is turned off 12V sensor power is turned on
3 · ●	**Radio Sleep Mode** Radio is always awake Radio sleeps when not transmitting
4 · ●	Auto-OFF Functionality (v23) Disabled (Outputs will remain in the last known state) Enabled (Outputs turn off after 5 minutes if no transmissions received)
5	Reserved
6 7 8 · · · ● · · · ● · ● ● · · · ● ● · ● · ● ● ● ● ●	**Output functionality** Standard relay outputs (two outputs) Two wire latching solenoid (single output) Three wire latching solenoid (single output) Advanced pump start (single output) Flood gate operation (single output) Reserved Reserved Reserved *Note: If optional latching solenoid driver boards have been installed (allowing two latching solenoids per unit) then select the "Standard Relay" option.*

Table 1: DIP Switch Settings

Electrical Specifications

Maximum Ratings

Battery Terminals (w.r.t. Gnd) Note 1	-15V to +15V (9350/9351) -21V to +21V (9352)
Sensor Input Voltage Note 1	0V to +15V
Solenoid Output Voltage	0V to +Battery Voltage
Solenoid Output Current	2A (continuous) 4A (pulsed 250ms)
Sensor Supply Output Current Note 2	400mA

Typical Operating Conditions

Battery Voltage	+9V to +13.8V
Operating Current (12V supply, inputs open circuit, outputs off) Additional current with 12V Sensor Power enabled in "unregulated" mode	<1mA (Radio sleeping, 12V sensor power disabled) 10mA (Radio awake, idle) 55mA (Radio transmitting) 4mA approx.
Sensor Input Voltage Note 3	0V to 3.3V
Sensor Output Voltage Note 4	12V
Solenoid Output Current Note 5	4A pulsed for 50ms <500mA continuous

Notes:

1. Inputs are clamped for surge protection. Continuous DC inputs outside these extremes will cause overheating and possible destruction of the clamp diodes.
2. The sensor output voltage is current limited and able to withstand a continuous short circuit.
3. Voltages are generally not directly applied to the input pins. Each sensor input has a 10k pull-up resistor to +3.3V. This represents the OFF condition. The input is typically shorted to ground through a voltage free contact to represent an ON condition.

   Applying a voltage outside these limits will cause the input protection diode to conduct, placing approx. 1k resistance between the input and ground.
4. While the maximum sensor output voltage is limited to 12V it is derived from the battery voltage and, therefore, always be slightly less than the battery voltage.
5. The charge current into the standard Lithium battery pack is limited to 1A. Regardless of the charging source, drawing a total of more than 1A of continuous current will cause the batteries to have a net discharge.

Power Considerations

Sensor Power

The CR-X provides a 12V 400mA power source from which any attached sensors may be powered. This power is sourced from a linear regulator and can never produce more voltage than the input supply. (In the case of the Lithium battery pack, this could be as low as 9.6V.) When the input voltage drops below approx. 12.5V the linear regulator is no longer capable of supplying a regulated 12V and runs in its "unregulated" mode.

In its unregulated mode, current consumption increases considerably.

If 12V sensor power is not required then it is recommended that it be turned off.

Radio Sleep

If one end of the link is only transmitting switch states (i.e. it is not receiving switch states) then the link is considered unidirectional. In this case the radio in the transmitter unit may be put to sleep when not transmitting. This considerably reduces power consumption.

Reducing Power Consumption

In solar powered installations, reducing power consumption should be considered as a priority. As discussed previously, in the case of unidirectional transmission, the radio in the transmitter unit can be put into sleep mode between transmissions. Also, units that do not require sensor power should have the "12V Sensor Power" feature disabled.

Implementing both these options will significantly reduce the operating power of the CR-X.

However, another source of power consumption that needs to be considered is the type of load attached to the output port. A typical 12VDC non-latching relay may draw between 100 and 200mA which is several times more than the CR-X unit, even when transmitting.

Replacing non-latching relays with latching types will considerably reduce power consumption as power is only consumed for the period the relay is latching, typically 50ms.

Pairing Units

The CR-X bidirectional switch must be paired with another CR-X unit for correct operation.

If unidirectional operation is acceptable then the CR-X may also be paired with an Analog Transmitter (CR-T) or an Analog Receiver (CR-R).

Repeaters may be used in any of the above combinations. Simply pair one unit with the repeater and then pair the second unit with the same repeater.

Steps for Pairing Devices

1. On the first unit, press and hold the pairing button for at least five seconds. The red and green indicator lights will start flashing alternately to indicate “pairing mode”. Release the pairing button.
2. Within three minutes, press and hold the pairing button on the second unit for at least five seconds. The red and green indicator lights will start flashing alternately to indicate “pairing mode”. Release the pairing button.
3. If radio communications is acceptable the units will pair within a few seconds indicated by the red and green indicators flashing simultaneously for a period of five seconds.

The units will retain the pairing information even if power is removed.

For repeaters, the process is performed a second time to pair with the second unit. The last two paired units will be retained in the repeaters memory.

“Un-pairing” Devices

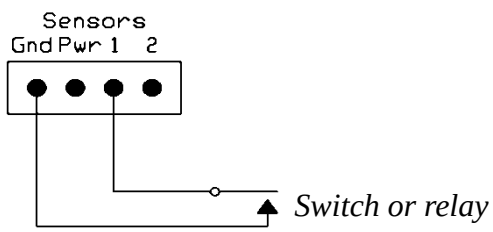
Pairing units with each other automatically removes any prior pairing information. However, Analog Receivers (CR-R) may be paired with two transmitters so, to ensure all prior pairing information is removed, an “un-pairing” option has been provided. The “un-pairing” procedure may be used on all cable replacement units.

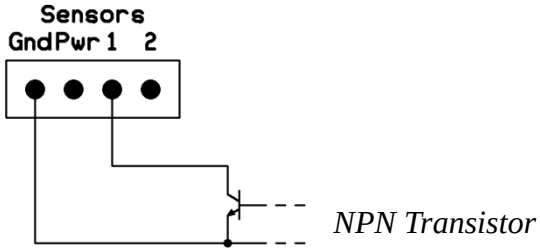
To “un-pair” a module, hold down the pairing button. While the pairing button is held down, reset the unit by shorting the two pins just above the pairing button. After the initial flashing sequence, the two lights will stay solid for one second and then flash in unison six times. Once the lights start flashing, the unit is “un-paired” and the pairing button may be released.

Application Notes

Typical Input Wiring

The digital input ports are pulled to +3.3V via an internal 10k resistor. Typically they would be left floating in the OFF state and pulled to ground in the ON state.

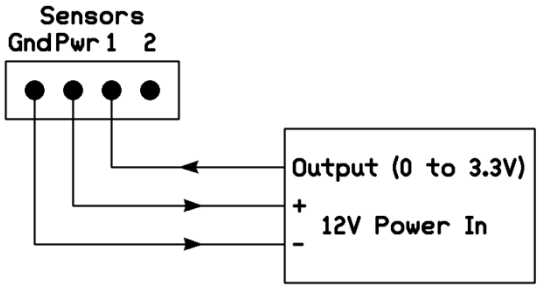




A voltage may be applied to the inputs providing it is within the specified limits and the input state is determined as follows:

<1V	ON
1 to 2V	Undefined
>2V	OFF

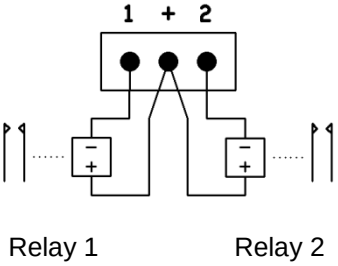
If the input sensors require power, 12VDC (max. 400mA) is available from the **Pwr** pin. This voltage is short circuit protected so is the preferred power source for external wiring.



Powered sensor with voltage output

Standard Relay Outputs

The Standard Relay Output option will drive two separate, independent relays. Wire the two relays as per the diagram to the right.



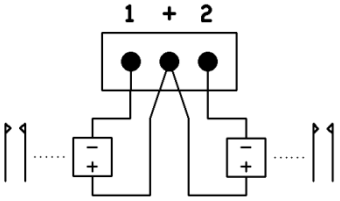
In the OFF state, output ports 1 and 2 are high impedance. They are taken to ground when the output is turned on. The relays or solenoids are then referenced to the center + pin which provides fused 12VDC from the battery.

Relay 1 is controlled by Sensor 1 at the transmit end. Relay 2 is controlled by Sensor 2 at the transmit end.

Pump Start and Flood Gate Options

The Pump Start and Flood Gate Options also use two relays. However, the second relay is intrinsically tied to the state of Port 1. Both relay ports are controlled by Sensor 1 at the transmit end. The second sensor port at the transmit end is ignored and the CR-X becomes a single channel system.

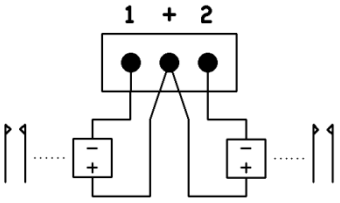
Relay 1 (Run Relay) operates whenever sensor 1 at the remote end is ON.



Relay 2 (Start Relay) operates for 5s when relay 1 is turned on and then drops out. This may be used to bypass pressure and flow switches during pump startup.

Pump Start Option

Relay 1 operates for 120s when sensor 1 at the remote end turns ON. This opens the flood gate.

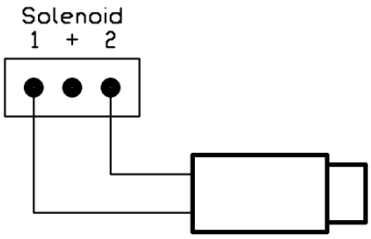


Relay 2 operates for 120s when sensor 1 at the remote end turns OFF. This closes the flood gate.

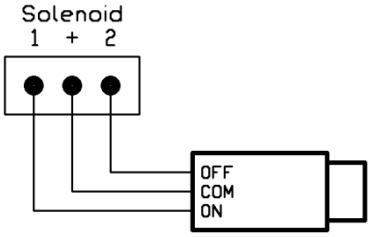
Flood Gate Option

Latching Solenoid Options

Latching solenoids require both outputs to operate. One output pulses for 50ms to turn the solenoid on and the other pulses for 50ms to turn the solenoid off. Sensor 1 at the transmit end controls the solenoid. The second sensor port at the transmit end is ignored and the CR-X becomes a single channel system.



Two Wire Latching Solenoid



Three Wire Latching Solenoid
(Centre terminal is positive)