SAFE-E-STOP™

Personal Safety System
User Guide

9M02-8978-A002-EN

CONNECT. CONTROL. PROTECT.

Revision History

VERSION	DATE	NOTES
13	1/28/2018	Added cautions, updated Fault finding and simplified frequency selection
14	02/2021	Rebranded
15	03/2021	Section 8.6 – Added ethernet LEDs description and reference to IPconfig tool Appendix II – Removed reference to unavailable frequencies in the Band F Appendix iV – Updated Ethernet messages mapping tables. Added Modbus TCP
16	Feb 2023	Corrected connection sketches

Contents

1. Introduction

This manual provides guidance to installers and users of the Cattron Safe-E-Stop Personal Safety System.

1.1 Terminology

The following represent important acronyms and long form used in this document:

PSD	Personal Safety Device (the unit worn by a machine operator)
MSD	Machine Safety Device (the unit connected into the hard-wired E-Stop wiring and monitoring systems)
PSS	Personal Safety System (the entire E-Stop System)
PLC	Programmable Logic Controller
MASTER-ADDRESS	The Primary address used by the system to ensure adjacent systems is unique and will not cross talk
SUB-ADDRESS	The appended address used to identify specific PSDs within a system
COMM LOSS	A loss of RF communication between PSD and MSD
LINKING	Associating a PSD with an MSD and placing into operation as an active E-Stop device
UNLINKING	Disassociating a PSD from an MSD and removing from an active E-Stop group
DIN	Deutsches Institut fur Normung, i.e. German Institute for Standardization.
PL	Performance Level
SIL	System Integrity Level
SC	Systematic Capability

2. Warnings and Cautions

WARNING and CAUTION statements are strategically placed throughout all text prior to operating or maintenance procedures, practices or conditions considered essential to the protection of personnel or equipment and property. Before starting any task, review and understand the WARNINGS or CAUTIONS included in the text. All WARNINGS and CAUTIONS appearing in this manual are included below.

WARNING SYMBOL

Meaning: *CAUTION*

Function: Indicates that caution is necessary relative to the associated content and that the current information must be followed in order to avoid undesirable consequences.

2.1 MSD wiring warning

WARNING

The MSD must be hard-wired in series with at least one E-stop switch so that an e-stop is still available when no PSDs are connected.

Failure to comply with the above warning may result in serious injury or death to personnel and damage to equipment.

2.2 Verification of configuration warning

WARNING

More than one PSD may be used in, around, or nearby your machine; therefore before using any PSD, you must ensure by checking the configuration ID or other means of identification that the correct unit has been selected and that it matches the machine being protected.

If the PSD is not associated with the machine you are using it may still link to another MSD on a close by machine and not be providing the protection you are expecting and need.

Failure to comply with the above warnings may result in no protection being provided to stop your machine, which in turn could result in loss of ability to stop an impending emergency situation and may lead to injury or death.

2.3 Verification of correct linking warning

WARNING

After linking the PSD to the machine, there should be a means for the operator to verify the connection; several methods can be used including color coding, numbering, or by using the ethernet connection with a PLC and pressing the green button on the PSD and ensuring the indicator (light or buzzer) on the machine confirms your connection.

Failure to comply with the above may result in no protection being provided to stop your machine, which in turn could result in loss of ability to stop an impending emergency situation and may lead to injury or death.

2.4 Placement of PSD in charger warning

WARNING

Unlinked PSDs should not be visible to personnel in the area and potentially confused for an available e-stop switch. **If PSDs in chargers are unlinked** they should not be visible. The easiest way to do this is to place the charger within a secondary enclosure or position it so that the e-stop switch faces toward a wall and away from personnel.

Failure to comply with the above may result in no immediate available protection being provided to stop your machine, which in turn could result in loss of ability to stop an impending emergency situation and may lead to injury or death.

2.5 No serviceable parts warning

WARNING

There are no user serviceable parts in this PSD / MSD system, please return damaged units to Cattron or a Cattron authorized service centre for service and do not attempt to repair these units.

Unauthorized repairs will void the unit's safety rating and could compromise the unit's ability to stop your machine, which in turn could result in loss of ability to stop an impending emergency situation and may lead to injury or death.

2.6 Regulatory warning

WARNING

Observe the statutory regulations and directives applicable for the intended purpose, e.g.:

- Accident prevention regulations
- Safety rules and directives
- Standards
- Generally applicable statutory and other binding regulations for accident prevention and environmental protection, and general safety and health requirements.

2.7 Awareness of PSD range and Hazards around the machine

WARNING

The operators and the personnel in general should be trained to know the operational range limits of the PSD and the surrounding hazards.

2.8 The system may cause unexpected stop of the machine

WARNING

The design of the machine shall consider the risk associated with an unexpected stop of the machine.

2.9 The Safety analysis shall consider the reaction time of the system

WARNING

The safety analysis of the application shall consider the reaction time of the system.

2.10 Ethernet may not be used for safety critical function

WARNING

The ethernet port must only be used for informational purposes. The functionality of green button on the PSD should must not be used for any safety critical functionality such as restarting the machine.

2.11 General Safety Information

- Persons under the influence of drugs, alcohol and/or other medicine that impairs reaction may not install, repair, or operate this product.

- All installations must conform to the relevant safety requirements. Only qualified, trained, authorized personnel may perform work on the equipment, in accordance with the relevant safety requirements.
- In the event of malfunction and/or visible defects or irregularities, the operation must be protected by other PSDs or alternate external means. The PSD/MSD system must be returned to good working order before being returned once more to operational service.
- The operating manual should be permanently accessible at the place of product use.
- Personnel assigned to work with the product must have read and understood the operating manual and the safety instructions.
- The safety instructions should be supplemented with work instructions concerning the job organization, work sequences, qualified personnel, etc.
- All repairs made during the warranty period must be carried out by the manufacturer or appointed authorized service center, failure to comply will invalidate the warranty.
- Only trained personnel may perform maintenance and repair on the product.
- All repairs made by these authorized agents should be carried out in a suitably clean static-safe environment, free from contaminants such as metal filings, water, oil etc.
- It is the user's responsibility to ensure that the product is maintained in good condition and that all applicable safety requirements and regulations are observed.
- Product modifications may not be carried out.
- Only original spare units from Cattron must be used.
- Periodical inspections either required by law or prescribed in this user manual shall be carried out within the prescribed intervals.

2.12 Intended Use

Only use the product in good condition, by trained personnel, and subject to the compliance with the applicable operating safety and accident prevention rules and regulations.

2.13 Improper Use

Certain use and work on / with the product is not permitted, in particular:

- Deviating from the voltage / frequency data on the type plate
- Working on live components
- Insufficient maintenance
- Failure to observe the operating temperature range

2.14 Equipment rating warning

CAUTION

Damage of the device

The PSD is rated at IP67 and an operating temperature range of -20°C to +60°C; do not use the PSD for conditions beyond these limits.

The PSD battery cannot be charged if its temperature exceeds 40°C.

The MSD is rated at IP30 and a temperature range of -20°C to +60°C, up to 90% non-condensing RH, for environments harsher than this use an appropriate secondary enclosure.

Exceeding these ratings could compromise the unit's ability to stop your machine, which in turn could result in loss of ability to stop an impending emergency situation and may lead to injury or death.

CAUTION

The choice of connection will be determined by the safety level required for the target application and machine. To achieve SIL3 capable safety levels a dual channel connection approach will be required and is recommended, but single channels are optional for lower safety levels and are also illustrated.

Additionally, it must be remembered that the Ethernet port is not safety critical, only informational, therefore the functionality of the green button on the PSD should not be used for safety critical functionality such as restarting the machine.

Use of the green button for safety critical functions could result in unexpected actuation of function and may lead to injury or death.

3. Operating Principle

3.1 General

The MSD has two safety relays that are wired in series with an external hard-wired E-Stop circuit that provides a machine with the ability to run. The MSD safety relays are normally open types: if the MSD power were removed, the relays would open and the machine would be brought to a halt as though an E-Stop had been pressed.

The MSD is a complex safety PLC. In the event of any fault it will open its safety relays; in its normal operating mode, it will maintain these safety relays in a closed state.

A normal operating mode can be maintained in the absence of any online PSD, as well as with one or more PSDs in a linked and normal operating state.

PSDs can come and go as required without affecting the MSD E-Stop safety relays, provided that the PSDs join and leave the system by the deliberate act and process of linking and leaving the active group. (Patent Pending)

When a PSD is part of the active group, it will trigger an E-Stop if it has its E-Stop switch pressed or if it loses the RF link to the MSD either because a) it goes out of range, b) it shuts down due to low battery c) it has a fault, or d) it has its RF linked blocked by interference.

Both the MSD and PSDs feature fully redundant hardware and safety critical software. They individually and jointly meet the safety level of SIL3 according to ISO61508.

The MSD polls the PSDs in turn and assigns a PSD an active slot if one is available. The linked PSDs return the poll after each MSD poll, forming a closed loop safety system.

3.2 Radio Transmission

The connection between the MSD and PSDs is performed by means of radio communication. With regard to the actual radio frequency that is used, there are several radio frequency bands available.

A specific RF frequency band and channel is selected prior to delivery of the system.

Depending on the frequency band, a defined number of RF channels are available.

The MSD and PSDs must operate on the same RF channel in order to be able to communicate.

Some systems use two RF channels in a frequency diversity mode to increase immunity to RF interference.

3.2.1 Continuous Transmission

Once the units are linked, transmission between MSD and PSD must be continuous. The MSD uses this as part of the information required to maintain its E-Stop safety relays in a closed state. If the MSD does not receive a valid telegram from a linked PSD after a short time, it turns off the E-Stop safety relays.

In order to ensure optimum communication between the MSD and PSD, operate the PSD with line-of-sight to the MSD antenna as far as possible. Avoid total shielding of the signal path by extensive metal and other thick solid obstructions.

3.2.2 Radio Interference

Signals from other RF-emitting sources might interfere with the radio communication between the MSD and PSD. If the radio link reliability is affected by interference, changing the RF channel or even the RF band may be necessary.

3.3 Telegram Security

The transmitted telegram contains several security features.

3.3.1 Frame Type

Each message has an 8-bit message type identifier that is unique to the equipment in use.

3.3.2 System Address

Your Personal Safety System uses 32,768 unique Master Addresses, and 15 Sub Addresses per MSD (one per each possible associated PSD).

This system address is contained in every telegram sent between the MSD and PSD. The data is considered valid only when the address combination matches. This is a safety measure to ensure that the MSD will act only upon its assigned PSDs.

3.3.3 CRC

The telegram is checked for integrity by the use of a 16-bit CRC. Frames containing a mismatched CRC will be rejected.

3.3.4 Frame Counter

Each message has an embedded frame counter that changes with every data frame. This prevents frozen data and data frame hacking.

4. Frequency Selection

Reliable operation of the Safe-E-Stop system is dependent on the correct selection of one or more interference free RF channels; inappropriate selection may lead to unexpected machine shut down. The Safe-E-Stop system operating frequency is factory set and cannot be field set, so correct frequency selection is required prior to the system being built. If the operating frequency needs to be changed after it has left the factory, it will be necessary to return the PSDs and MSDs to the factory for re-programming.

Depending on your region there may be licensed channels and/or license exempt channels available:

- Licensed channels provide the greatest level of signal reliability because issuance of channels is regulated and controlled within the geographic region.
- License exempt channels are not regulated and hence the onus lies with the user to monitor and control frequencies in use in their facility, but knowledge of other users that may exist close by is harder to determine, operation within a steel clad building will provide a level of isolation from external sources, an open site however may be better off using licensed channels.

It is the user's responsibility to maintain a frequency plan to ensure interference free operation of the Safe-E-stop and other RF equipment on site. Selection of an appropriate operating frequency requires both knowledge of RF channels in use and the application of the rules set out below.

Table 1: Frequency Spacing by RF band

BAND	START FREQ HZ	END FREQ HZ	CH SPACING KHZ	START CHANNEL	END CHANNEL	CH, SPACING
A	418,000,000					
B	433,077,500	434,777,500	25	A00	A68	2 (50kHz)
C	447,000,000					
D	450,000,000	470,000,000	12.5	A00	Q00	4 (50kHz)
E	868,000,000					
F	902,600,000	927,500,000	100	A00	C49	2 (200kHz)

Table 1 defines the six operating bands; currently Cattron have only released the B, D, and F bands.

- In North America, the D band is licensed and the F band is license exempt.
- Europe and many other regions including Brazil use the license exempt band B.

4.1 Rules for Frequency selection

1. A channel can be any frequency between the Start Freq. and the End Freq. that is wholly divisible by the CH Spacing.
   - e.g. Band D channel 6 is 450,000,000 + (6*12,500) = 450,750,000.

And for any given frequency;

2. If any other systems (including other Safe-E-Stop systems) are operating within 10m of the location that the Safe-E-Stop will be used, then a frequency that is at least as far away as is shown in the 'CH SPACING Separation' column should be chosen.
   - e.g. If another system is operating on 450,700,000 required minimum separation Table 1 is 50kHz so 450,700,000 – 50,000 = 450,650,000 and 450,700,000 + 50,000 is 450,750,000 and both of these are within the Band Start and band End frequencies. Make sure it is a valid channel according to rule 1 above.
3. Finally make sure the derived frequency is not in the table below.

Table 2: Frequencies Not Supported

AVOID FREQUENCIES				
Band B	**Band D**		**Band F**	
434,177,500	466,937,500	902,600,000	912,100,000	921,600,000
		902,700,000	912,200,000	921,700,000
		902,800,000	912,300,000	921,800,000
		902,900,000	921,100,000	921,900,000
		911,700,000	921,200,000	922,000,000
		911,800,000	921,300,000	922,100,000
		911,900,000	921,400,000	
		912,000,000	921,500,000	

Cattron can supply support and help with frequency selection if they are provided with a list of frequencies in use in the immediate operating location.

4.2 Site Planning

As far as is practical RF systems frequency separation should be at least as shown in the last column of the
table below.

Table 3: Channel Spacing for Adjacent Systems

BAND	START FREQ HZ	END FREQ HZ	CH SPACING KHZ	START CHANNEL	END CHANNEL	CH, SPACING
A	418,000,000					
B	433,077,500	434,777,500	25	A00	A68	2 (50kHz)
C	447,000,000					
D	450,000,000	470,000,000	12.5	A00	Q00	4 (50kHz)
E	868,000,000					
F	902,600,000	927,500,000	100	A00	C49	2 (200kHz)

NB: channels are identified on the equipment by a three digit identity xnn see columns 5 and 6 above.

Channels run A00 through A99, and then B00 through B99 etc. until the End Channel is reached.

For the purposes of adjacent system channel spacing we can use the figure in the final column.

This simplifies somewhat the method of determining what channels should be chosen on a site.

When all available channels have been used, (not likely with 450MHz or 915MHz band) with the designated channel spacing we can start using intermediate frequencies (1 channel apart) provided that they are 100m away from the systems 1 channel away.

5. PSD and MSD Configuration Parameters

The factory set system parameters— include the selected RF Band, Primary RF channel, Secondary RF channel (if any), System master address, and the PSD specific sub-address.

Each system's configuration is identified in clear text on its labelling.

A system of one MSD and one or more PSDs must have a correct set of configuration parameters to be able to operate. Most of the configuration details must match exactly; only the Sub-Address (the first C in the example below) must be different between PSDs but will be included in the range of Sub-Addresses that the MSD is capable of using.

In summary:

- A PSD only has ONE Sub-Address and each PSD must have a different Sub-Address.
- An MSD has a range of Sub-Addresses.
- Both PSDs and MSD have a number of other parameters that must match exactly.

5.1 PSD Configuration Detail

Figure 1: PSD Configuration Label

Figure 1 shows the labelling on the PSD. The configuration example identifies this PSD as having a configuration of D-C23*00-C-CB6A, referring to Table 1.

Band D=450MHz, single channel C23 in that band, Sub-Address C, and Master Address CB6A.

As an aid to visual identification and differentiation, the following are available as options:

- A sheet of labels of various colors of Cattron Logo as a user installation item.
- Differently colored rubber bumpers as a factory installed item.

5.2 MSD Configuration Detail

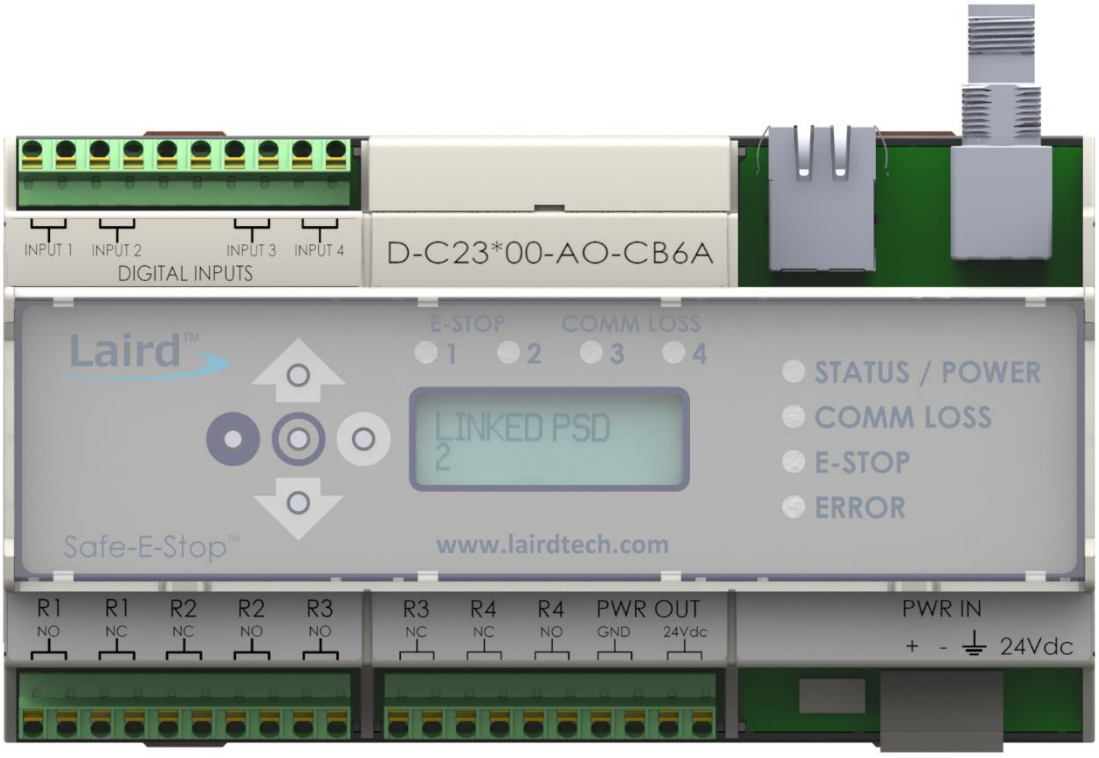


Figure 2: MSD Configuration Label

Figure 2 shows the labelling on the MSD; the configuration example shown identifies this MSD as having a configuration of A-23-00-AO-CB6A referring to Table 4.

Band A=418MHz, single channel 23 in that band, Sub-Address range A thro O, and Master Address CB6A.

In this example, the MSD is capable of operating with the PSD in Figure 1 above because the PSD has a matching Band, Channel, and Master Address, plus a Sub-Address of C that is within the acceptable range for this MSD of A through O.

Table 4: Configuration Parameter Examples

HARDWARE SECTION EXAMPLES				CONFIGURATION SECTION EXAMPLES											
				1st RF Channel			2nd RF Channel			Sub Address		Master Address			
Version of MSD/PSD		RF Band	PSD Color	1st Sub Band	Chan dec	Chan unit	2nd Sub Band	Chan dec	Chan unit	SAC Start	SAC End	MA1 (MSB)	MA2	MA3	MA4 (LSB)
		A – Z		A – Z	0 –	99	A – Z or *	0 –	99	A – O	A –O	0 – E	0 – F	0 – F	0 – F
PSD	1	A	R	A	1	1	*	0	0	A		0	0	0	1
	1	B	B	B	1	2	A	0	0	B					
	1	C	G	C	6	4	B	0	0	C					
	1	D	O		0	4		2	6	K		C	B	6	A
	1	E	R	Y	7	6	Y	0	0	L					
	1	F	R	Z	9	9	Z	0	0	O					
MSD															
	1	A		A	1	1	A	0	0	A	O				
	1	B		B	1	2	B	0	0	A	O				
	1	C		C	6	4	C	0	0	A	O				
	1	D			0	5		0	0	A	O				
	1	E		Y	7	6	Y	0	0	A	O				
	1	F		Z	9	9	Z	0	0	A	O	E	F	F	F

Table 5: Frequency Bands

BAND	FREQ MHZ	TYPICALLY USED IN
A	418	China
B	433	EU & Other
C	447	EU Licensed
D	450	NA and Other Licensed
E	869	EU
F	915	NA

Table 6: Examples of Configuration Number Use

SELLING PART #	FULL CONFIGURATION PART #	ON DEVICE
PSD-1-A-R MSD-1-A	PSD-1-A-R-D23*00-A-CB6A MSD-1-A-D23*00-AO-CB6A	A-D23*00-A-CB6A A-D23*00-AO-CB6A

6. PSD

6.1 PSD Overview

PSDs can be considered as a set of wireless E-Stop switches that are dynamically linked to the MSD on an as-needed basis. The MSD does not need a PSD to be connected in order to keep its E-Stop Safety Relays closed; as long as power is connected to the MSD and it has no faults, these relays are held closed and the hard-wired E-Stop circuit is maintained.

The MSD provides the physical link into the hard-wired E-Stop system of the machine. Its E-Stop Safety Relays are wired in series with this circuit and reflecting the status of the PSDs E-Stop switches.

Up to five out of a total of fifteen PSDs can be linked to an MSD at any one time.

If a PSD is linked to the MSD, the MSD E-Stop Safety Relays are then also subject to additional rules relating to the RF communication link between the PSD and MSD being uncorrupted and continuous, as well as the PSD E-Stop switch remaining out.

Corruption / loss of the RF link or an E-Stop switch being pressed will open the MSD E-Stop relays.

Corruption / loss of the RF link will also open the COMM LOSS relays.

A controlled process is in place to enable PSDs to link to and unlink from the MSD.

6.2 PSD Status Indications

PSDs have audible, visual (LED and LCD) and haptic (vibration) warning systems to indicate the current status such as normal operation, low battery, low RF signal etc.

Figure 3: PSD Indications

6.2.1 PSD LEDs

Referring to Figure 3 above, there are four LEDs above the E-Stop switch. These are:

STATUS	This will be flashing: **GREEN:** Normal operation **ORANGE:** Conditions that require the user to be aware **RED:** Conditions that require the user to take corrective action
COMM LOSS	Illuminates **RED** if this PSD loses communication
	Illuminates **ORANGE** if another PSD loses communication
LOW BATTERY	Illuminates **RED** when the battery requires charging
ERROR	Illuminate in case of internal error

6.2.1.1 PSD LCD

The LCD provides valuable information to the user. A backlight turns on each time there is a change of displayed message and the backlight will remain on for 10 seconds.

6.2.1.2 Radio signal level Monitoring

The RF signal level is monitored and displayed on the PSD using a graphic icon, as shown in Figure 4.

More bars mean more signal. Very low signal will be accompanied by the icon flashing.

Figure 4: RF Signal Level Monitoring

6.2.1.3 Battery Monitoring

The estimated battery level is monitored and displayed on the PSD by using a graphic icon and time in hours, as shown in Figure 5.

Resolution is approximate and shown within 0.5 hour increments; accuracy may vary under some conditions such as low temperature.

The icon flashes when the battery charge state is very low.

Note that if the low battery LED illuminates, this indicates an imminent shut down due to low battery regardless of the hours shown on the LCD.

Figure 5: Battery Level Monitoring

6.2.1.4 General Status Monitoring

The main LCD display area gives general status as defined in the tables below.

6.3 Joining an E-Stop Group

For a PSD to link to a group:

1. Verify that the PSD has the correct configuration for the MSD to be joined.
2. Ensure the PSD is in good physical condition and that the E-Stop switch is in the released position.
3. Briefly press the '|' button on the PSD; this will power it on. The LEDs and Display will show a state from the following table. If functioning properly, the LCD displays 'LINK? HOLD |'. If no action is taken after 30 seconds, the unit will power off.
4. Verify that the LCD display shows sufficient battery life for the duration of work to be performed.

Table 7: PSD Unlinked Operational States

	BUTTON PRESSED	STATUS LED	COMM LOSS LED	LOW BATT LED	ERROR LED	HAPTIC FEEDBACK	DISPLAY
PSD UNLINKED STATE							
PSD unlinked - ESTOP pressed	ESTOP	Red				3 short pulses	REL ESTOP
PSD unlinked						1 short pulse	LINK? HOLD I
Automatic 30 sec shutdown						3 short pulses	SHUTDOWN
Manual shutdown	Follow Unlink process, then press 'O' for 3 sec					3 short pulses	SHUTDOWN
Links full		Red				3 short pulses	LINKS FULL
MSD not seen		Red	Flashing Orange			3 short pulses	MSD NOT SEEN

When ready to join the group, ensure that you are in the work area and press and hold the '|' button for longer than half a second. Monitor the PSD display for information on the linking status. The PSD returns a status message depending on several factors as displayed in the following table.

If functioning properly, the unit will have a green flashing Status LED and the display will show 'PSD # ACTIVE' where # represents the PSD sub-address.

Table 8: PSD Linking Operational States

	BUTTON PRESSED	STATUS LED	COMM LOSS LED	LOW BATT LED	ERROR LED	HAPTIC FEEDBACK	DISPLAY
PSD LINKING STATE							
PSD linking	'I' for 500mS					1 short pulse as soon as link is established	LINKING (flashing until linked
PSD LINKED STATE							
PSD linked (normal operation mode)		Green (flashing)				1 short pulse (at state transition to PSD linked – see PSD Linking above)	PSD # ACTIVE

Once a PSD has joined and become an active member of the E-Stop group, the PSD displays its current status as indicated in the following table, where # is the current ID of this or another PSD:

Table 9: Linked Operational States

	BUTTON PRESSED	STATUS LED	COMM LOSS LED	LOW BATT LED	ERROR LED	HAPTIC FEEDBACK	DISPLAY
PSD LINKED STATE							
PSD linked (normal operation mode)		Green (flashing)				1 short pulse (at state transition to PSD linked)	PSD # ACTIVE
Unlink PSD stage 1	'O' until Status LED changes to fast flash; release 'O' for 0.5 seconds, then	Green (slow to fast flashing) Returns to normal operation if no 2nd press within 5 seconds					PSD # ACTIVE
Unlink PSD stage 2 within 5 seconds	Press 'O' again for 1 second	Green (flashing fast to off)				1 short pulse (at state transition to PSD unlinked)	*Changes to : PSD unlinked state above*
ESTOP pressed	ESTOP	Red (flashing)				3 short pulses	ESTOP
ESTOP pressed – other PSD		Red (flashing)				3 short pulses	ESTOP #
ESTOP re-opened	Reopen ESTOP	Green (flashing)				1 short pulse on all PSDs	PSD # ACTIVE
Comm Loss		Red (flashing)	Red			3 short pulses	COMM LOSS
Comm Loss - other PSD		Red (flashing)	Red			3 short pulses	COMM LOSS #
Comm Loss recovery within 30 sec of Comm Loss	'I' for 500mS	Orange (flashing)				3 short pulses	LINKING

	BUTTON PRESSED	STATUS LED	COMM LOSS LED	LOW BATT LED	ERROR LED	HAPTIC FEEDBACK	DISPLAY
Failure to recover from Comm loss; Recover at MSD		Red (flashing)	Red flashing after 30 sec			3 short pulses (at state transition to PSD unlinked)	RESET MSD COMM LOSS #
BATTERY/ RSSI MONITORING							
Low RF signal		Green (flashing)	Orange flashing			3 short pulses every 10 sec, 1 short pulse when re-entering good RF signal area	PSD # ACTIVE
Low battery level		Red Flashing		Orange flashing		3 short pulses every 10 sec.	PSD # ACTIVE
ERROR					Red		

The Status LED generally has the following meaning:

Table 10: PSD Status LED General Meaning

GREEN	Normal operation
ORANGE	Items of note
RED	Action is required to correct a problem

The Haptic feedback (vibration) generally has the following meaning:

Table 11: Haptic Feedback General Meaning

ONE PULSE	Confirmation
THREE PULSES	Warning of an abnormal event

6.4 Normal Operation

Once linked to an MSD, normal operation can commence.

For normal operation, all linked PSDs must have their E-Stop switches released, good battery capacity, and be within a good RF range (typically within 300 feet of the machine but distance will vary by environment).

6.4.1 Communication Loss

Moving a PSD out of RF range results in an E-Stop; this is a safety critical feature to ensure that the E-Stop of a linked PSD is always available. As this is not ideal, the PSD warns the user if the signal is getting too low by flashing the status LED Red (requiring action by the user), changing the COMM LOSS LED to Orange, displaying REDUCE RANGE on the display, and Haptic vibration in groups of 3 pulses. The user must move closer to the machine or risk causing an E-Stop by COMM LOSS.

If a PSD moves out of range and causes a COMM LOSS, both the E-Stop and COMM LOSS safety relays on the MSD open.

6.4.2 Communication Loss Recovery Stage 1

The PSD causing the COMM LOSS has 30 seconds to move back into RF range, after which the user can press the ‘|’ button on the PSD to recover the MSD operation. The machine will still need to be reset.

6.4.3 Communication Loss Recovery Stage 2

If the offending PSD is not moved back into range within 30 seconds, a full COMM LOSS is enforced. All PSDs unlink and an MSD reset will be required by pressing a button that is wired to the MSD COMM LOSS reset switch safety inputs. Afterwards, all PSDs will need to relink to rejoin the operation, and the machine will need reset.

This process makes it possible to recover from a PSD that has for instance been accidentally removed from site without de-linking.

As part of the recovery process, it is important that all users are accounted for.

6.4.4 Issuing an E-Stop

In normal operation, the E-Stop switch can be pressed at any time. This results in the MSD E-Stop Safety Relays opening within 500mS, bringing the machine to a safe state. Note that the MSD COMM LOSS relays remain closed.

The PSD issuing the E-Stop will have the Status LED flashing Red and the display will show ESTOP. The Haptic will buzz three times.

The Status LEDs of other PSDs (if any) will flash Orange. The display will show ESTOP #, where # is the current number (1-5) of the issuing PSD. The Haptic will buzz three times.

6.4.5 Recovery of an E-Stop

To recover an E-Stop, the problem requiring the E-Stop must be satisfactorily resolved. The PSDs that issued the E-Stop need to release their E-Stop switches, after which the MSD E-Stop Safety Relays will close and the machine can be reset to restart operations.

6.5 Leaving an E-Stop Group

An active member of the E-Stop group may have reasons to want to leave an operation, such as finished working, needing a rest break, shift change etc.

Members may leave the group at any time without causing an E-STOP or COMM LOSS by following a simple procedure that informs the MSD that the PSD user wants to leave the group in a controlled and safe way.

The user simply needs to press and hold the ‘O’ button for 1 second until the Status LED starts to flash fast then release the ‘O’ button for 0.5 seconds and then press the ‘O’ button again for 1 second, then the PSD will unlink from the MSD. Note that if the ‘O’ button is not pressed a second time within 5 seconds, the PSD will return to normal operational state. (This process ensures a PSD is not accidentally unlinked)

When the PSD transitions to the unlinked state the Haptic buzzes once to confirm and the LCD displays ‘LINK? Hold I’.

6.6 Switching OFF the PSD

From the unlinked state, the PSD can be turned off either by leaving it for 30 seconds (after which it will turn off automatically), or by pressing and holding the ‘O’ button for three seconds.

6.7 Charging the Battery

1. Ensure the charging adapter is connected to a power socket.

2. Connect the adapter to the charging cradle.
3. Insert the PSD into the cradle.
4. Ensure the power to the charging adapter is switched on and the LED on the adapter is illuminated.
5. Battery charging now begins.
6. The PSD battery charging process will be completed within about 3 hours.

6.7.1 Battery Capacity and Operating Life

The battery in the PSD will slowly degrade over time and will reach an 80% capacity after about 500 charge/ discharge cycles, reducing the maximum run time of the PSD. Other factors also affect the run time of the PSD including temperature; very low temperatures will significantly reduce available battery capacity; at -20°C the capacity will be approximately 30% lower than at 25°C.

Cattron recommends that the customer estimate the usage of their PSDs so they can plan for a battery replacement after 500 charge/ discharge cycles.

The battery is not user serviceable, so the PSD must be returned to Cattron or an authorized service agent.

6.8 PSD Belt Clip

The PSD Belt clip provides a secure means to wear the PSD so that the E-Stop switch is presented with the best possible aspect for immediate access; in a safety critical application this is far superior to an end mounted switch that may even require a two-handed approach to activate the switch.

Figure 6: PSD Belt Clip

The Belt clip should be attached to a belt that is no wider than 1.5 inches (38mm), to ensure that the clip securely attaches to the belt.

The PSD attachment can be rotated as required by the user.

To attach the PSD to the clip, see the diagram below, the PSD can be attached to the clip, either way round.

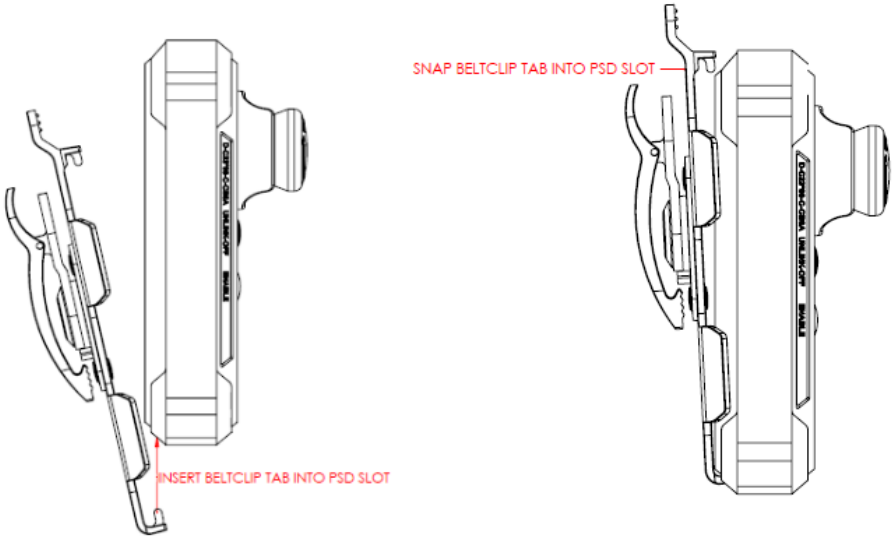


Figure 7: PSD Belt Clip Attachment

To detach the PSD from the clip, press the tab away from the PSD as shown below.

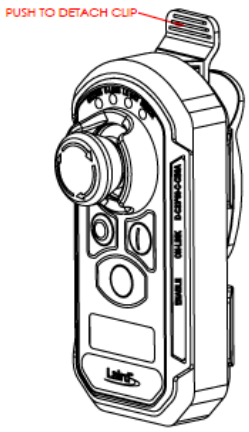


Figure 8 PSD Belt Clip Detachment

7. Battery Chargers

7.1 General Information

There are two versions of the battery charger, a single bay unit with part number 1PRT-8778-A001, and a six-bay charger with part number 1PRT-8779-A001.

Both of these units have been specifically designed to work with the Cattron Safe-E-Stop PSDs version 1 having part numbers PSD-1-x-x.

These chargers will rapid charge the battery, monitor the battery for safe charging, and provide years of reliable service with proper care.

The chargers require no special maintenance, but in the event of damage to the unit, the external power supply or cord, contact Cattron customer service for a replacement.

Unlinked PSDs should not be visible to personnel in the area and potentially confused for an available E-Stop switch. If PSDs in chargers are unlinked they should be placed within a secondary enclosure or positioned so that the E-Stop switch faces toward a wall and away from personnel.

Always fully charge the PSD before initial use, the PSD's battery may be charged when it is partially discharged. It is neither necessary nor advantageous to fully discharge the battery before recharging.

Return the PSD to Cattron for service or recycling and do not discard unwanted PSDs in the trash or incinerate its battery may explode if exposed to fire or excessive heat.

7.2 Caution

Keep the Battery Charger in a dry location and only operate it within a temperature range of 0 and 40° Celsius (32 to 104° Fahrenheit).

Make sure contacts in charging pod and on the PSD are clean. If contacts require cleaning, disconnect charger from power supply and wipe with a dry, lint free cloth.

Do not allow wire or metal objects to touch contacts in charging slot or any internal part of the charger.

Do not remove the charger's housing or make any modification to the charger. The charger has no user serviceable parts.

Use only the power supply included with the charger. Use of other power supplies may damage the charger or the battery being charged.

7.3 Single Bay Charger

A single bay charger can charge one PSD at a time. A PSD will fully charge within 3 hours.

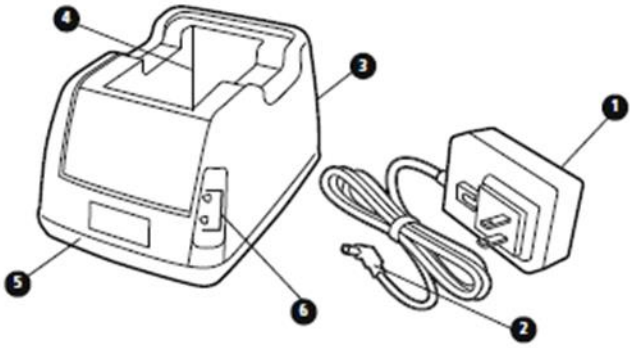


Figure 9: Single Slot Charger Features and Power Cord

1. Power supply (input 100V – 240V AC).
2. DC plug (9V DC output).
3. DC power connection – back of charger.
4. Charging slot for PSD-1-x.
5. Charger base.
6. Charge status and power-on LEDs.

7.4 Six-Bay Charger

A six-bay charger can charge up to 6 PSDs at a time. Each PSD will fully charge within 3 hours.

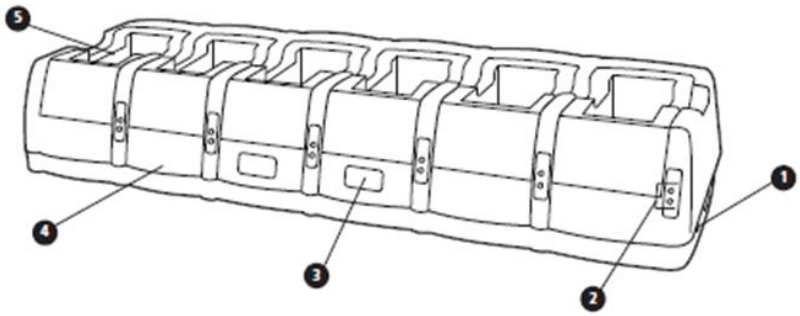


Figure 10: Six Slot Charger Features

1. DC power connection.
2. Charge status and power-on LEDs.
3. Quick reference information for charge status LEDs.
4. Charger base.
5. Charging slots for batteries.

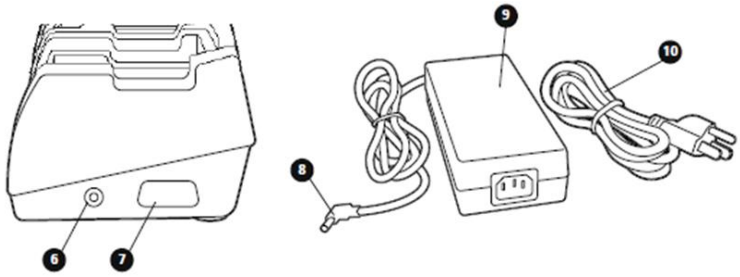


Figure 11: Six Bay Charger, Side View and Power Cord

6. DC power connection for power supply (included).
7. DC power connection for optional 12V-24V kit.
8. DC plug (12V DC output).
9. Power supply (input 100V – 240V AC).
10. AC cord for power supply.

NOTE: Additional reference information for charge status LEDs is located on bottom of charger.

7.5 Battery Charger Status and Indicators

The Battery charger LEDs indicates the current charging state.

The bottom LED illuminates Green when the unit is connected to power.

The top LED is the status LED and conforms to the following table.

When the charge status LED flashes RED, a fault condition exists and when it flashes ORANGE you are receiving an advisement concerning the condition of the PSD's battery. There are two flash patterns for faults and two flash patterns for advisements. Each is described in the following table.

To initiate charging, place the PSD to be charged in a charging slot. The Top LED will initially illuminate RED to confirm the battery is charging normally.

When charging is complete and after removing the PSD, the charge status LED will illuminate ORANGE for a few seconds. Allow the charge status LED to go off before placing another PSD in the charging pod.

Table 12: Battery Charger Status indication

TOP LED COLOR	FLASH PATTERN	MEANING
GREEN	FLASHING	Battery's capacity is over 80% charged. It is recommended that the battery be charged to at least 80% capacity before use.
GREEN	SOLID	Battery is fully charged and charging has terminated. When the PSD's battery is fully discharged, it will be completely charged in less than 3 hours.
RED	SOLID	Battery in PSD is rapid charging. Charge level is less than 80% of battery capacity.
RED	TWO FLASHES	Indicates battery contact in the PSD is "open" and current is not passing through the (+) and (-) contacts on the battery. A double flash pattern is also provided if the battery has a short circuit. For either condition, charging is immediately terminated. Have the battery checked by a qualified technician.
RED	THREE FLASHES	High temperature condition. Battery temperature is >45°C and cannot be charged safely. Do not attempt charging a battery if it is excessively warm when touched.

AMBER	SOLID	Low temperature condition. Battery temperature is <0°C (below freezing) and cannot be charged. Charger will monitor battery temperature for two hours and begin charging once it rises above 0°C. Remove battery from charger if not charging after two hours.
AMBER	ONE FLASH	Under charged condition. Battery remains under charged after the charger completes a full charging cycle. A single flash pattern is also provided when if the battery temperature remains <0°C (below freezing) after monitoring for two hours.

8. MSD

8.1 MSD Overview

The MSD provides the physical link into the machine's hard-wired E-Stop system. Its E-Stop Safety Relays are wired in series with this circuit.

The PSDs are dynamically linked to the MSD on an as-needed basis.

A controlled process must be in place to ensure that PSD users verify that they have linked to the MSD when joining and when leaving have unlinked from the MSD.

Remember that the PSD has distinct and clear operator feedback to show if it is UNLINKED or LINKED. Provided the user is correctly trained and aware, there should be a very low likelihood that an operator has failed to Link and yet still thinks that they are linked. Additional confirmation may be obtained by having a PLC monitor the Ethernet port data and turn on a lamp or buzzer by the machine when any PSD green button is pressed, this can be used as a final confirmation that the PSD is on and linked to that machine.

NOTE 1: The MSD does not need a PSD to be connected in order to keep its E-Stop Safety Relays closed; as long as power is connected to the MSD and it has no faults, these relays are held closed and the hard-wired E-Stop circuit is maintained; only the COMM LOSS relays will be open without a PSD connected.

NOTE 2: The COMM LOSS relays are an automatic function and have a safety rating of SIL3. The COMM LOSS relays are a positive indication that at least one PSD is linked and that none of those PSDs are in a state of COMM LOSS.

NOTE 3: The E-Stop relays are triggered by human action (the PSD E-Stop switch) and so are not an automatic function; however, from the point of being triggered (E-Stop switch pressed by the user) the system has a SIL3 performance level.

NOTE 4: "If the machine will at times be used without any of the Safe-E-Stop PSDs in use the MSD COMM LOSS relays will be open; therefore the COMM LOSS relays cannot be wired in series with the E-Stop relays because the hard-wired machine E-Stop circuit will never be closed; therefore, if the COMM LOSS relays are required they would either a) need an override switch, b) not be used or c) used to alter operating mode by a PLC."

NOTE 5: When one or more PSDs are linked the E-Stop and COMM LOSS relays require good communications to stay in their closed state; a COMM LOSS will be triggered by any PSD leaving the operating range or RF interference corrupting or blocking the RF signal.

8.2 MSD Connections

The MSD features multiple interface ports for various connections:

- COMM LOSS reset switch connects to inputs 1 and 3 (polarity reversible)

- INPUTS 2 & 4 are unused (polarity reversible)
- RJ45 Ethernet port
- Antenna port TNC
- 24Vdc power input (9-36Vdc)
- E-Stop Safety Relay outputs R1 & R2
- COMM Loss Safety Relay outputs R3 & R4
- Auxiliary dc output (same as 24Vdc input voltage but protected by a fuse)

CAUTION

The choice of connection will be determined by the safety level required for the target application and machine. To achieve SIL3 capable safety levels a dual channel connection approach will be required and is recommended, but single channels are optional for lower safety levels and are also shown below.

Additionally, it must be remembered that the Ethernet port is not safety critical, only informational, therefore the functionality of the green button on the PSD should not be used for safety critical functionality such as restarting the machine.

USE OF THE GREEN BUTTON FOR SAFETY CRITICAL FUNCTIONS COULD RESULT IN UNEXPECTED ACTUATION OF FUNCTION AND MAY LEAD TO INJURY OR DEATH.

8.2.1 Single Channel Connections Example when using the COMM LOSS Relays

The following configuration combines the SIL3 function of the COMM LOSS relays with the systematic capability of 3 provided by the E-Stop relays in a single channel configuration.

If a single PSD is always to be used, then use of the COMM LOSS relays will also provide additional status information. Once one PSD is 'LINKED', it is placed into service as an additional E-Stop and the COMM LOSS relays are closed. If a user fails to link their PSD and confirm that it is linked, it will not be detected and the machine could be reset unless the COMM LOSS relays are wired in series with the E-STOP relays, this will enforce the need for a single PSD.

However, each additional PSD will not make any further difference to the COMM LOSS relays; if one of those additional users failed to LINK correctly and confirm LINK status, it will not be detectable via the COMM LOSS relays. If further confirmation is required, it is possible to implement additional verification using the Ethernet bus data and a PLC control system to ensure that one, two or a minimum number of PSDs are Linked for operation to commence. Once linked any PSD that has a COMM LOSS will cause the COMM LOSS and E-STOP relays to open.

Additionally, if the machine is to be run without a PSD connected at times, this will not be possible without either overriding or not using the COMM LOSS relays, because their state will be open without a PSD linked.

The single channel connection method below will not provide protection against an external wiring fault.

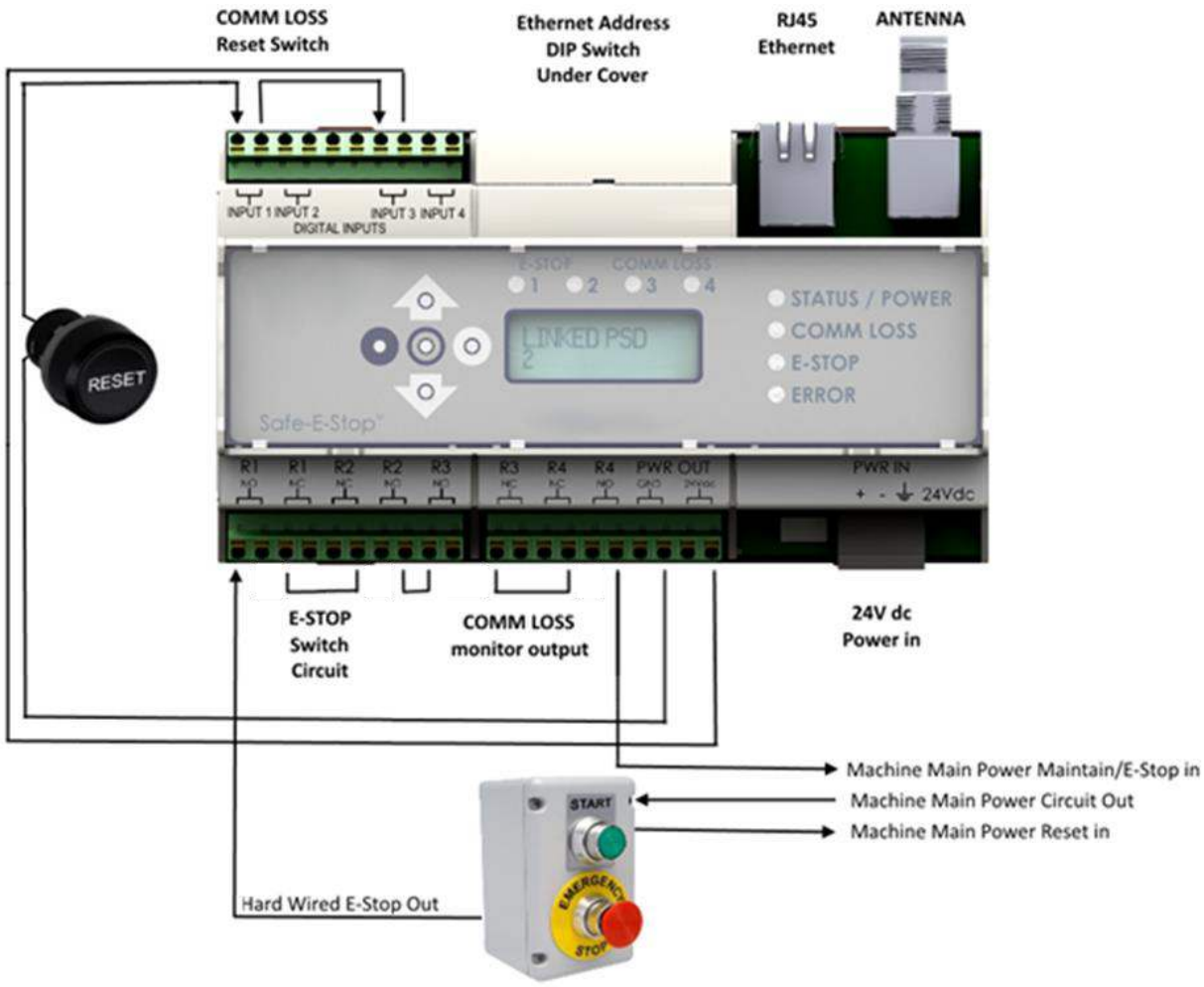


Figure 12: MSD Typical Single Channel Connections When Using the COMM LOSS Relays

8.2.2 Single Channel Connections Example when not using the COMM LOSS Relays

The following configuration does not use the SIL3 function of the COMM LOSS relays but does use the systematic capability of 3 provided by the E-Stop relays.

Where a strong process is in place that ensures the users confirm that the PSD is LINKED before starting to work, the use of the COMM LOSS relays may not be needed. The Ethernet bus may also provide a way to give visual feedback of PSD status, total number of PSDs Linked, or using the Green button to light a lamp etc. This then makes it possible to run the machine with the hard-wired E-Stop switch in use and no PSD in use.

The single channel connection method below will not provide protection against an external wiring fault.

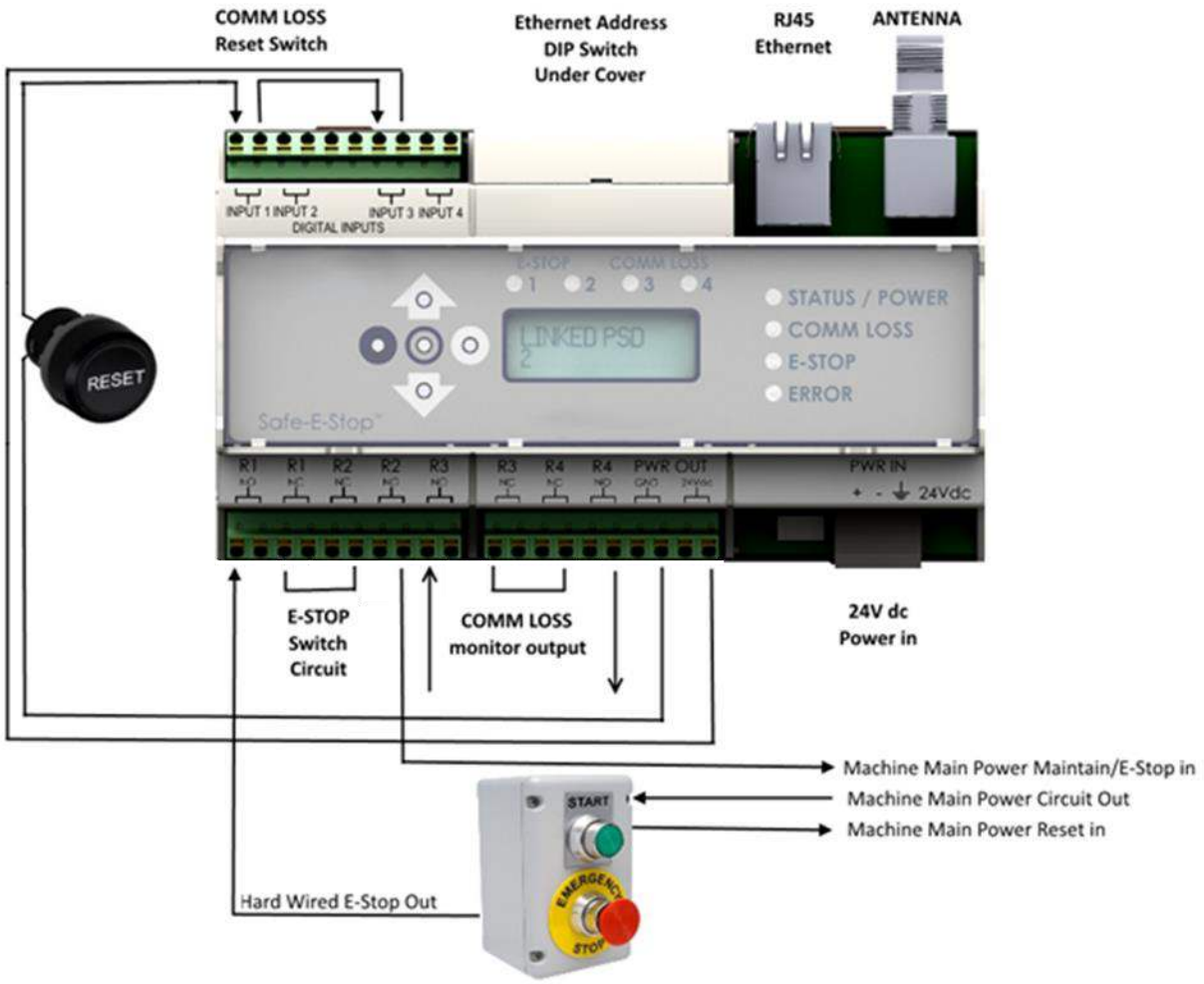


Figure 13: MSD Typical Single Channel Connections When Not Using the COMM LOSS Relays

8.2.3 Dual Channel Connections Example when not using the COMM LOSS Relays

The following configuration provides the systematic capability of 3 provided by the E-Stop relays in a dual channel configuration.

Where a strong process is in place that ensures the users confirm that the PSD is LINKED before starting to work, the use of the COMM LOSS relays may not be needed.

The Ethernet bus may also provide a way to give visual feedback of PSD status, total number of PSDs Linked, or using the Green button to light a lamp etc. This then makes it possible to run the machine with the hard-wired E-Stop switch in use and no PSD in use.

The dual channel connection method below ensures a high level of reliability and monitoring is imposed; no single channel wiring fault will be possible.

The COMM LOSS reset function is not shown but is still required, see 9.2.1 and 9.2.2.

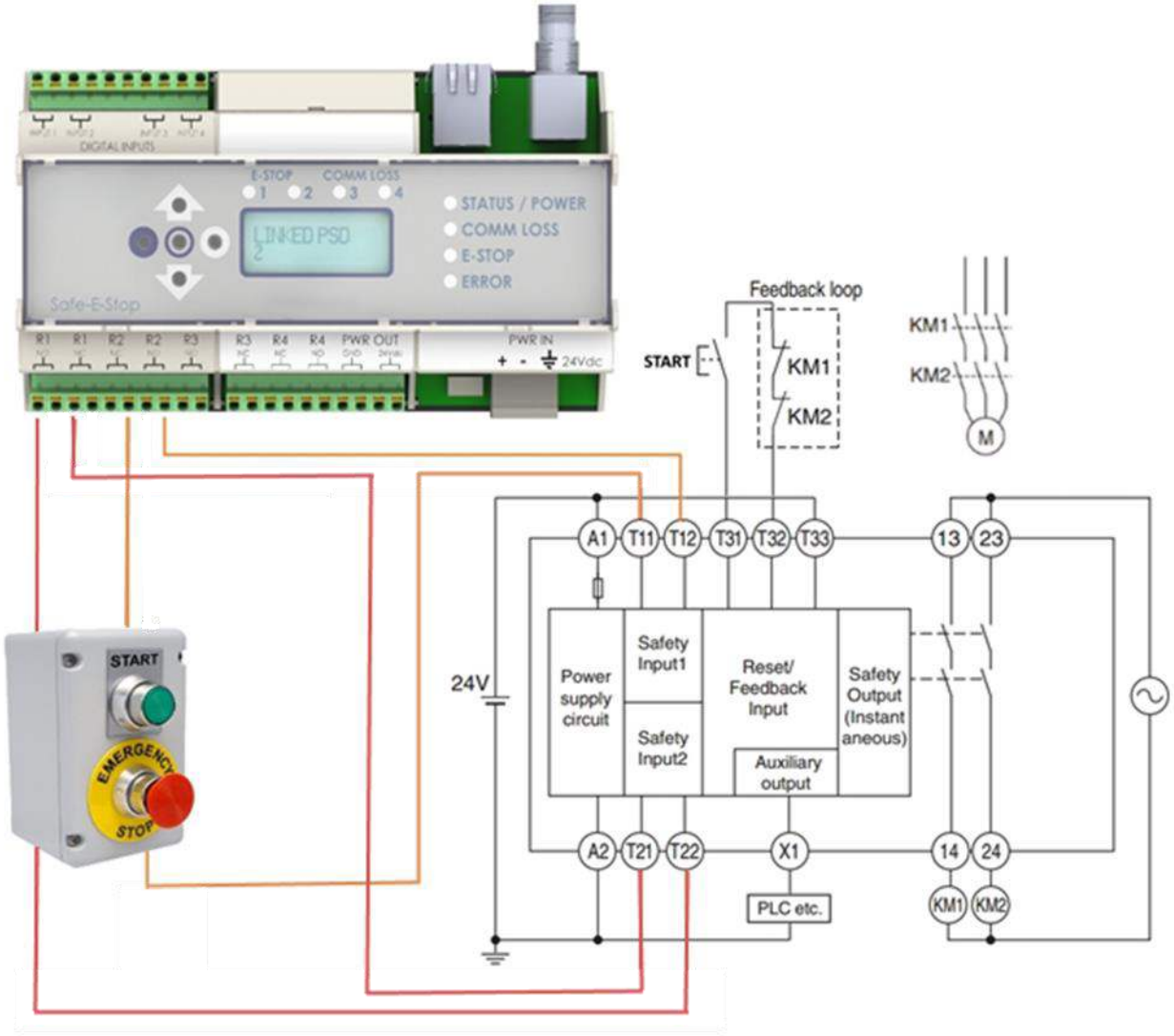


Figure 14: MSD Typical Dual Channel Connections When Not Using the COMM LOSS Relays

8.2.4 Dual Channel Connection Example using E-Stop relays and the COMM LOSS relays

The following configuration combines the SIL3 function of the COMM LOSS relays with the systematic capability of 3 provided by the E-Stop relays in a dual channel configuration.

The Ethernet bus also provides a way to give visual feedback of PSD status, total number of PSDs Linked, or using the Green button to light a lamp etc. This then makes it possible to run the machine with the hard-wired E-Stop switch in use and no PSD in use.

The dual channel connection method below ensures a high level of reliability and monitoring is imposed; provided the safety PLC inputs are OR'd no single channel wiring fault will be possible.

Additionally, if the machine is to be run without a PSD connected at times, this will not be possible without either overriding or not using the COMM LOSS relays, because their state will be open without a PSD linked.

The COMM LOSS reset function is not shown but is still required, see 9.2.1 and 9.2.2.

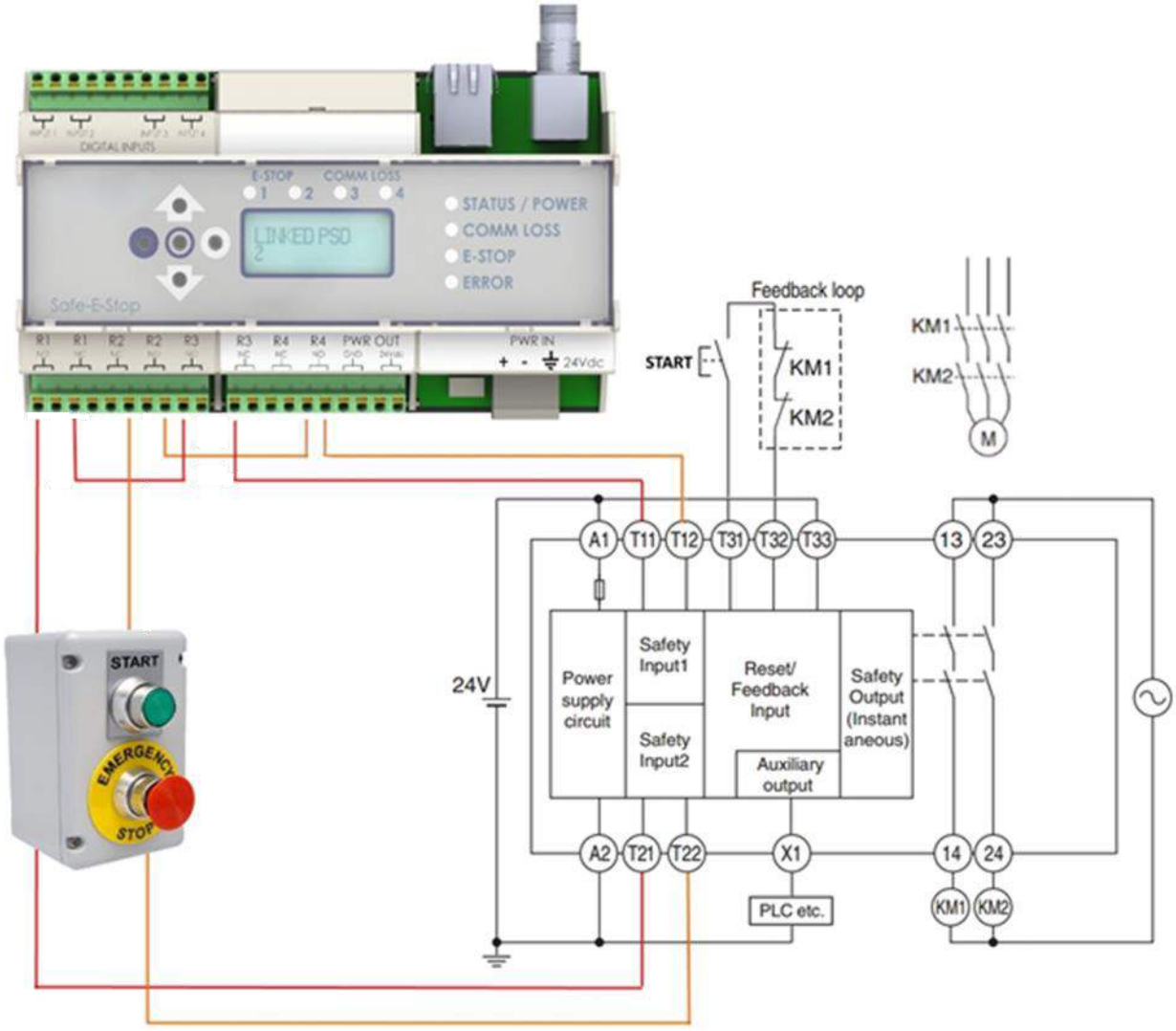


Figure 15: MSD Typical Dual Channel Connections When Using the COMM LOSS Relays

8.3 MSD Status Indicators

With both LED and LCD displays, the MSD provides an overview of operational status.

The Ethernet/IP port can provide detailed operational status of linked wireless E-Stops to operations personnel. This information includes:

- The number and identity of linked PSDs
- The Activation state of each PSDs green enable button
- The state of each PSDs E-Stop switch
- The communication state and RF signal level of each PSD

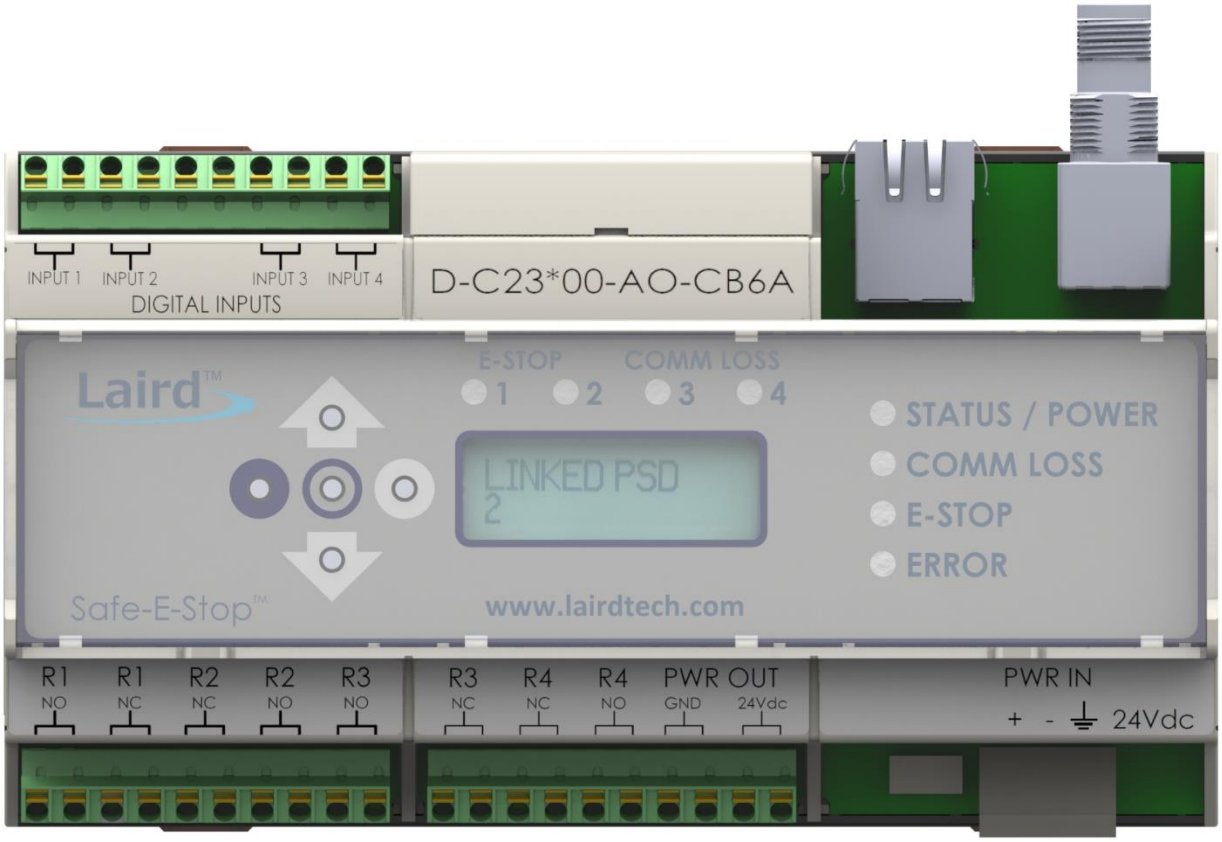


Figure 16: MSD Status Indicators

8.3.1 MSD LEDs

The Status of the four Safety relays is indicated by the four red LEDs above the LCD display. When the LED is on the NO terminal will be closed, and when the LED is off (and in all cases when the MSD has no power) the NC terminals will be closed.

The four LEDs to the right of the LCD display relate more to operational status as follows:

- STATUS / POWER shows that the unit is on and other various states, as shown in Table 13.
- COMM LOSS illuminates if one of more PSDs are either in danger of losing, or have lost, communication.
- E-STOP illuminates when one or more PSDs have an active E-STOP switch.
- The ERROR LED illuminates if there is an internal error.

8.3.2 MSD LCD

The MSD LCD gives guidance to the current operational state as detailed in Table 13.

The LCD display also provides additional information when using the five-button cluster to the left.

The MSD LCD remains illuminated.

represents the PSD sub-address

8.4 MSD Operational States

Table 13: MSD Operational States

	SIDE STATUS LED	SIDE COMM LOSS LED	SIDE ESTOP LED	SIDE ERROR LED	DISPLAY
MSD INACTIVE STATE					
No PSDs linked	Orange				LINKED PSD NONE
Any PSD Linking	Orange / Green Flashing				LINKING #
MSD ACTIVE STATE					
PSDs linked (normal mode)	Green				LINKED PSD # # # # #
ESTOP pressed	Red		Red		ESTOP # # # # #
Low RF signal	Red	Orange flashing			PSD (with low signal) # blinking
COMM LOSS longer than 30 seconds	Red	Red	Red		CL RESET MSD
ERROR				Red	

8.5 MSD Information and Setup

The MSD LCD display in combination with the five pushbuttons to the left allow access to three different screens plus the bootup screen that shows the current firmware revision, you can cycle around the screens by using the up down buttons on the MSD, the screens are;

- The default status screen, See the table above.
- The Ethernet/IP Address Setting screen, see the next section.
- The RF Received Signal Strength Indication (RSSI) screen; this shows the signal strength of each PSD that is currently linked, a lower number (around 50-60) indicates a very strong signal and a higher number (around 90-100) shows a weaker signal.

8.6 MSD Ethernet Interface

8.6.1 Ethernet LEDs

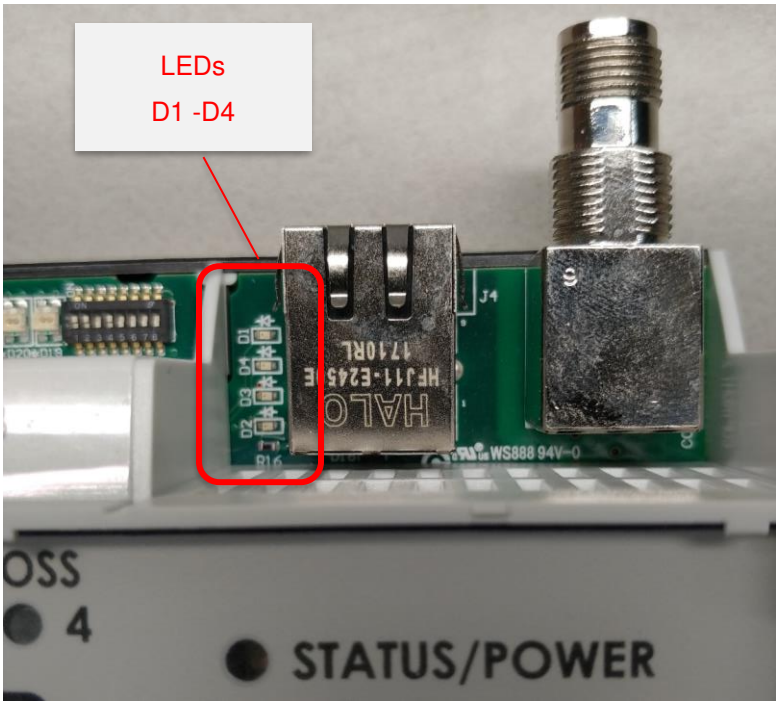


Figure 17: Ethernet Interface LEDs

The four single-color LEDs located beside the Ethernet connector, D1 to D4, provide a representation of the Ethernet interface status. They are installed in the following order from the board edge: D1–D4–D3–D2.

Table 14: Ethernet LEDs description

LED	FUNCTION	STATE	DESCRIPTION
D1	Link/Activity	ON Flashing	: MSD is connected to an Ethernet network : RX / TX Activity
D4	Ethernet Module Status	ON Flashing	: Ethernet module is powered and alive : Self-test in progress
D3	(*internal usage)*		
D2	*(internal usage)*		

8.6.2 IP Address Configuration

There are two methods for setting the MSD IP address: with the dip switches or with IPconfig software tool.

Configuration with the Dip Switches

This method supports DHCP and static IP addresses in the 192.168.1.x subnet.

If the top center cover is removed from the MSD, a dip switch can be found that is used to set the IP address.

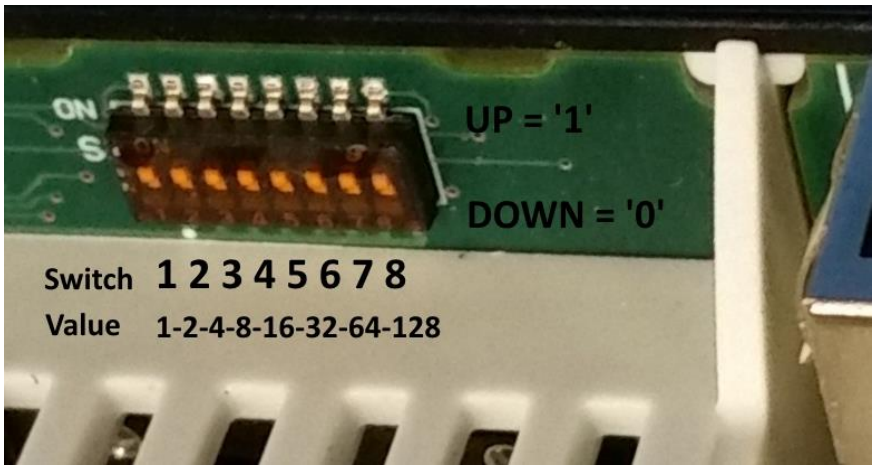


Figure 18: IP Address Setting

IP Address Setting is as follows:

- To set Dynamic Address Selection (DHCP); Set all DIP switches to '0'.
- To set a Static IP address the following process should be followed;
  - **Unlink and turn off all PSDs**
  - **Re-boot the MSD by removing and re-applying power.**
  - The MSD has a partly variable IP address (192.168.1.X);
    Set the dip switches to select 'X'
  - On the MSD, navigate to the MSD 'IP Address' display page using the up or down arrows
  - Press the MSD pushbutton at the center of the 5 buttons for confirmation: A message will appear for 10 to 15 seconds during reconfiguration: 'Setting IP Address...'
  - The new IP address will now be shown on the display.

Configuration with IPconfig software tool

IP Address can be configured with a third-party tool freely available from HMS, the manufacturer of the Anybus EtherNet modules used in the MSD. This method allows configuring the address to any subnet.

a. To download and install the **IPconfig** software tool onto your PC follow this link:

https://www.anybus.com/support/file-doc-downloads/anybus-support-tools?orderCode=tools

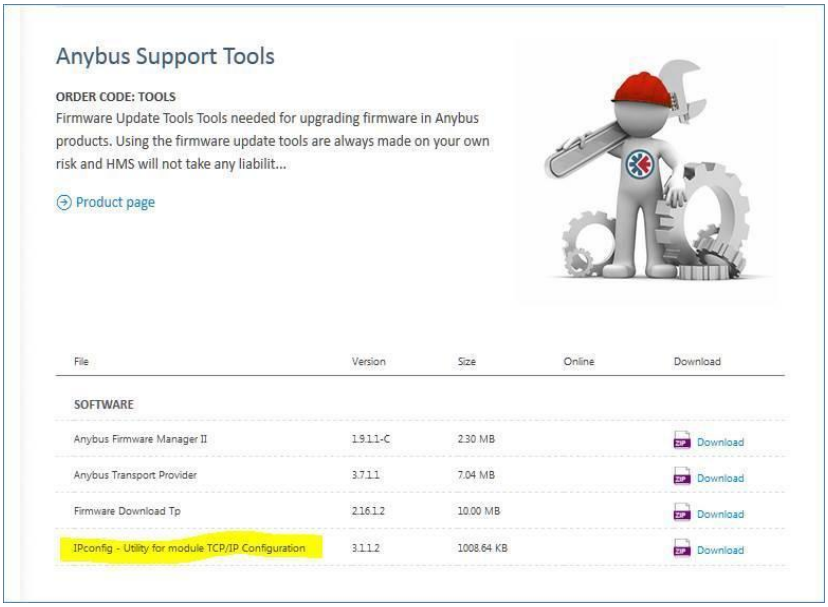


Figure 19: Anybus download webpage

b. Connect your PC to the same LAN the MSD is connected to. They do not need to be configured to the same subnet.

c. Start the tool. A simple window will open.

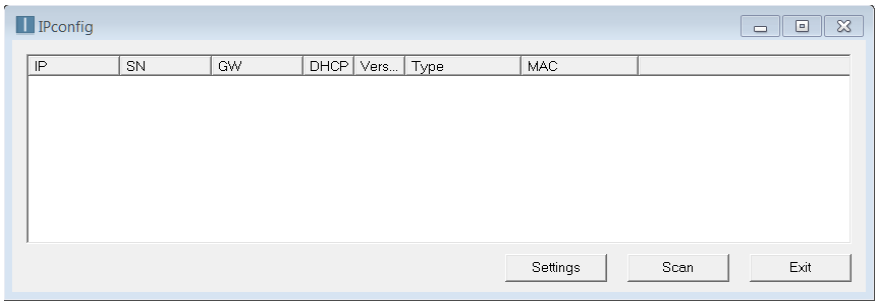


Figure 20: IP Configuration Window

d. Press the **Scan** button. All devices using Anybus Ethernet interface will be detected and shown.

e. Double-click on the device you wish to configure, and a new window will appear where you can set all IP parameters (IP address, subnet mask, gateway, etc.)

f. The MSD's current setting can be reviewed on the IP address screen

8.6.3 Ethernet Messages Specification

NOTE: The MSDs Ethernet/IP interface is NOT designed to be used for safety critical applications, it is exclusively a system status and information mechanism.

The MSD Ethernet interface supports EtherNet/IP and Modbus TCP protocols. The detail of the messages mapping is given in Appendix IV: Ethernet Configuration & Data Mapping .

8.7 MSD Operation

The MSD is a critical part of your machine control system. For reliable operation, it is important that it is operated within designed limits as directed and maintained in good order.

As long as the MSD remains powered on, the only interaction that may be required will be the result of one or more PSDs going out of RF range, resulting in communication loss for longer than 30 seconds. This condition requires the remaining (if any) users to confirm that the user of the offending PSD was not subject to an accident. To enforce this check, all PSDs will automatically unlink and the MSD will require its COMM LOSS RESET button to be pressed as a confirmation before any PSDs are able to re-link.

The Reset button is wired into one pair of the MSDs safety inputs; this enables the button to be placed at a convenient location near the operators.

8.8 MSD Installation

8.8.1 Safety Instructions for Installation

Only trained and qualified persons may perform installation and maintenance work.

NOTE: Ensure suitable and appropriate transient protection devices are fitted to relays contacts. Ensure correct wiring of the machines' main contactor and reset circuits. Use appropriate gauge wiring and under no circumstances use wire of less than 24AWG and ferrules should be used to protect against lose wire strands and proper insertion into the terminals. Thoroughly test each hard-wired and
Safe-E-Stop MSD prior to handing over to production.

- Isolate the system from the electrical power in accordance with the applicable regulations.
- Observe user-specific regulations.
- Only use suitable tools.
- Secure the installation area.

8.8.2 MSD Installation Notes on Enclosure

The MSD must be housed in a secondary enclosure for protection; a suitable option kit (2OPT-8637-A102) is available from Cattron. This enclosure provides visibility to the MSD, this is helpful to allow local users to better understand its operational status by reference to the MSD LEDs and LCD, also all required information can be obtained from the Ethernet port.

In any case the enclosure must provide an appropriate protection level for the environment in which it is installed and also maintain the MSD within its stated operating parameters, see appendix.

The enclosure should provide suitable mechanical rigidity, IP rating etc. the wiring should carry a suitable rating for voltage, current, insulation, temperature rating etc. The objective being the protection from fire and electrical hazards of the persons exposed to it.

It is suggested that an enclosure that is approved for use by a recognized authority such as UL, CSA, Intertek, TUV, etc. be selected. The optional enclosure (Cattron Part Number 2OPT-8637-A102) provides a suitable level of protection for most generic industrial and commercial environments.

8.8.2.1 MSD Dimensions

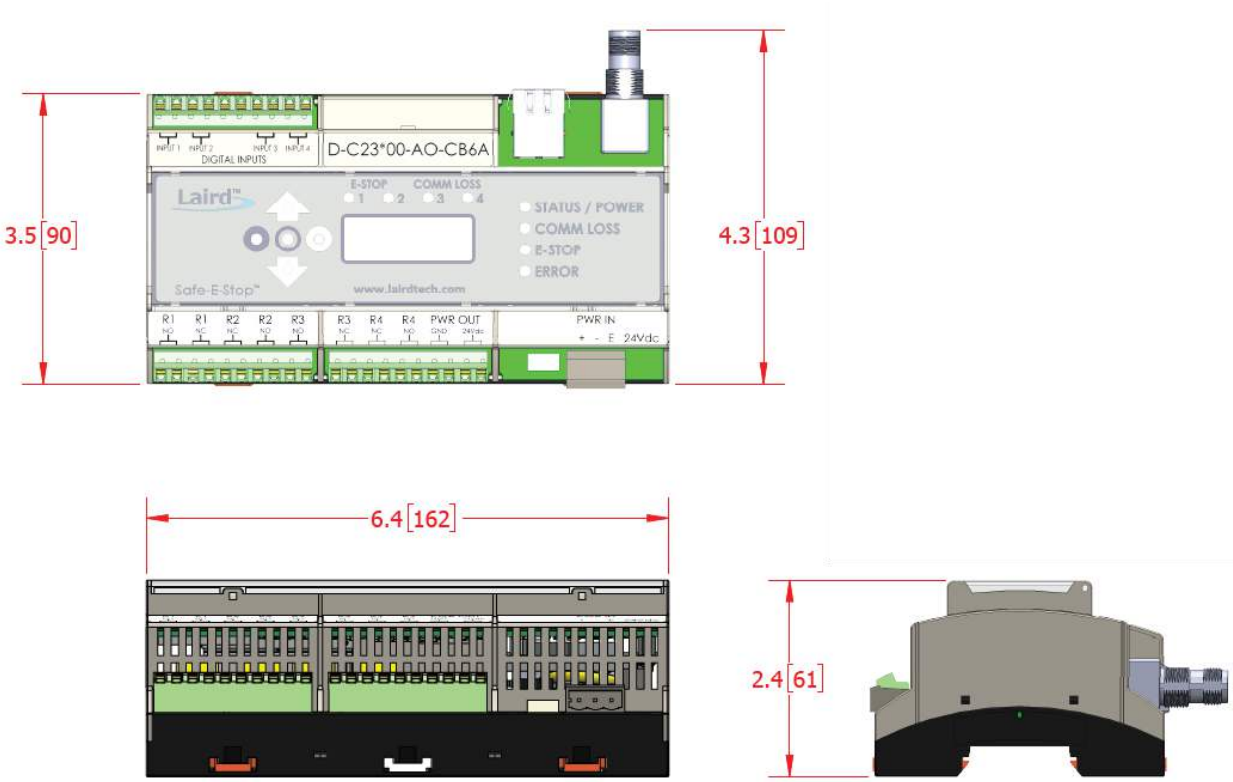


Figure 21: MSD Dimensions

8.8.2.2 Secondary Enclosure Option Kit (2OPT-8637-A102) Dimensions

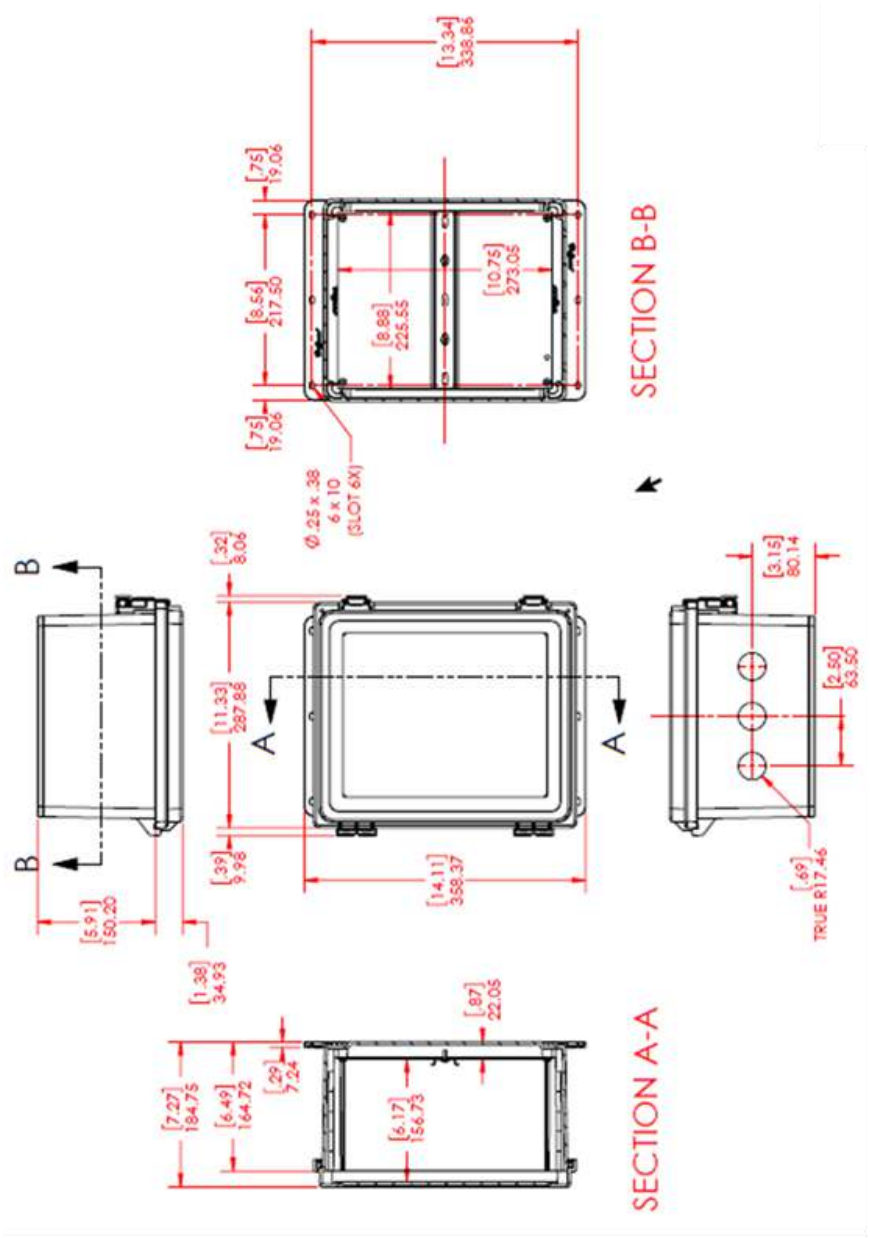


Figure 22: Secondary Enclosure Dimensions

The Secondary enclosure kit comprises the enclosure, an internal back plate with DIN rail mounted and three 25mm Conduit connection points, one for the antenna and two for the remainder of the wiring.

Metallic conduit must be bonded together and grounded, the backplane must also be grounded if a 110Vac supply is used or switched by the MSD.

Figure 23: MSD Optional Secondary Enclosure and Power Supply

8.8.3 General Rules for Mounting the MSD

The MCU is designed for DIN rail mounting, is rated at IP30, and must be protected from moisture and dust. Mount the MCU on a DIN rail in a secondary enclosure (see 9.8.2) (a suitable option kit is available from Cattron).

Select a location to minimize any possible interference from RF sources, such as motors. Ideally, install the MSD enclosure close to the area where the hard-wired E-Stop is located and where it can be viewed easily by users and maintainers. An approved enclosure with a window is ideal.

All wiring entering the enclosure must be terminated inside the enclosure.

To prevent interference on signal lines, do not install high and low voltage cables in the same conduit.

The MSD ships with an external antenna kit. When installing the external antenna, keep the antenna cable separate from all other wiring both inside and outside the MSD secondary enclosure.

If the MSD is in a stand-alone application i.e. not being used with a PLC, it will be necessary to also have a suitable DIN rail mounting 24Vdc power supply (an option available at time of order).

8.8.4 MSD Connections

Before installing the MSD, prepare an electrical wiring diagram that defines all electrical interface connections between the system and the equipment being controlled.

Cattron also advises you to first read the following topics of discussion at the same time; you should locate and refer to the example mainline drawing provided.

Do not exceed the relay rating, see Appendix V. When connected to contactors, protect these relay contacts with suitably rated transient suppression devices to maximize contact life expectancy and prevent whiskers growing.

Overload protection <=8A for the relays and 1A for the power supply and means to isolate the MSD from power when required should be in place. The Supply voltage is 24Vdc nominal (9-36Vdc), maximum current is 1A, nominal current at 24V is 250mA. The MSD is fitted with a protective fuse next to the DC input terminal (Cattron part number PRT-0001852) rated at 1A. An optional wide range (85-264VAC 47-63Hz 1A) power supply is available from Cattron.

Care should also be taken to provide suitably rated overload protection and isolation device when using the external power supply, this should also have a 1A overload protective device.

The Safety inputs are rated at 24Vdc +- 4Vdc, Omni-directional (non-polarized).

8.8.5 MSD Terminals

The MSD is fitted with spring clamp terminals to ensure reliable connections are continuously maintained.

These terminals require the use of a size 3 screwdriver to open the clamp for release, (CAUTION, do not press the release clamp too hard or it may damage the terminal); the ferrules are simply pushed in for insertion.

The use of ferrules to eliminate any possibility of wire strands shorting to adjacent terminals and to aid insertion into the spring clamps is required.

8.8.5.1 Terminal and Wire Specifications

NB: Wire sizes less than 0.459 mm^2, 24AWG are not allowed and the temperature rating must be approved for greater than 80 Celsius, for electrical safety certification compliance.

*For voltages greater than 24Vdc wire sizes of 18AWG (0.82mm^2) minimum are recommended, but in all cases the wiring must be correctly rated for its intended service,

Wire gauge : https://en.wikipedia.org/wiki/American_wire_gauge

Insulation: http://iq.ul.com/awm/stylepage.aspx?style=1015

Table 15: Terminals Maximum Wire Capacity

	INPUTS AND OUTPUTS	POWER IN	TEMPERATURE RATING	USE OF FERRULES
Size mm^2	0.459* to 1.5	0.459* to 2.5	>80C (176F)	Required
Size AWG	24* to 16	24* to 12	>80C (176F)	Required

8.8.6 Connecting the Antenna

Installation rules:

- Mount the antenna on the ground plane provided with the system. (Loctite 262 or equivalent glue could be used on the thread to tight the antenna to the socket when it is necessary.)
- The antenna should have a clear line-of-sight to the operating area and be within 300ft of all PSDs.
- The antenna extension (coaxial) cable must be no longer than required, and at most 50 feet long (without further reference to your supplier).
- Coaxial cable should be type RG58AU, similar or lower loss; appropriate cables are available from Cattron and may have been provided with your system.
- If the coaxial cable is going to an antenna remote from the MSD location, keep it separate from any power-carrying conductors and mount it within a metallic conduit system for protection.
- If the MSD is mounted within a secondary enclosure, correctly mount any metallic conduit with earth bonding to the secondary enclosure.

Figure 24: Typical Antenna

Figure 25: Antenna Mount

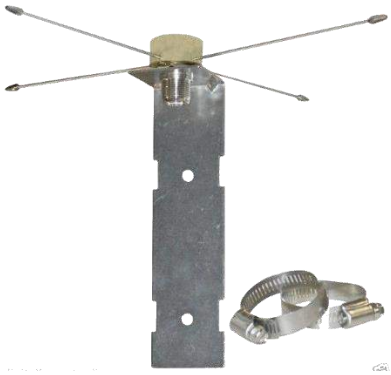


Figure 26: Ground Plane (typical)

Figure 27: Typical Antenna Assembly

There are minor physical differences between these parts, depending on the RF Band.

NOTE: Cable type may vary depending on required cable length; standard 25ft and custom length cables are available from Cattron.

9. System Commissioning

When the system has been installed, the functionality should be tested thoroughly as follows.

1. Charge the PSDs.
2. Verify that the MSD is in a protective secondary enclosure suitably rated for the environment.
3. Inspect all wiring to ensure it is correct, secure and neatly restrained according to good engineering practice and compliant with all local and national rules.
4. Any metallic conduit that was used should be suitable cross bonded when connecting to a non-metallic enclosure.
5. Verify that appropriate supply protection has been installed to the MSD
6. Verify that the correct operating voltage is being applied, 24Vdc to the MSD and that the polarity is correct; higher voltages require the optional power supply.
7. Verify that the MSD reset switch has been installed and is accessible to the operators.
8. Verify the antenna is mounted correctly and in such a way that it has good line of sight to the operating area and that the cables are secure.
9. Apply power and observe that the MSD powers up correctly and the LCD is displaying ‘LINKED PSD NONE’
10. Verify that the machine can be started as normal
11. Verify that each of the existing fixed E-Stop switches still operate correctly
12. Link each of the PSDs in turn and verify that each links correctly and operates the E-Stop correctly.
13. Ensure operators are trained in the use and features of the system, particularly in the use of the battery charger, logging on and logging off requirements, activation and release of the E-Stop switch, use of the belt clip and an understanding of the operating range and consequences of exceeding the operating range and use of the MSD reset switch in the event of a prolonged communication loss, finally expectations to maintain the equipment in good operating order.

10. System Decommissioning

If the system is to be decommissioned it is important to ensure that the machine is left in a fully operational state and that any hard-wired E-Stop switches are fully functional. Decommissioning must be carried out by competent and trained personnel. Equipment removed should be disposed of in compliance with local and national rules related to disposal and recycling of electronic equipment and batteries.

11. Parts Lists

11.1 System Part Numbers

The following part numbers must be specified with the RF Band letter in place of the 'X1' according to the following frequency chart. If you are unsure of the band you require, contact Cattron or your authorized distributor for advice.

Table 16: Frequency Chart for Part Number Matrixes

RF BAND	FREQ MHZ	WHERE TYPICALLY USED
A	418-419	China
B	428-434	EU, Brazil & others
C	447	EU Licensed
D	450-470	North America and Other licensed
E	869	EU
F	902-928	North America

Table 17: System Part Numbers Examples

PSS PART NUMBER	DESCRIPTION
PSS-1-A-R-1	PSS version 1, for Band A, One MSD, One Red PSD
PSS-1-B-R-2	PSS version 1, for Band B, One MSD, Two Red PSDs
PSS-1-C-R-3	PSS version 1, for Band C, One MSD, Three Red PSDs
PSS-1-D-R-4	PSS version 1, for Band D, One MSD, Four Red PSDs
PSS-1-E-O-5	PSS version 1, for Band E, One MSD, Five Orange PSDs
PSS-1-F-B-6	PSS version 1, for Band F, One MSD, Six Blue PSDs
PSS-1-D-R-8	PSS version 1, for Band D, One MSD, Eight Red PSDs
PSS-1-E-R-10	PSS version 1, for Band E, One MSD, Ten Red PSDs

The available options include up to 15 PSDs, Red is standard, and other colors may be available by request.

Systems include PSD belt clips, antenna, antenna mount, antenna ground plane, 25ft coaxial cable, user manual.

11.2 Accessory Parts Lists

Table 18: Individual Accessory Part Numbers

ITEM	PART NUMBER	DESCRIPTION
Spare or additional PSD	PSD-1-X-Y	SPARE PSD, must identify band (X) Color (Y) and master address (nnnn) of target system if ordered after main system
Spare MSD	MSD-1-X	SPARE MSD, must identify band (X) and master address (nnnn) of target system if ordered after main system
MSD Secondary Enclosure kit	2OPT-8637-A102	Enclosure IP66, NEMA 4, Clear hinged locking lid with DIN rail with 3 Cable glands
Power Supply 100-264Vac to 24Vdc 1A DIN Rail mount	2OPT-8637-A103	Power supply 110Vac – 24Vdc
Antenna Mount	PRT-0001816	Bracket, L Shape Wall Mount
Antenna Ground Plane	PRT-0001817	Ground Radials, NMO-N-Type, 800-960MHz (Bands E,F)
Antenna Ground Plane	PRT-0001818	Ground Radials, NMO-N-Type, 142-512MHz (Bands A,B,C,D)
Antenna mount and Ground plane kit 400	2OPT-8637-A101	KIT: Antenna mount & Ground Plane (Bands A,B,C,D)
Antenna mount and Ground plane kit 900	2OPT-8637-A201	KIT: Antenna mount & Ground Plane (Bands E,F)
Antenna Cable 25ft	2CAB-6861-A001	Coaxial Cable RG58, 25ft, (7.69m), TNC male to N-Type Male
Antenna Cable Nft	2CAB-9110-A601	Coaxial Cable, TNC male to N-Type Male, custom length N
Antenna 406-440MHz	PRT-0001814	Antenna 406-440MHz Band (A,B)
Antenna 430-490MHz	PRT-0001715	Antenna 430-490MHz Band (C,D)
Antenna 806-960MHz	PRT-0001815	Antenna 806-960MHz /GPS, 2.4GHz Band (E,F)
Full Antenna Kit, ABCD	PSA-1-ABCD	PSS version 1, One *Antenna mount and ground plane kit band A-B-C-D, One 25ft antenna cable.*
Full Antenna Kit, EF	PSA-1-EF	PSS version 1, One *Antenna mount and ground plane kit band E-F, One 25ft antenna cable.*
PSD Belt Clip Version 1	1PRT-8795-A001	PSD Belt Clip Back mount open face
Battery Charger Single Slot	1PRT-8778-A001	PSD Two-hour Battery Charger 110v-240Vac Single Slot
Battery Charger Six Slot	1PRT-8779-A001	PSD Two-hour Battery Charger 110v-240Vac Six Slot
Label sheet, multi-color logo	3LBL-8777-A101	Label sheet with 6 different color replacement logos for easy identification of the PSD
MSD Fuse	PRT-0001852	Fuse, Ceramic, 1.5A

12. Maintenance

The Safe-E-Stop personal safety system is a safety critical device that is designed, built, and maintained to the strictest of standards. There are no user serviceable parts within either the PSD or MSD.

For any repairs that may be required to these units, return to Cattron or an authorized service agent is required.

12.1 PSD Maintenance

Each time the PSD is put into operation, examine it for any obvious physical damage that may affect safe and reliable operation. When switching on the unit, verify that the Status LED, LCD display, and Haptic feedback
all work.

Your PSD battery will slowly degrade over time; by the time it has been charged and discharged 500 times it
will have lost 20% of its capacity. Cattron therefore recommends that you calculate your usage so that you can determine when the battery will need to be replaced and plan to ship the PSD back for service at that point
in time.

The PSD must remain in good physical condition and operated within its specified limits. The enclosure sealing
is carefully maintained by tamper proof screws set at a critical torque setting.

If any physical damage is apparent on the PSD that may compromise the sealing of the enclosure or operational performance, return it for repair.

The PSD may be cleaned with warm soapy water using common dish washing soaps. Stubborn stains may be removed with a cloth dampened with isopropyl (rubbing) alcohol.

Do not use:

- Heavy industrial cleaners
- Citrus or oil based cleaners
- Ethanol (denatured alcohol, methylated spirits)
- Acetone and acetone based cleaners
- Chlorine based cleaners (bleaches)

Do not store your PSDs at elevated temperatures; a temperature of 68°F or 20°C is much better for your battery life than 86°F or 30°C.

12.2 MSD Maintenance

The MSD must remain in good physical condition and operated within its specified limits. The enclosure it is mounted within must be rated for the environment and the inside of this enclosure kept free of condensation. Cable and conduit entry points must be kept in good condition.

If the MSD is damaged or faulty, return it to Cattron or an authorized service agent for repair.

If the enclosure housing the MSD is damaged, it should be repaired to prevent damage to the MSD.

The MSD should not need cleaning if it has been installed in a secondary enclosure according to the instruction in this manual; dust may be removed with a dry cloth or use of a light air jet or vacuum.

If the MSD fails to power on (No LEDs or display), verify that the incoming supply is correct on the 24V incoming connector first, if this is correct there should be 24Vdc between P4 terminals 7+8 and 9+10, if this is missing F3 adjacent to the incoming power terminal may be faulty. Take care because the MSD

may have more than one source of power on its terminals, isolate if necessary. Remove power from the MSD then F3 can be removed by carefully pulling the fuse straight out using tweezers or needle nose pliers. Replacement is the reverse of the removal procedure. F3 is a 1.5A, 125V slow blow ceramic fuse, Cattron part number PRT-0001852.

No further maintenance of the MSD should be required.

Appendix I: Part Number Unit Configuration

Table 19: RF Bands

BAND	START FREQ HZ	END FREQ HZ	TYPICALLY USED IN
A	418,000,000		China
B	433,077,500	434,777,500	EU, Brazil, Many Others unlicensed
C	447,000,000		EU Licensed
D	450,000,000	470,000,000	North America & Other Licensed
E	868,000,000		EU unlicensed
F	902,600,000	927,500,000	North America unlicensed

Table 20: PSD and MSD Configuration Examples

HARDWARE SECTION EXAMPLES				CONFIGURATION SECTION EXAMPLES												
				1st RF Channel			2nd RF Channel			Sub Address		Master Address				
Version of MSD/PSD		RF Band	PSD Color	1st Sub Band	Chan dec	Chan unit	2nd Sub Band	Chan dec	Chan unit	SAC Start	SAC End	MA1 (MSB)	MA2	MA3	MA4 (LSB)	
		A – Z		A – Z	0 –	99	A – Z or *	0 –	99	A – O	A –O	0 – E	0 – F	0 – F	0 – F	
PSD	1	A	R	A	1	1	*	0	0	A		0	0	0	1	
	1	B	B	B	1	2	A	0	0	B						
	1	C	G	C	6	4	B	0	0	C						
	1	D	O		0	4		2	6	K		C	B	6	A	
	1	E	R	Y	7	6	Y	0	0	L						
	1	F	R	Z	9	9	Z	0	0	O						
MSD																
	1	A		A	1	1	A	0	0	A	O					
	1	B		B	1	2	B	0	0	A	O					
	1	C		C	6	4	C	0	0	A	O					
	1	D			0	5		0	0	A	O					
	1	E		Y	7	6	Y	0	0	A	O					
	1	F		Z	9	9	Z	0	0	A	O	E	F	F	F	

Table 21: System Configuration Examples

ORDERING NUMBER EXAMPLES				CONFIGURATION DETAIL, FACTORY DEFINED												EXAMPLE CONFIGURATIONS
Version	RF Band	PSD Color	# of PSDs	1st Sub Band	Chan 1 D	Chan 1 U	2nd Sub Band	Chan 2 D	Chan 2 U	SAC Start	SAC End	MA1 (MSB)	MA2	MA3	MA4 (LSB)	
	A – F	R,O,Y,G,B		A – Z			A – Z or *					0 – E	0 – F	0 – F	0 – F	
PSS 1	A	R	1	A	1	1	*	0	0	A		0	0	0	1	Band 418MHz-1PSD-Red-Single Channel A11-PSD SA A-Master Address 0001
1	B	R	2	B	0	2	*	0	0	A	B	2	3	4	F	
1	D	R	3	C	1	6	*	0	0	A	C	E	2	3	4	Band 450MHz-3PSDs-Red-Single Channel C16s-PSDs SA A thru C-Master Address E234
1	C	R	4	H	0	4	*	0	0	A	D	1	2	3	4	
1	F	R	10	C	0	5	L	1	8	A	J	1	0	1	4	Band 915MHz-10PSDs-Red-Dual Channel C05L18-PSDs SA A thru J-Master Address 1010
1	D	R	6	V	0	5	*	0	0	A	F	C	B	6	A	Band 450MHz-6PSDs-Red-Single Channel V05-PSDs SA A thru F-Master Address CB6A
1	E	R	8	Y	0	6	*	0	0	A	H	E	F	F	F	
1	F	R	15	K	0	9	V	0	0	A	O	0	1	F	C	Band 915MHz-15PSDs-Red-Single Channel K09-PSDs SA A thru O-Master Address 01FC

Table 22: Example System Contents

EXAMPLE PART NUMBER	ITEMS INCLUDED IN SYSTEM PART NUMBER
PSS - 1 - A - R - 1	Band 418MHz - One Red PSD with belt clip - One MSD - One antenna accessory kit, One Antenna, One Manual
PSS - 1- D - R - 15	Band 450MHz - Fifteen Red PSDs with belt clips - One MSD - One antenna accessory kit, One Antenna, One Manual

Table 23: Antenna Accessory Kit Contents

	PSS VERSION	BANDS COVERED	MSD ANTENNA	MSD ANTENNA CABLE	GROUND PLANE	CO-AXIAL CABLE 25FT
ORDERING NUMBER EXAMPLE - Items Included						
PSA -	1 -	ABCD	1	1	1	1
PSA -	1 -	EF	1	1	1	1

Appendix II: RF Channel Number vs Operating Frequency

The operating frequency must be assigned in compliance with the rules set out in each RF band section below. Frequency is factory set, so at time of order the factory must be advised which RF channel should be selected based on knowledge of existing RF systems that are already operating on site.

Band B (433-434MHz)

This band starts at 433.0775MHz, channel spacing is 25KHz.
There are 69 channels available and channel frequency is coded with a letter and two digits.
Channel A00 will be 433.0775MHz. Channel A68 will be 434.7775MHz.

Band B Channel Spacing Rules

If the MSD is to be installed less than 100m (330') from another RF system (Cattron or other), then select a frequency at least 50KHz (2 channels) away from other frequencies in use.

Band D (450-470MHz)

This band starts at 450.000MHz, channel spacing is 12.5KHz.
There are 1600 channels available and channel frequency is coded with a letter and two digits.
Channel A00 will be 450.000MHz. Channel B00 will be 451.250MHz. Channel Q00 will be 470.000MHz.

Band D Channel Spacing Rules

If the MSD is to be installed less than 100m (330') from another RF system (Cattron or other), then select a frequency at least 50KHz (4 channels) away from other frequencies in use.

Band F (902-927MHz)

This band starts at 902.6MHz, channel spacing is 100KHz.
There are 349 channels available and channel frequency is coded with a letter and two digits.
Channel A00 will be 902.6MHz. Channel B00 will be 912.600MHz. Channel C49 will be 927.500MHz

Band F Channel Spacing Rules

If the MSD is to be installed less than 100m (330') from another RF system (Cattron or other), then select a frequency at least 200KHz (2 channels) away from other frequencies in use.

Appendix III: Approvals and Compliance Notifications

FCC Caution

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

EU Caution

Hereby, Cattron, declares that the Safe-E-Stop™ system is in compliance with the essential requirements and other relevant provisions of Directive 2014/53/EC.

Appendix IV: Ethernet Configuration & Data Mapping

EtherNet/IP

Table 24: Configuration Parameters for the Ethernet/IP Telegram

Parameter	Assembly Instance	Size (in bytes)
Input (T->O)	100	64
Output (O->T)	150	64
Configuration	3	0

Table 25: EtherNet/IP Device Identity information

Class: Identity Object (01h)				
Instances #1 Attributes				
#	**Access**	**Name**	**Type**	**Value**
1	Get	Vendor ID	UINT	1367 (Cattron)
2	Get	Device Type	UINT	12 (Communication Adapter Profile)
3	Get	Product Code	UINT	2
4	Get	Revision	Struct of:	Firmware revision number
		Major Revision	USINT	(co-controller firmware revision, 1st segment)
		Minor Revision	USINT	(co-controller firmware revision, 2nd segment)
5	Get	Status	WORD	Status summary of the device.
6	Get	Serial Number	UDINT	Serial number of HMS ABIC
7	Get	Product Name	SHORT_STRING	“Safe-E-Stop”

Table 26: Device Status (Attribute 5) - as Provided by HMS ABIC

Bits	Name	Value/ Description
0	Owned	1: Module has an owner
1	(Reserved)	Read as 0
2	Configured	1: Device has been configured (differently from out-of-the-box default)
3	(Reserved)	Read as 0
4-7	Extended Device Status	Supported values: 0: Unknown 2: At least one faulted I/O connection 3: No I/O connection established 4: Non-volatile configuration bad 6: At least one I/O connection in Run mode 7: At least one I/O connection established, all in idle mode Other: (Reserved)
8	Minor recoverable fault	
9	Minor unrecoverable fault	
10	Major recoverable fault	
11	Major unrecoverable fault	
12-15	(Reserved)	Read as 0

Table 27: Input (to Remote Device) Data Mapping

BYTE #	FIELD	TYPE	DESCRIPTION / VALUE
1	Message Format Revision	USINT (0-255)	Revision of the Message Format Definition. Set to 1
2	Message Update Counter	USINT (0-255)	Free running counter: Increments each time the Ethernet/IP message content is updated inside the MSD. This is value is independent from the Ethernet/IP packet rate or RF transactions rate.
3-4	System Address	UINT (0-65535)	
5	MSD status: Bit 0: ESTOP Bit 1: COMLOSS Bit 2: COMLOSS_RPERIOD Bit 3: TILT	bit field: BOOL BOOL BOOL BOOL	 Set to 1 when the MSD is in ESTOP state (a PSD ESTOP is pressed or a PSD sends a TILT indication) Set to 1 when the MSD is in COM LOSS state Set to 1 when the MSD is in COM LOSS state, and the COM LOSS recovery period is not expired yet. Set to 1 when a PSD TILT event is detected
6	PSD1 ID	USINT (0-255)	IDs of the PSD currently linked to MSD (up to 5 PSD) 0 : empty field 1-15 : PSD ID 16-255 : not used
7	PSD2 ID	Same	
8	PSD3 ID	Same	
9	PSD4 ID	Same	
10	PSD5 ID	Same	
11	Offending PSD ID	USINT (0-255)	PSD ID broadcasted by the MSD to all other PSDs after an ESTOP or COMLOSS event, to be shown on the PSD displays. 0 : no PSD event (if MSD status is zero), or ESTOP due to MSD wired ESTOP button 1-15 : Offending PSD ID 16-255 : not used
12	MSD display buttons Bit 0: up arrow Bit 1: down arrow Bit 2: right arrow Bit 3: left arrow Bit 4: center button Bits 5-7: Reserved	bit field: BOOL BOOL BOOL BOOL BOOL -	 Bits are set to 1 when the corresponding button is pressed Future use. Set to 0
13-16	Reserved	-	Future use. Set to 0
17	PSD1 – Status byte 1 Bit 0: TILT WARNING indicator Bit 1: REQUEST button pressed Bit 2: GREEN button – 2nd step Bit 3: LOW RSSI indicator Bit 4: LOW BATT indicator Bit 5: RELEASE request Bit 6: Reserved Bit 7: ESTOP pressed	bit field: BOOL BOOL BOOL BOOL BOOL BOOL - BOOL	 Set to 1 when a 'Link Release' Request is being processed for that PSD. This bit turns off few seconds after the PSD is de-linked.
18	PSD1 – Status byte 2 Bit 0-6: Reserved Bit 7 : TILT indicator	bit field: BOOL BOOL	 Future use. Undefined value
19	PSD1 – RSSI	SINT (-128 to 127)	Received signal strength of last telegram received, in dBm
20-22	PSD2 Status bytes 1-2 & RSSI		(same structure as PSD1)
23-25	PSD3 Status bytes 1-2 & RSSI		(same structure as PSD1)

26-28	PSD4 Status bytes 1-2 & RSSI		(same structure as PSD1)
29-31	PSD5 Status bytes 1-2 & RSSI		(same structure as PSD1)
32	Reserved		Future use. Set to 0
33	MSD transactions counter	USINT (0-255)	Free running counter: increments each time a RF transaction is initiated by the MSD.
34	PSD1 responses counter	USINT	Free running counters: each counter increment each time a valid response is received from the corresponding PSD. Valid responses are responses with right System Address and no CRC or framing error With the current transaction structure, if no responses are missed, each PSD response counter increments twice as fast as the MSD transaction counter
35	PSD2 responses counter	USINT	
36	PSD3 responses counter	USINT	
37	PSD4 responses counter	USINT	
38	PSD5 responses counter	USINT	
39-64	Reserved		Future use. Set to 0

***NOTE – TILT function :** The TILT indicators mentioned in the table above are always reset to '0', as the TILT function is not enabled in the standard PSD configuration.

Modbus TCP Configuration

The MSD implements a Modbus TCP server that provides access to the I/O Data.

The Modbus TCP server is available on both the EtherNet/IP and PROFINET versions.

- The server is accessible over **TCP port 502**
- Up to 8 simultaneous Modbus/TCP connections are supported

Table 28: Supported Function Codes

MODBUS FUNCTION	FUNCTION CODE	DESCRIPTION
Read Coils	1	Output Data Readback (discrete)
Read Discrete Inputs	2	Input Data Read (discrete)
Read Holding Registers	3	Output Data Readback (16-bit register)
Read Input Registers	4	Input Data Read (16-bit register)
Write Single Coil	5	Output Data Write (discrete)
Write Single Register	6	Output Data Write (16-bit register)
Write Multiple Coils	15	Output Data Write (discrete)
Write Multiple Registers	16	Output Data Write (16-bit register)
Mask Write Register	22	Output Data Modify (16-bit register)
Read/Write Registers	23	Output Data Write and Readback in a single operation (16-bit register)

Table 29: Exception Codes

CODE	NAME	DESCRIPTION
01h	Illegal function	The function code received in the query is not supported
02h	Illegal data address	The data address received in the query is outside the initialized memory area
03h	Illegal data value	A value contained in the query data field is illegal

The Input registers follow the same structure as the EtherNet/IP messages, where the 64 bytes from the EtherNet/IP messages are mapped to 32 Modbus 16-bit registers.

Table 30: Input Registers

MODBUS REGISTER ADDRESS	MSB	LSB	REFERENCE: ETHERNET/IP MESSAGES BYTES #
1	Registers mapping Revision	Input Registers Update Counter	1, 2
2	System Address - MSB	System Address – LSB	3, 4
3	MSD status	PSD1 ID	5, 6
4	PSD2 ID	PSD3 ID	7, 8
5	PSD4 ID	PSD5 ID	9, 10
6	Offending PSD ID	MSD display buttons	11, 12
7	(reserved)	(reserved)	13, 14
8	(reserved)	(reserved)	15, 16
9	PSD1 – Status byte 1	PSD1 – Status byte 2	17, 18
10	PSD1 - RSSI	PSD2 – Status byte 1	19, 20
11	PSD2 – Status byte 2	PSD2 - RSSI	21, 22
12	PSD3 – Status byte 1	PSD3 – Status byte 2	23, 24
13	PSD3 - RSSI	PSD4 – Status byte 1	25, 26
14	PSD4 – Status byte 2	PSD4 - RSSI	27, 28
15	PSD5 – Status byte 1	PSD5 – Status byte 2	29, 30
16	PSD5 - RSSI	(reserved)	31, 32
17	PSD1 responses counter	PSD2 responses counter	33, 34
18	PSD3 responses counter	PSD4 responses counter	35, 36
19	PSD5 responses counter	(reserved)	37, 38
20 -32	(reserved)	(reserved)	39 – 64

Output Registers

32 output registers are implemented. No functions are defined for this release. Writing output registers have no impact.

Appendix IV: Troubleshooting

System

Communication Losses

Repeated communication losses from random PSDs may be caused by one of four factors:

Required Operating Range is Too Long

Required operational range is beyond system capability within the operating environment. The system range will be about 300ft (100m) line of sight to the MSD antenna, but when machinery and obstacles are interposed, this range will be reduced. If operating range is too short even when line of sight is within the stated range, check the next three items. In the case of a 'Frequency Diversity' (Dual Channel) system, if both channels are less than solid, check for common issues such as antenna, cable and faulty equipment, if only one channel is below nominal, look for interference issues.

Bad Antenna or Coaxial Cable

Check that the coaxial cable is securely attached at the MSD and at the antenna ground plane, and that the cable is dry and undamaged. Also check that the antenna is securely attached to the ground plane.

If the above are correct, check the resistance of the coaxial cable at the MSD between center and screen:

- If it is short circuit, the cable is faulty.
- If it is open circuit, then short circuit the connector at the antenna end and make sure that the connector at the MSD end now shows a short circuit. If not, the cable is faulty.
- If all is OK, remove the short at the antenna end and reconnect the cable at both ends.

RF Interference

The PSS can only operate correctly in the absence of RF interference.

If RF interference is suspected, an audit of other wireless systems in the area should be conducted, if a problem is found remove the source of interference or the Safe-E-Stop system frequency will need to be reprogrammed at Cattron or an authorized service facility.

NOTE: Use of Licensed frequencies will normally provide a protected RF environment; use of unlicensed frequencies will require careful management on a site to ensure reliable system operation.

MSD Radio is Faulty

If the items above have been eliminated as possibilities, the radio in the MSD may be faulty. This can be checked by returning the MSD to Cattron for analysis and repair.

PSD

Error Light is On

The Error LED will be flashing.

Generally, if switching the PSD off and back on does not resolve the problem, return the device to Cattron or an authorized service facility.

Error 1 Shown on LCD

The Main controller has an error.

The PSD will remain in this state for 3 minutes and then turn off.

Return unit for service.

Error 2 Shown on LCD

The unit is unable to read the battery state.

Displays ERROR2 for 30 seconds and then turns off.

Haptic pulses three times when the fault is initially detected

The operator can unlink during this 30 seconds period to avoid a COMLOSS.

Return unit for service.

Error 3 Shown on LCD

The unit is unable to correctly read or decode the status telegrams for other PSDs or MSD.

Displays ERROR2 for 30 seconds and then turns off.

Haptic pulses three times when the fault is initially detected

The operator can unlink during this 30 seconds period to avoid a COMLOSS.

Return unit for service.

Battery Operating Time is Shorter than Expected

The PSD operates for 14+ hours on a fully charged battery at a temperature of around 20°C. Very low temperatures will reduce this time and this is a feature of the battery technology and cannot be changed; at minus 20C the capacity will be reduced by about 30%.

A battery that has been charged more than 500 times will have lost an additional 20% of its capacity. This can be rectified by having a new battery installed by Cattron or an authorized service facility.

Cannot Link to MSD

If 5 PSDs are already linked to the MSD, it will not be possible to link another PSD.

MSD Not Seen

A PSD and MSD must have matching configurations as identified on their labels; check the configuration labels for a match.

If other PSDs are successfully linked to the MSD and the configuration is correct, then this PSD is faulty. Return to Cattron or an authorized service facility.

Operating Range is Short

If all PSDs have the same issue, see the System section above. If only one PSD has the problem, the PSD is faulty; return to Cattron or an authorized service facility.

MSD

Error Light is On

Generally, if switching the MSD off and back on does not resolve the problem, return to Cattron or an authorized service facility.

No Power

If all lights are off, request the services of an authorized and trained service agent to conduct the following analysis and repair.

Verify that the 24Vdc input supply is available and if necessary check the fuse to the left of the supply terminal and replace if necessary.

If the fuse blows again, disconnect all input and output terminals and replace the fuse again. If it blows again, the MSD is faulty; return to Cattron or an authorized service facility. If the fuse no longer blows, check all external wiring for an intermittent short circuit on the 24V line and correct.

Operating Range is Short

If all PSDs have the same issue see System section above.

Cannot Reset Unit after a PSD Communication Loss

Check the wiring and voltages between the reset input, the external reset button, and the 24V supply to the reset button. If this supply is not common to the MSD supply, ensure the 0v line of the external supply is connected to the 0V line of the MSD supply.

Battery Charger

The chargers require no special maintenance, but in the event of damage to the unit, the external power supply or cord, contact Cattron customer service for a replacement.

Make sure contacts in charging pod and on the PSD are clean. If contacts require cleaning, disconnect charger from power supply and wipe with a dry, lint free cloth.

Do not charge PSD batteries below 0° Celsius or above 40° Celsius.

Appendix V: Technical Data and Specifications PSD and MSD

ELECTRONIC DATA	
Functions	E-Stop, Link (activate), Unlink (deactivate) and dual-step Permissive functions.
Digital Circuitry	Dual-processor self-monitoring safety technology
Response Time E-Stop	320mS typical
Radio Link Communications	Black Channel secured
MSD Supply voltage	24Vdc (18-36Vdc) 1Amax.
MSD Optional Power Supply	85-264VAC 47-63Hz 1A
PSD Battery	Rechargeable Li-ion >14h at 20° C 3-hour re-charge
Relay outputs	150VAC/DC, 10mA minimum to 6A maximum resistive load, Overvoltage category II according to IEC60364
Ethernet/IP port	Full diagnostics data (not safety rated)
EMC MSD	ETSI EN 301 489-3 V2.1.1 ▪ EN55032: Class A ▪ EN 61000-4-2: Level II ▪ EN 61000-4-3: 30V/m ▪ EN 61000-4-5:2006 ▪ EN 61000-4-4: Level III
EMC PSD	EN 301 489-3 V2.1.1 ▪ EN 55032: Class A ▪ EN 61000-4-2: Level II ▪ EN 61000-4-3: 30V/m

OPERATION AND INDICATION	
E-Stop switch	Dual force guided contacts
PSD Buttons	1 dual-step permissive 1 request to link 1 request to unlink
PSD LEDs	4 Operational Status
MSD LEDs	4 Operational Status 4 Safety Relay Status
PSD / MSD LCD	Status reporting
PSD HAPTIC	Operator Alerting

MECHANICAL DATA	PSD	MSD
Weight **Dimensions** **(L x W x H)**	Approx. 200g (8oz.) 138 x 65 x 54mm (5.4 x 2.6 x 2.1 in.)	162 x 109 x 61mm (6.4 x 4.3 x 2.4 in.)
Housing Material	High-impact polymer and rubber bumper	Polymeric
Housing Protection Rating	IP 67 Outdoor use	IP30 Secondary enclosure is required. Option is available.
Operating Temp. **Battery Charging**	-20° to +60°C / (-4° to +140°F) 0° to +40°C / (32° to +104°F)	-20° to +60°C / (-4° to +140°F)
Shock, Vibration and Free Fall	Shock IEC60068-2-27 Vibration IEC60068-2-6 Free Fall IEC60068-2-31	Shock IEC60068-2-27 Vibration IEC60068-2-6 Free Fall IEC60068-2-64
Humidity		RH 10-95% non-condensing Class 2
Altitude		<2000m
Environment	Pollution degree 3	Pollution degree 2
RF		
Frequency Range & Power	433-434MHz @ 5mW 450-470MHz @ 10mW 902-928 MHz @ 1mW	
Antenna	PSD Internal	MSD External

STANDARDS	
Compliance	CE ISO 61508 SIL 3 Comm loss Function ISO 61508 SC 3 Stop Functions TÜV NORD certified ISO 13850

ACCESSORIES	
PSD Mounting **MSD Mounting**	Ergonomic belt mounting DIN rail
Battery Charger	Processor-controlled three-hour fast charger; One-bay and six-bay versions available.
Labeling	Pre-configured and marked

Appendix VI: Technical Data and Specifications Battery Charger

CHARGER MODEL	1PRT-8778-A001	1PRT-8779-A001
Dimensions (W x L x H)	101 x 137 x 81 mm 3.9 x 5.4 x 3.2 inches	509 x 148 x 94 mm 20.0 x 5.8 x 3.7 inches
Weight (Charger Only)	290 g / 0.64 lbs.	1.63 kg / 3.6 lbs.
Weight (Power Supply)	153 g / 0.34 lbs.	0.86 kg / 1.9 lbs.
Compatible Device	PSD-1-x-x	PSD-1-x-x
Operating Temperature	0° C – 32° C / 32° F – 104° F	0° C – 40° C / 32° F – 104° F
Storage Temperature	-20° C – 60° C / -4° F – 140° F	-20° C – 60° C / -4° F – 140° F
Power Supply Input	100V–240V AC / 50–60 Hz / 0.58A (max)	100V–240V AC / 50–60 Hz / 2.2A (max)
Charger Input	9V DC / 2.2A	12V DC / 7.0A (DC port) 12V / 7.0A - 24V / 3.5A (hardwire port)
Charger Output	4.2V DC / 1.3A	4.2V DC / 1.3A (each position)
Charge Rate	1.3A, 3 to 4-hour charge cycle	1.3A (each position) 3 to 4-hour charge cycle
Approvals (Charger)	FCC / CEC / DOE	FCC / CEC / DOE
Approvals (Power Supply)	UL / FCC	UL / FCC
RoHS	Compliant	Compliant

Appendix VII: Safety Manual for Safe-E-Stop

Functions

The Safe-E-Stop product has been designed to provide a wireless Emergency Stop function. Since it is a wireless system, any loss of communication between the Machine Safety Device (MSD) and any of the linked Personal Safety Devices (PSDs) will result in the machine stopping.

A safety function must be fully automatic hence there is one safety function in the system; this is the communication loss function. This function is controlled by the MSD, it ensures that if communication with one of the linked PSDs is lost for more than 2 seconds, the MSD will open all of its safety relays. This safety function has a safety performance level of SIL3 according to IEC61508:2010, vol 1-7.

The Emergency Stop function is implemented between any linked PSD and the MSD. The Emergency Stop function is not fully automatic because the initiating event occurs when an operator presses the emergency stop switch. The design of the system from this point to the opening of the E-Stop safety relays of the MSD has been designed to the Systematic Capability of 3 as per IEC61508:2010, vol 1-7.

Once the E-Stop event is triggered, the Stop function has a safety performance level of SIL3 according to IEC61508:2010 vol 1-7.

Failure Modes

PSD

Any failure of the PSD will lead to the PSD transitioning into a Safe State. In Safe State, the PSD will terminate all wireless communications; the MSD will as a consequence detect a communication loss and open all the safety relays (E-Stop and COMM LOSS), this will bring the machine to a safe state. The display on the PSD will show ERROR 1 and the Error LED will flash.

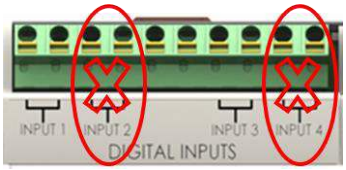
MSD

Any failure of the MSD will lead to the MSD transitioning into a Safe State. In Safe State, the MSD will open all safety relays and stop all wireless communication with the PSDs. The display on the MSD will show ERROR 1 and the Error LED will flash.

Operational Constraints

The PSD is a personal safety device; it is the responsibility of the operator/user to verify that the PSD is linked. In an environment where multiple systems are in use, the operators need to be trained to verify that the correct PSD is in use for the machine being used. Several methods are suggested to help the operator select the right PSD; clear identification of the machine under control that corresponds with the configuration labels on the PSD side labels can be used. A color code can also be used such as the colored logo label option or the different colored PSD option. Finally, by connecting a PLC using the Ethernet/IP interface, the PLC could provide some indication of each PSD that is connected and by using the green button on the PSD the PLC could also provide a visual or audible indication that it is in fact acting on the intended machine.

The input contacts INPUT 2 and INPUT 4 have no assigned function and SHALL NOT BE CONNECTED. They are reserved for future use.



Several warnings and cautions have been inserted in the manual and needs consideration, they are found in chapter 2, sections as follows:

2.1 MSD wiring warning

2.2 Verification of configuration warning

2.3 Verification of correct linking warning

2.4 Placement of PSD in charger warning

2.5 No serviceable parts warning

2.6 Regulatory warning

2.7 Awareness of PSD range and Hazards around the machine

2.8 The system may cause unexpected stop of the machine

2.9 The Safety analysis shall consider the reaction time of the system

2.10 Ethernet may not be used for safety critical function

2.11 General Safety Information

2.12 Intended Use

2.13 Improper Use

2.14 Equipment rating warning

Safety Performance Level

The Safety performance level provided below was calculated with the Safety Relays R1 NO and R2 NO for the Emergency stop function are connected in series

The Safety performance level provided here was calculated with the Safety Relays R3 NO and R4 NO for the Communication loss function are connected in series.

FUNCTION TYPE	ACTION	SAFETY PERFORMANCE LEVEL	PROBABILITY OF FAILURE PER HOUR (PFH)
Safety Function	COMMUNICATION LOSS	SIL3	PFH = 1.58248e-09
ESTOP operation	ESTOP	SC3 (SIL3 after initiating event)	PFH = 1.90565e-09

Due to continuous product improvement, the information provided in this document is subject to change without notice.

Cattron Support
For remote and communication control systems support, parts and repair, or technical support, visit us online at:
www.cattron.com/Contact
Safe-E-Stop™ is manufactured at the following location:
Cattron North America Inc., 655 N River Rd NW, Suite A, Warren, OH 44483