

SAFEMINE CAS INSTALLATION GUIDE

Firmware V3.0

Version Control

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Topic:	This document is the reference manual for the installation, configuration and operation of SAFEmine units and tools.		
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1. Preface

1.1. Objective of this document

This document is the main reference manual for the installation and configuration of SAFEmine CAS MainUnits and its associated accessories. It shall serve the technical personnel to correctly set up installations and enable them to maximize the SAFEmine CAS performance.

1.2. Operation Safety Precautions

Operating any type of vehicle inside a mine at any time of the day is an inherently dangerous activity which is associated with considerable risks for crew, passengers, third parties, pedestrians, other vehicles and any object in its vicinity. In order to make full and safe use of SAFEmine QC200 series products, it is absolutely essential to be fully aware of the risks, operating conditions, restrictions and limitations associated with their use, including to ensure a proper installation and to perform regular software updates. This includes familiarity with and strict adherence to the Operating Manual and the Installation Manual.



A vehicle equipped with the SAFEmine System must be operated in the same safe manner as if the SAFEmine System was not installed. The system is not a substitute for normal safe driving procedures and may never be relied upon.

The SAFEmine System will provide no warning for some hazards, such as vehicles, obstacles, and other objects not equipped with properly operating SAFEmine devices.

SAFEmine products are intended as an additional tool in determining potential traffic threats, supporting an alert and conscientious driver. SAFEmine products are never to be used in any application where failure of the products could result in personal injury or material damage. Before using, the latest versions of the respective manuals are to be consulted for familiarization with product operation and limitations.

SAFEmine makes no warranties with respect to the product. In no event will SAFEmine Ltd be liable for lost use, profits, revenue, cost of procurement of substitute goods, or any damages.

SAFEmine products may not be used in the USA and Canada unless the operator or customer has been authorized to do so in writing by SAFEmine Ltd.

Customers agree to indemnify and hold harmless SAFEmine Ltd., its subsidiaries, and affiliates, and their respective successors and assigns, from and against all third party claims, loss, damage or expense, and any other liabilities whatsoever, which may be incurred by SAFEmine Ltd. with respect to any of the SAFEmine products.

In addition, SAFEmine Ltd.'s current "General Terms and Conditions of Sale" apply.



1.3. Installation Safety Precautions

All work done to install the SAFEmine Collision Avoidance System shall be done in accordance with safe work standards and shall comply with the latest Health, Safety, and Reclamation Code for mines in the local jurisdiction.

1.4. Legend of Symbols



Attention Symbol: Indicates a required actions and conditions.



Information Symbol: Indicates best practices and recommendations.



Document Symbol: Indicates a reference to an external document for in-depth information.



Contact Symbol: Call SAFEmine Support for further assistance and information.

2. Introduction

2.1. Purpose of the CAS system

The main task for SAFEmine QC2xx series products is to support the operator while he scans the space ahead and around the vehicle with his own eyes, cameras and other aids. SAFEmine products are simple to use and are designed not to distract the operator from operating the vehicle.

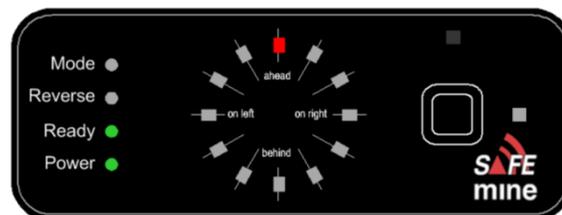
2.2. The Collision Avoidance Principle

The SAFEmine collision avoidance device is equipped with a GPS receiver, additional sensors and an RF transceiver. The GPS receiver will provide the unit with a position, speed and heading. This information is continuously broadcasted over the air thanks to the RF transmitter/ receiver.

A vehicle will receive the information from all the surrounding vehicles while transmitting its own information. Based on this information, sophisticated SAFEmine algorithms will determine a collision risk level and indicate it to the operator of the vehicle via the display.

As every vehicle has different dynamics and every mine has different rules, SAFEmine provides a list of features and configuration possibilities which can custom tailored to the needs of our customers.

The display, either remote (QC230/QC24x/QC250) or integrated (QC235), warns the driver of potential threats, gives the status of the device, and allows user interaction with the Square button. Additionally to the LED indicators it also has a buzzer, an ambient light sensor and a noise sensor.



The image above shows a display while the device is operating in a vehicle, traveling forward ('Reverse LED' is OFF) and a vehicle (equipped with another SAFEmine device) is detected. The led on in the 12 o'clock position indicates the presence of a vehicle in front. Several colors and sounds indicate different threat levels. Depending on the distance to other vehicles and on the configuration parameters an alarm might be audible. The center compass displays direction and distance of vehicles within the RF transmitter / receiver range but it also serves to display error codes in the case a system failure was detected.

The LEDs on the left side of the display show the status of the SAFEmine device. They indicate if the device has enough power, has acceptable GPS reception or is traveling backwards as well as other information about the system.

Depending on the configuration, pushing the square button on the right of the display can trigger three functions:

- 1) Flag special events in the unit's log-file: for example an incident or a situation where the user believes the SAFEmine device didn't perform as expected.
- 2) Announce the ID of nearby vehicles: If the 'Voice Option' is enabled, surrounding vehicles are announced.
- 3) Acknowledge an alarm: The operator can stop the warning sound for example when being towed by another vehicle.

Pressing the button for 3 seconds or longer seconds will restart the SAFEmine unit.

All alarms are indicated during a minimum of 1.5 seconds to allow the operator to see and react to it. The alarm will stop once the threat is gone or if one of the two vehicles stops.

For further information regarding the collision avoidance and proximity awareness offered by the SAFEmine system please contact your support responsible or write to support@safe-mine.com requesting the operator training.

2.3. Technology used

The SAFEmine system – based on technology widely used in aviation – consists of a main unit, an operator's interface (both output and input) and a dual antenna (one for GPS, one for radio communication). Depending on the product selected, the operator's interface is either integrated into the main unit or mounted as a separate display unit. The main unit contains all main sensors (GPS engine, radio transceiver, micro-controller, memory, data interfaces and a series of sensors), The operator interface provides both a directional display of nearby traffic and danger, the beeper/loudspeaker for acoustical warnings and one button for input.

SAFEmine QC200 series products receive position and movement information from an internal high-sensitivity 50 channel GPS receiver with an external antenna. Additional sensors and logic further enhance the accuracy of position measurements. The predicted driving path of the vehicle, in which a SAFEmine QC200 series product is installed, is calculated by the main unit and the obtained information is transmitted by radio as a low power digital burst signal at frequent intervals. Provided they are within receiving range, these signals are received by other vehicles also equipped with SAFEmine QC200 series products. The incoming signal is compared with the driving path calculated and predicted for the second vehicle, taking into account configuration parameters like maximum acceleration or vehicle dimension. At the same time, SAFEmine QC200 series products optionally compare the predicted driving path with known static obstacle data, e.g. electric power lines.

If a SAFEmine QC200 series product determines the risk of dangerous proximity to another vehicle or to an obstacle equipped with a SAFEmine QC200 series product, the unit gives the operator a warning of the greatest danger at that moment. This warning is given by a buzzing sound (beep) and bright light emitting diodes (LED). The display also gives indication of the threat level, plus the horizontal bearing to the threat.

The operating range is very dependent upon the antenna installation in or outside the vehicle. The normal range is about 500m for line-of-sight operations, but up to 2 km may be achieved in individual cases.

For their radio communication, SAFEmine QC200 series products use a proprietary patent- and copyright-protected protocol. Any non-licensed use, dissemination, copying, implementation or reverse engineering of the SAFEmine QC200 series radio communication protocol, their hardware and software or parts of it is forbidden by law and will be prosecuted. SAFEmine is a registered trademark and may not be used without license.

2.4. Limitations of the System



SAFEmine is **not** designed for use

- in deep or narrow open pit mines where availability of GPS satellites is not sufficient
- in any other application than open pit mining
- on vehicles with excessive vibration

SAFEmine units are only to be used with other SAFEmine units, otherwise inconsistent function may occur. SAFEmine Ltd. cannot assume any liability from correct or incorrect use of above specified products other than regular warranty according to SAFEmine Ltd. General Terms and Conditions.

3. Hardware Components

3.1. Main Unit

3.1.1. Overview

The main unit houses the GPS receiver, RF transceiver, processor, interface logic and additional sensors. The housing is made of aluminum with plastic end-bezels. All connectors are on the backside of the unit.

The main unit is produced in six different models: QC230, QC235, QC220, QC24x, QC250 and QN555.

All units, with the exception of the QN555, are enclosed in a black anodized aluminum casing in order to minimize glare. The QN555 has a plastic, watertight enclosure for outdoor operation.

	QC230	QC235	QC220 ¹	QC24x	QC250	QN555
CAS	■	■		■	■	■
GSM/LTE/UMTS/ LTE			■	■		
WiFi					■	
Integrated display		■				
Digital IOs	1 ²	1 ²	4	4	4	
Digital Inputs			2	2	2	
Analog Inputs			2	2	2	

¹ Always delivered with speaker and voice option.

² Early versions had limited IO functionality. Please consult chapter 3.4 for specific information

3.1.2. QC230 & QC235



The QC230 and QC235 models represent the basic line of SAFEMine CAS units. The QC230 is meant to be installed with an external display while the QC235 unit offers a built-in display but can also be upgraded with an external display. Installation of these units can be realized with a minimal amount of effort.



3.1.3. QC220 & QC24x



The QC24x and QC220 models provide networking capability through GSM/LTE connectivity and are meant to be operated with an external display. This is in addition to the functionality offered by the QC230 and QC230. This enables the support of online vehicle tracking. To enable this feature, a SIM card with an activated data plan must be placed in the SIM card slot of the SAFEmine unit and the corresponding parameters need to be configured. Further information on vehicle tracking is provided in chapter 3.5.

3.1.4. QC250



The QC250 model provides network connectivity through WiFi and is meant to be installed with an external display. The QC250 model supports vehicle tracking via WiFi. In order to provide this functionality the QC250 unit requires to be configured with the WiFi network specific parameters. Further information on tracking is provided in chapter 3.7 and **Error! Reference source not found..**

3.1.5. QN555



The QN555 is a roof top magnetic mount, self-powered and self-contained CAS device which offers ease and speed of installation on the roof of e.g. a temporary installation on a light vehicle. It is a solution for contractors and temporary visitors in surface mines where all mine vehicles require having SAFEmine installed. Detailed information regarding the QN555 QuickMount unit can be found in the QN555 user guide. QN555 requires an external display but no additional antenna is required.

3.2. Displays

3.2.1. Overview

An external display is required for all Main Units to work correctly. The only exceptions are the QC235 and the QC220 units. The QC235 have an inbuilt display and thus do not necessarily require an additional external display. The QC220 main application is vehicle tracking which does not require anti-collision and can work without the indication of nearby SAFEmine CAS systems.

All other SAFEmine CAS systems require a display in order to be fully operational. The display not only indicates the proximity and direction of other SAFEmine CAS systems but also issues audible warnings, indicates system errors and malfunctions and provides an interface for interaction.

3.2.2. QD200 RemoteDisplay



The QD200 remote display unit can be connected to all QC2xx units. The QC230 and QC235 units only require a QD221 (1.5m) or QD222 (5m) display cable extension. To connect to QC220, QC24x or QC250 units an additional QM106 display Y-cable is required.

The QD200 Interface offers the following attributes:

- Indication of surrounding vehicles through 12 dual color LEDs (red/green) in a circle
- Status Indication through 4 dual color LEDs (red/green): Power, GPS, Reverse and Mode
- Multifunction push-button
- Piezoelectric buzzer
- Ambient light sensor

The maximum length of the display cable is 15m. This can be achieved by connecting several display extension cables together.

The LED brightness is automatically controlled based on ambient light, in order to provide dimming for night operation.

The buzzer, with a maximum volume of 85dB (at 10cm distance), can be automatically controlled based on ambient noise.

3.2.3. QD204 ScopeScreen



The ScopeScreen provides a 4" graphical display showing a bird-view map of the vehicle's surroundings. Its main use lies in rotational vehicles and stockpile applications which require detailed information on their environment. However SAFEmine strongly recommends the QD204 ScopeScreen to be installed with the QM105 Power Saving Display Cable connected to ignition, in order to preserve the vehicle battery from draining. Its installation is compulsory for light vehicles.

The QD204 further provides 2 USB connectors for FW upgrades and log-files extraction.

3.3. Antennas

3.3.1. *Overview*

The antennas provided by SAFEmine are customized and combined GPS and RF antennas especially designed for the harsh environments of mines.



Only antennas supplied by SAFEmine may be attached to the antenna connectors

The following matrix shows the antennas main attributes:

Antenna	QF012	QF020	QF024	QF026	QF028	QF034	QF036	QF037	QF038
Through hole mount	■	■					■		
Magnetic mount			■	■				■	
Adhesive (in-cabin)					■	■			
Bracket mount									■
GPS	■	■	■	■	■		■	■	
RF	■		■				■	■	
GSM/LTE		■		■	■	■			
WiFi							■	■	
LongRange WiFIRF									■

3.3.2. *Antenna Selector*

Please refer to the following matrix to select the correct antenna corresponding to your CAS main unit:

QC Model:	QF012	QF020	QF024	QF026	QF028	QF034	QF036	QF037	QF038
QC230	■		■						
QC235	■		■						
QC220		■		■	■				
QC24x	■		■			■			
QC250	■		■				■	■	■

The following matrix indicates the pairing of CAS units and antennas for specific applications:

Application:	QF012	QF020	QF024	QF026	QF028	QF034	QF036	QF037	QF038
CAS only	QC23x		QC23x						
CAS and TRACK	QC24x QC250		QC24x QC250						
TRACK only		QC220		QC220	QC220	QC24x	QC250	QC250	QC250



3.3.3. Through Hole Antennas



SAFEmine recommends the installation of through whole antennas (QF012 GPS/RF, QF020 GPS/GSM and QF036 GPS/RF/WiFi) for all permanent installation for its superior stability even in heavy vibration. This type of antenna is equipped with a threaded tube at the bottom to secure its position. The antenna is equipped with 15cm pigtail of coaxial cable with 50Ω wave impedance.

Short cable pigtails on antennas have the advantage to be able to replace either the antenna or the extension cable in case either is being damaged.



Furthermore, testing of the cable and antenna independently with an SWR-meter is strongly recommended (please contact SAFEmine for SWR-meter recommendations).

3.3.4. Magnetic Mount Antennas



The magnetic mount antennas (QF024 GPS/RF, QF026 GPS/GSM and QF037 GPS/RF/WiFi) are equipped with a 3.5m pigtail of coaxial cable with 50Ω wave impedance. Its magnetic base attaches to any reasonably magnetic material. It allows an easy installation on vehicle roof tops and is ideal for light or other vehicles with moderate vibration.

3.3.5. Adhesive Antennas



These antennas (QF028 GPS/GSM/LTE and QF034 GSM/LTE) are installed on the inside of the windshields. They are not waterproof and thus require to be installed in a dry environment.

3.3.6. Bracket Mount Antennas



The bracket mount antennas (QF038 WiFi) are designed to be mounted on handrails and similar structures. Their main field of application is extending the range of WiFi communication.

3.4. Accessories

3.4.1. *Overview*

Several accessories are available to extend the SAFEmine CAS system functionality. All accessories, with exception of the QR310 TrackingRadars, can be easily installed on existing basic SAFEmine CAS Systems and extended further when needed. As regarding the TrackingRadars, specific training of your technical staff is required.

All accessories require FW upgrades for activation. The QL015 Loudspeaker requires additional SW to be installed (voice file).

 If you consider upgrading your CAS system with any of our accessories, please contact your local SAFEmine support responsible for further guidance.

For the different accessories available, please consult the corresponding documentation for configuration and use the correct cables for connection:

	Documentation	Y-Cable	Extension Cables	Other
Loudspeaker QL015	SM Voice Application Note	QM108	Not needed	
DriverID Reader QL460	SM KeyControl Application Note	QM106	QD221 (1.5m)	KeyCards
SerialExtender QS430	SM SerialExtender Application Note	QM103 or QS422	QD221 (1.5m)	
TrackingRadar QR310	SM TrackingRadar Installation Manual	QS413	QR321 (2m) QR322 (5m) QR323 (10m) QR324 (20m)	QR320 (CAN Y) QR421 (Terminator)
Panic Button QP137	Panic Button Application Note	Not needed (GPIO)	Not Needed	

3.4.2. *QL015 Loudspeaker plus Voice Option*



In order to install the SAFEmine Voice option, the CAS system requires the installation of the QL015 loudspeaker for audible output.

The loudspeaker enables the CAS to voice different messages regarding vehicles ahead, collision warnings, tailgating, over-speed and many more.

For in-depth information on SAFEmine Voice configuration and the installation of QL015 loudspeakers please consult the voice application note.

For further information please contact support@safe-mine.com



3.4.3. QL460 DriverID Reader



The QL460 DriverID Reader enables the CAS system to verify the authorization of the operator through contactless RF-ID cards. The installation of QL460 DriverID Reader requires a QS430 SerialExtender.

For in-depth information on SAFEmine DriverID configuration and the installation of QL460 keycard - reader please consult with your support responsible or contact support@safe-mine.com.

Please refer to the Key-Control Application Note for further information.

3.4.4. QS430 SerialExtender



The QS430 SerialExtender adds 3 additional ports serial ports to the CAS unit. Several serial devices such as QD200 RemoteDisplay, QD204 ScopeScreen, QL460 DriverID or a QS400 SafetyCenter can be connected to this extension.

The QS430 SerialExtender does not need configuration for the QD200 remote display to work but it is recommended to consult the documentation on `dataport` and `port_dataport` configuration parameters.

For in-depth information on SAFEmine Serial Extender configuration and the installation of QS430 please consult with your support responsible or contact support@safe-mine.com.

Please refer to the SerialExtender Application Note for further information.

3.4.5. QR310 TrackingRadar



QR310 TrackingRadar is a complete subsystem which enables the CAS system to become sensible to bigger obstacles and ground personnel in the close surroundings of the vehicle.

Please refer to the SAFEmine TrackingRadar Installation Manual for further information and ask your support responsible for guidance. You may also choose to write to support@safe-mine.com for further assistance.

3.5. Connectors

3.5.1. Overview

The available interfaces on the CAS main unit depend on the models in question. In the following section each of this connectors is specified in detail in order to provide all necessary information for correct connection.

The below matrix shows the different interfaces and their presence on the specific main unit models:

Connector	QC230 / QC235	QC220 / QC24x	QC250
GPS	■	■	■
RF	■	■	■
GSM/LTE		■	
WiFi			■
Main	■	■	■
Dedicated Serial	■		
I/O		■	■
SIM-Card Bay		■	

3.5.2. GPS Connector



SAFEmine main units include a 50 channel GPS L1 receiver chip with SBAS (WAAS, EGNOS) capability, integrated RAIM (Receiver Autonomous Integrity Monitoring) and active multipath detection and elimination algorithms. The receiver is GALILEO ready.

The implemented connector is female with center sleeve contact and outside threads, gold plated SMA for 3.3V active GPS antennas. The wave impedance is 50Ω.



Only GPS antennas supplied by SAFEmine may be used.



3.5.3. RF Connector



SAFEmine includes RF transceiver chips with typically less than 1% duty cycle and effective radiated power (ERP) is below 15mW. The CAS main units make use of the freely available industrial, scientific and medical (ISM) radio frequency bands for short range devices (SRD) and is thus license free. The transmission frequency of the system is software selectable by indicating the specific channel.

The country of Origin is Switzerland with a harmonized system customs code (HSCC) 852610. The connector for the RF transceiver is a female SMA with center sleeve contact and outside threads for passive RF antennas with 50 Ω wave impedance.



Only RF antennas supplied by SAFEmine may be used.

3.5.4. GSM/LTE/GPRS Connector (only QC220 & QC24x)



The QC24x and QC220 SAFEmine devices feature a quad-band GSM/LTE module with embedded TCP/IP stack. The module is Class 4 (2 W) for the 850/900 MHz bands and class 1 (1 W) for the 1800/1900 MHz bands.

Its GPRS rating is class 10 (4 downlink, 2 uplink, max. 5) and mobile station class B module. It supports PBCCH ,CS1 to CS4.



The module is approved for AT&T, R&TTE, CE, GCF, FCC, PTCRB and many more. Please contact your SAFEmine contact if you require further information.

The connector is a reverse polarity female SMA (RP-SMA) **with center pin** contact and outside threads for passive GSM/LTE Antennas with 50 Ω wave impedance.



Only antennas supplied by SAFEmine may be used.

3.5.5. WiFi Connector (only QC250)





The QC250 SAFEmine devices include a self-contained WLAN module. The module is a complete IEEE 802.11 b/g/n based wireless device.

The module supports WPA2-PSK, WEP (64 and 128 bit) and TKIP security encryption.

The typical transmit power is 17dBm for 801.11b, 15dBm for 802.11g/n. The sensitivity is -97dBm @ 1Mbps to -71dBm @65 MBps.

The connector is a reverse polarity female SMA (RP-SMA) **with center pin** contact and outside threads for passive WiFi Antennas with 50 Ω wave impedance.



Only antennas supplied by SAFEmine may be used.

3.5.6. Main Interface



The main interface has a 8-pin M12 male connector. This interface is connected to the vehicle and optional add-on modules. It provides the connection points for power supply and communication ports a dedicated voice signal line as well as one configurable digital I/O:

Pin	Color	Symbol	Function	Min.	Typ.	Max.
1	White	+V _{batt}	Power supply from Battery	+9V _{dc}	+12V _{dc} +24V _{dc}	+28V _{dc}
2	Brown	-V _{batt}	Power ground from Battery, connected internally to system ground GND		-V _{batt}	
3	Green	CAN-low	CAN-Bus Port (ISO-11898)	GND		+V _{batt}
4	Yellow	CAN-high		GND		+V _{batt}
5	Grey	Rx	Serial Communication Port - QC23x: RS485 - QC220/2240/250: RS232	GND		+V _{batt}
6	Pink	Tx		GND		+V _{batt}
7	Blue	I/O1	Configurable ¹ Digital Input / Output	GND		+V _{batt}
8	Red	Audio	Signal wire for SM Voice output	GND		+V _{batt}

¹Please consult chapter 4.6 for general instructions on configuration of I/O's.

Use of CAN-Bus, Serial Port, I/O1 and Audio connection depends on the application. They may be left unconnected if not used.

The main interface also includes a hardwired input (I/O0) which is internally connected to pin 1 in order to monitor the power supply voltage.

The SAFEmine CAS system can operate with a supply voltage down to 9V_{dc}, but if the supply voltage is below 9.6V at startup, an error code or a message indicating the low supply power is displayed and the device will refuse service. If the supply voltage drops below 9.6V during operation, the 'power' LED will turn red and the error message is issued. In case the voice option is enabled 'error'



'power' is announced every 30 seconds on the speaker as long as the supply voltage is sufficient to do so.

3.5.7. Display / Serial Connector (only QC230 & QC235)



The QC230/35 MainUnit has a female 4-pin M8 display connector and is placed next to the main connector interface. On the QC24X/220/250 devices the display connector has been integrated into the main connector and is branched out through the QM106 serial Y-cable.

This connector provides the data and power necessary for the display. The display connector can also be used for debugging and firmware update purposes. The protocol used on the display serial connector is standard RS232

Pin	Color	Symbol	Function	Min.	Typ.	Max.
1	Brown	V_{supply}^1	Power supply for displays	+9V _{dc}	+12V _{dc} +24V _{dc}	+28V _{dc}
2	White	Rx	Serial Communication Port ² Input	GND		V_{supply}
3	Blue	GND	System ground for displays	GND		V_{supply}
4	Black	Tx	Serial Communication Port ² Output	GND		V_{supply}

¹The display power supply on QC230/235s is stabilized to 12V whereas on QC220/240/250s it is directly connected to +V_{batt}

²The serial communication port is used for the display communication as well as for configuration, programming and debugging.

3.5.8. I/O Connector (only QC220/240/250)



The I/O connector is an 8-pin M12 male type. The general purpose input output (GPIO) ports present on the I/O interface of the device can be used to monitor and record vehicle parameters such as: reverse gear, seatbelt clicked, bucket position, bucket load, fuel gauge, etc. The vehicle signals can be used to influence the behavior of the CAS system in order to react to different situations.

Additionally, the traffic and GPS information gathered by the CAS MainUnit can be used to trigger outputs in order to control external applications.

The GPIOs are almost all on the I/O connector with the exception of ports I/O0 and I/O1. I/O0 is hardwired to the pin 1 of the main connector in order to monitor the power supply voltage. I/O1 is

wired to pin 7 of the main interface and can be used in the same fashion as the GPIOs on the I/O connector.



Pin	Color	Symbol	Function	Min.	Typ.	Max.
1	White	I/O2	Analog Input	GND		Vsupply
2	Brown	I/O3	Analog Input	GND		Vsupply
3	Green	I/O4	Configurable ¹ Digital Input	GND		Vsupply
4	Yellow	I/O5	Configurable ¹ Digital Input	GND		Vsupply
5	Grey	I/O6	Configurable ¹ Digital Input Output	GND		Vsupply
6	Pink	I/O7	Configurable ¹ Digital Input Output	GND		Vsupply
7	Blue	GND	Signal ground for differential signals	GND		Vsupply
8	Red	I/O8	Configurable ¹ Digital Input Output	GND		Vsupply

¹Please consult chapter 4.6 for general instructions on configuration of I/Os.

For additional GPIO functionality please refer to the corresponding application note (GPIO AN).

If you require any further information please contact with your SAFEmine Supporter.

3.5.9. SIM-Card Bay Interface (only QC220 & QC24X)



SAFEmine devices QC220 and QC24X require SIM cards to connect to the local cellular network for data transmission. The amount of data transmission can vary depending on the configurations but a data plan of XXX MB per Month has given good results.

For satisfactory online performance of the SAFEmine system the cellphone network service must cover the area of use with either GPRS (2.0G) or EDGE (2.5G). The CAS system does not support higher generation protocols such as UMTS, HSDPA or LTE.

The SIM-card bay receives a standard size SIM-card. The Interface is spring loaded and the card has to be pushed in against the spring until a “click” can be heard. Use a thin nonmetallic piece to help push the card into its place.

QC220 and QC24X MainUnits are delivered with a transparent adhesive cover sticker to close the SIM-card bay and protect it against dust. Always install the cover sticker on the SIM-card slot to prevent voiding warranty.



Operation of the CAS MainUnit without the SIM card cover sticker voids warranty!



3.6. Cables

3.6.1. QD221 and QD222 Display Extension Cables



The QD221 and QD222 display extension cables provide 1.5m and 5m of cable in order to place the QD200 RemoteDisplay or QD204 ScopeScreen visible to the operator and remotely from the main CAS unit. The cable features a male and a female 4-pin plug with a pinout corresponding to the serial interface described in this chapter.

3.6.2. QM101 WiFi Stick Antenna Extension Cable



The WiFi stick antenna extension cable is an accessory for the QF0838 WiFi stick antenna. the cable acts as adapter from N-type connector to SMA and is 2.9m long.

3.6.3. QM103 and QS422 CAN-Bus Y-Cables



The CAN bus cables are required when using the QS430 SerialExtender. The QM103 cable is equipped with a 120Ω bus terminator resistance were as the QS422 has no such termination. The cable features a male and a female M12 plug with 8 threads and a female M8 plug with 4 pins.

QM103 is used when the QS430 SerialExtender is the only device connected to the can bus. In the contrary case, when both the QS430 SerialExtender and the QR310 TrackingRadar are connected to the CAS unit then the QS422 cable must be used. This is because the CAN bus is terminated by the TrackingRadar installation.

In any case consult with your support responsible or write to support@safe-mine.com in order to verify your installation.

3.6.4. QM104 MainUnit Power Cable



The QM104 MainUnit power cable is to be connected to battery voltage bypassing the regular vehicle isolation switch. When required, to remain within safety regulations, it is recommended to install a separate isolation switch dedicated only to the SAFEmine system.

The QM104 features a female M12 plug and an open ended 2m long pigtail of cable with 8 individual colored threads. The colors indicate the associated pin. Please refer to the tables provided by the Main and I/O Connector Documentation in this chapter.



3.6.5. QM105 Power Saving Display Cable



The QM105 Power Saving display cable is used to power the QD204 ScopeScreen from ignition, in order to save power when the ignition is turned off. The CAS MainUnit will remain powered on thanks to its direct connection and continues to provide its service regardless of the ignition status. The cable features a male and a female M8 plug with 4 pins and 2m open ended pigtail to connect to a ignition switch controlled power supply.

3.6.6. QM106 RS232 Serial Communication Y-Cable



The QM106 is used to access the main serial connection of the QC220 QC24X and QC250 MainUnits. The cable features a male and a female M12 connector with 8 pins each and a 4 pin M8 female connector for the serial connection. This cable serves for both, connecting the displays or programming the units via serial programming cable. The pinout of this cable corresponds to the pinouts of the main and serial interfaces of the CAS units respectively. Please refer to their documentation in this chapter. This cable replaces the QM109 cable

3.6.7. QM108 Speaker Power and Audio Signal Y-Cable



The QM108 Speaker Power and Audio Signal cable is required for SAFEmine Voice installation and connects the CAS MainUnit to the QL015 Loudspeakers. The cable features 2 female and one male M12 connectors.

3.7. Network

SAFEmine QC220, QC24X and QC250 MainUnits can provide vehicle tracking functionalities if connected to a SAFEmine Track server (SMTrack). The Movements and status of the vehicles can be consulted through the web interface of the SAFEmine Track server.

For additional information consult chapter **Error! Reference source not found.** of this manual.

The following information can be tracked and recorded:

- Vehicle Position
- Vehicle-ID
- CAS MainUnit serial number
- Installed firmware version and build number
- Power supply voltage
- State of the digital inputs and outputs (seatbelt, handbrake, idling, motor hours, etc.)
- Value of the analog inputs (bucket load, fuel gauge, etc.)



Please consult with your SAFEmine Support contact if you plan to implement this function or write to support@safe-mine.com for further information on this product.

4. Hardware Installation Instructions

4.1. General Rules and Best Practices

Please check on the following conditions before beginning any work. Differing installations will void the warranty of SAFEmine systems:



- Installations may only be carried out by trained electricians.
- **Only antennas supplied by SAFEmine may be used.**

Unless certified, installation and operation of CAS MainUnits and Accessories must be on the basis of non-interference with existing equipment. When certified, installation and operation must be done according to certification procedures in order to comply with official regulations and requirements.



Never connect SAFEmine equipment to critical vehicle signal lines without prior consultation and approval of the vehicle manufacturer and SAFEmine support staff.

Connecting the reverse signal to the CAS unit is compulsory in all vehicles that provide such signal. But rather than connecting to critical signal lines use the connection to noncritical signals such as reverse light, reverse buzzer and similar.

After installation, an appropriate entry should be made in the vehicle's technical logs including CAS MainUnit's serial number and the installed firmware version. A check should be performed in order to reinsure the installation's quality and its accordance with the requirements. Special focus has to be given that the mechanical or electrical performance of other vehicle's systems (e.g. radio) is not influenced by the CAS system.



SAFEmine highly recommends establishing a "Radio Map", containing all intentional transmitters present on the mine and their respective operating frequencies. This map will help identifying potential collisions between frequency ranges and avoid radio interference.



If you require 3D models of SAFEmine MainUnits and Accessories, please contact your SAFEmine support contact.

4.1.1. Required Tools



SAFEmine strongly recommends using pre-assembled coaxial cabling for quality reasons. However if you plan to lengthen and assemble your own coaxial cabling it is compulsory to use the correct tools. Do not use normal wire cutters or multi-purpose pliers. Inappropriate tools will result in potential faults and downtime. Always use a correctly adjusted 3-Blade wire cutter to strip the coaxial cable and then crimp the center pin with the correct gauge or solder with small tipped, 30 Watt soldering iron.



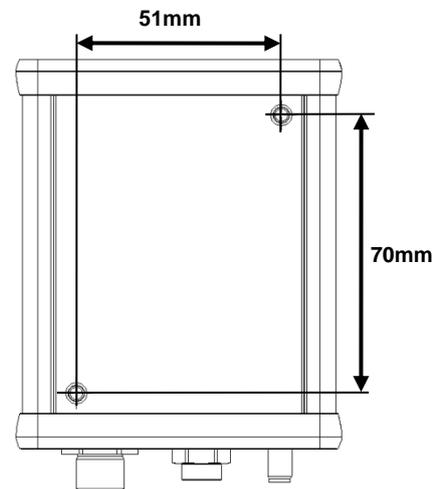
4.2. Main Unit

4.2.1. *Prior considerations*

-  The selected installation spot **must** be dry and reasonably free from dust.
-  Install the Main Unit so that it does not interfere with any of the vehicles operations.
-  The CAS MainUnit **must** not be placed where it could obstruct the operator's field of view.
-  At the same time the connectors at the back of the CAS MainUnit should remain easily accessible in order to perform maintenance tasks.
-  A good installation spot provides enough space for the cables and their connectors.
-  Avoid spots where temperatures can suddenly drop. It could cause the buildup of condensation inside the CAS MainUnit.
-  The mount surface should be flat in order to avoid mechanical stresses on the housing of the CAS MainUnit.
-  If the mount surface is metallic it **must** be insulated from the CAS MainUnit housing
-  If custom mounting plates would be needed, make sure the design does not force the two plastic end-bezels. Doing so would result in bending and consequently damage of the CAS MainUnit.

4.2.2. *Installation*

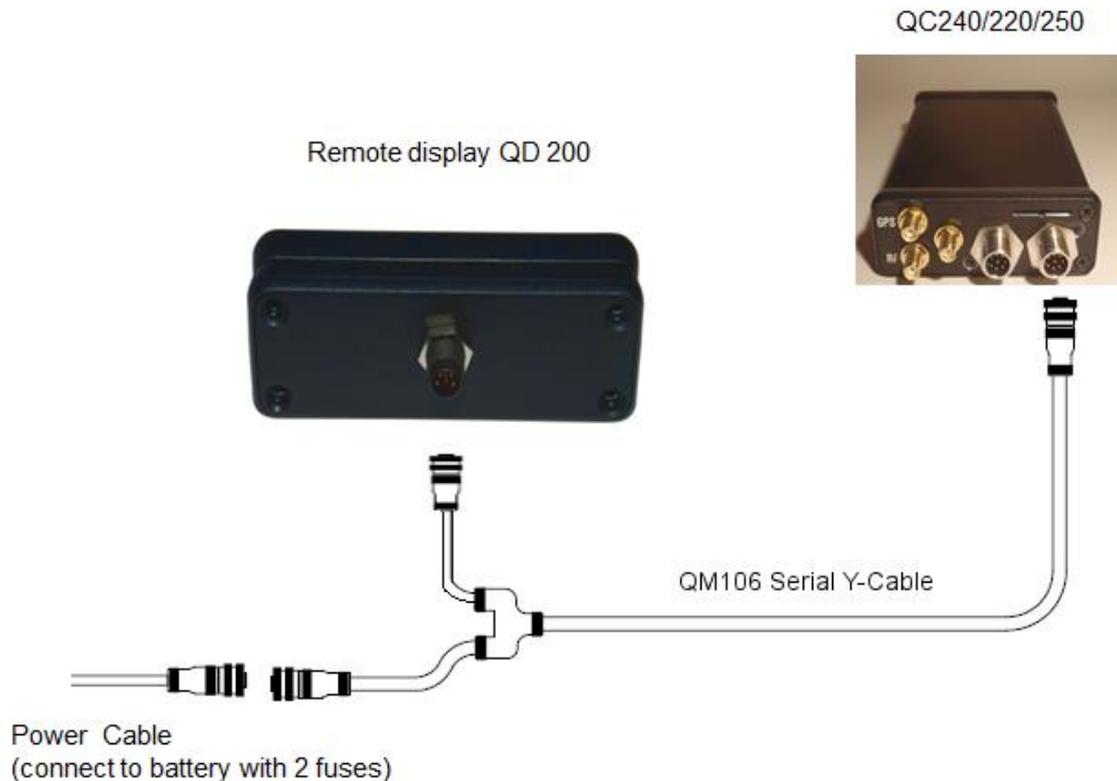
-  Custom mounting plates can be fastened to the lower face of the CAS MainUnit housing using the two 8mm deep M4 blind threads.
-  Do not force screws further than 8mm into the housing. Units damaged through improper handling lose their warranty.
-  Pay attention to metal parts near the CAS MainUnit. The QC units require being completely electrically isolated from any conducting part of the vehicle.
-  If installing QC220 or QC24X CAS MainUnits do not forget the provided cover sticker for the SIM-card bay. Operation of the CAS MainUnit with uncovered SIM-card slot voids its warranty.



Main unit bottom view

4.2.3. *Cabling*

-  The GPS, RF and Network (GSM/LTE/WiFi) cables **must** be tightened with an 8mm spanner in order to prevent manual removal or eventual loosening through vibration.
-  The power cable **needs** to be connected directly to the battery contacts, bypassing the ignition and the isolation switch. This is to ensure the CAS system keeps working even when the vehicle is switched off or being serviced.
-  A 3A fuse is **required** in the power connection for **both** power and ground.
-  Sealable fuse holders are highly recommended. Furthermore, the fuses should be secured with a cable tie to prevent tampering and make manipulations visible.
-  **Do not bend any cable** further than its minimum bending radius. Transmission in coaxial cables will deteriorate substantially while data and power cables risk to be sheared off.
-  Cables need to be long enough in order to avoid tension. If the installed cable is under tension, relocate the CAS unit or reroute the cable. If neither is possible replace the cable by a longer one.
-  Install the cables in a way (cable ties) allowing easy service and removal. Do not route them over or under access doors or removable plates.



4.3. Displays

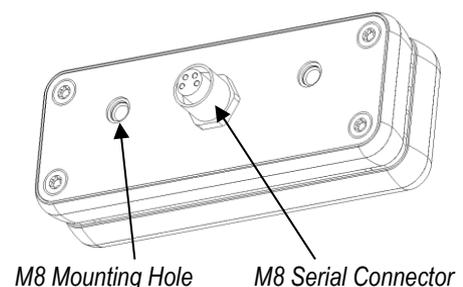
4.3.1. *Prior Considerations*

- The display should be positioned such that the front panel LEDs are in direct view of the Operator, the acoustic warning tone can be heard loud and clearly and control button can be operated easily.
- The view on the front panel display may not be obstructed at any time.
- The display may never interfere with the operation of the vehicle (incl. emergency procedures)
- **Special attention is required to not reduce the operator's field of view.**
- The displays can also be used with CAS MainUnits which do not explicitly require an external display, e.g. QC235 and QC220. Please contact SAFEmine for more information regarding this configuration.
- The remote display connection contains the data and power from the main unit.



4.3.2. *QD200 Remote Display*

- The QD200 Remote Display has a male M8 type connector with 4 contacts. It connects to the QD221 and QD222 extension cables.
- To connect with QC230 or QC235 no further cables are required. It can be connected directly to the display interface of the CAS MainUnit.
- To connect with QC220, QC24X or QC250s, a QR106 Y-cable is required in order to connect to the main interface of the CAS Main Unit.
- The back side of the display's aluminum housing





includes two 8mm deep M4 blind threads, so that the housing can easily be secured. Forcing screws longer than 8 mm into the nuts may cause damage and voids warranty.

- The remote display is light enough to be fixed with 3M dual lock. This is ideal for installations where the owner of the vehicle does not permit to drill holes in the dashboard.

4.3.3. QD204 Scope Screen

- All connectors are on the rear of the unit. The device can be installed with minimal effort and time, no IT and no radio infrastructure are required.
- Maintenance instructions for Scope firmware can be found in Appendix M

4.4. Antennas

4.4.1. Prior Considerations

In order for the SAFEmine CAS system to operate, the installation of GPS and RF antennas is required. The antennas provide access to the geolocation information from GPS-satellites and enable the communication between SAFEmine CAS MainUnits on the different vehicles.



For optimal performance of the SAFEmine CAS system the both GPS and RF antennas **must** be placed in the topmost position in order to provide free paths to broadcast and receive signals. The best option is to install the antenna on top of the roof. The antenna should not be mounted near metal structures for the same reasons. Leave at least 1m of space between the antenna and the nearest metal surface (with exception of the antenna pole itself).

In order to avoid interference or crosstalk with other antennas, leave enough space between any two antennas. SAFEmine **requires** a distance of at least 1m from any other antenna.



The antenna cable is the most sensible component of all of the SAFEmine system and requires proper installation by a trained and experienced electrician. Failing to conduct a correct installation of the high frequency coax cables is the most common cause for malfunction.

In order to keep the configuration workload low it is highly **required** to keep the same antenna position for each vehicle type. E.g. if you equip the first single cab pickup truck with the antenna at the center top of the rollover bar then you should continuing doing so for every following single cab pickup truck of the same model.



To guarantee the best possible transmission of the signal from and to the antennas, the bending radius of the coaxial cables **must** never fall below the minimum specifications. Bending the cables in a tighter curve would mean to introduce losses of signal strength and wave reflection points in the cable. If a cable got overly bent it must be replaced.

Buildup of snow, ice and mud can reduce the range and performance to the antennas. Remove all deposits prior to operation.



SAFEmine supplies special mounting brackets for various vehicles. Please contact your SAFEmine contact for more information.

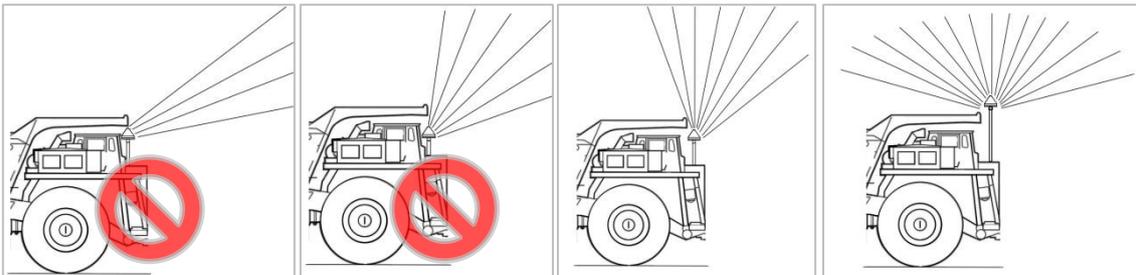
Resuming the general installation rules for antenna installations, the GPS/RF antennas must be:

- Installed. The CAS MainUnit cannot operate without GPS or RF antennas.
- Mounted on the highest possible point of the vehicle, ideally with 360° unobstructed view of the surroundings and the sky.
- At least 1m from any metal structure.
- At least 1m away from any other antenna.
- Only specific cable types and lengths are admissible. Please consult chapter 4.4.4 on antenna cabling for more information.
- Positioned at the same spot for a specific vehicle model.
- Connected to their correspondent inputs.
- Always connected to cable installations that respect the minimal cable bending radius.



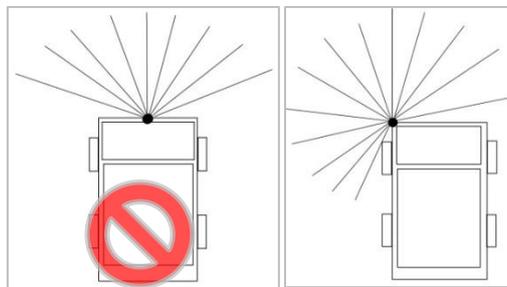
4.4.2. Antennas on Haul Trucks

It is not always possible to position the antenna on the topmost location. On haul trucks the bucket might be covering the entire structure of the vehicle and thus making the installation of an antenna on the top rather impractical. In this case SAFEmine recommends using a pole on which the antenna can be mounted. The best position for the antenna is one of the front corners. If the vehicles transit on the right side of the road than the left corner is most appropriate and vice versa. The pictures below show different configurations for pole sizes and positions.



Antenna positions in the above side view improve from left to right:

- The left most picture shows an antenna directly under the canopy. The Antenna's reception is very bad.
- In the second picture the antenna is positioned lower but still has bad reception due to being under the canopy.
- The third picture shows an acceptable position. The antenna is not covered by the canopy and is at least 1m from any metal structure such as the canopy, the handrail or the cabin platform.
- The fourth picture on the right extreme shows the antenna's recommended ideal position.



In the above top views:

- The left picture shows how the canopy shields a considerable part of the GPS and RF.
- This is why the right picture is SAFEmine's recommended position.

4.4.3. Antennas on Tracked Vehicles

On tracked vehicles, the antenna **must** be mounted as close as possible to the axis of rotation. For better accuracy, especially to sense a turning maneuver on the spot without losing heading, is to use two SAFEmine units in a master/slave configuration, minimum 5m apart from each other. If you require setting up such a configuration, please consult chapter **Error! Reference source not found.** on rotating vehicles.



4.4.4. Coaxial Antenna Cabling

The selection of coaxial high frequency antenna cables and connectors must be done carefully. SAFEmine recommends to source readily confectioned coaxial cables with SMA connectors already installed and quality checked. It will save precious installation time and avoid faultfinding and rework.



- Source cables from a professional local supplier.
- High frequency cabling work **must** be carried out professionally by trained personnel.
- Do not save costs on the coaxial cables and connectors. SAFEmine recommends only using high quality components.



- Be vigilant of the maximum cable length. Re-route if necessary. Consult the below list for more information.

If you plan to cut your coaxial cables to length and crimp the connectors yourself please attain to the following:

- The maximum acceptable attenuation for cables and connectors is 3dB/10m @ 900MHz
- Better: The required overall attenuation for a cable and its connectors must be below 5dB.
- The inner conductor **must** be a solid core

Find below the recommended maximum cable length between antenna and main unit per cable type based on a maximum attenuation of 5dB for the overall connection. These values are indications and may vary between manufacturers of coaxial cables. **Please see the datasheet and send it to SAFEmine prior to the installation.**

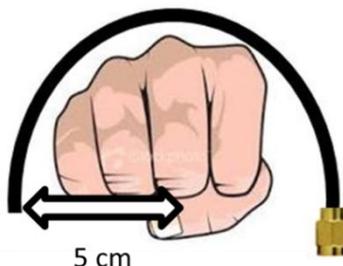
Cable Types ¹ :	RF @950MHz	GPS @1.575GHz	GSM/LTE @ 1.9GHz	WiFi @ 2.4GHz
RG58	6.5m	4.5m	3.9m	3.4m
RG174	4.9m	3.7m	3.4m	3.0m
HDF-195 CDF-195 LMR 195 RF195	12.0m	9.8m	8.9m	7.9m
LMR-200	14.0m	10.9m	9.9m	8.8m
LMR-400	36.8m	28.6m	26.0m	23.1m

¹Use of different coaxial cable types requires prior written approval by SAFEmine.

To calculate the attenuation rate, sum up the attenuation of all segments as specified by the cable manufacturer and add 0.3dB for every SMA connection.

Below you will find SAFEmine’s requirements regarding antenna cable installations:

- 
- Respect the minimum bending radius. Typical minimum bend radius for RF195 type cables is 1.8cm (3/4 in. or your thumb) for a one time bend (i.e during installation), 5cm (2 1/3 in. or your fist) for repeated bending (i.e after installation).
 - It is highly recommended to add a braided sleeve around the cables for further UV and abrasion protection.
 - Connections in the antenna cable **must** be sealed over the whole assembly with heat shrink tubing (glue type).
 - Outside connections **must** be sealed with silicone tape to ensure a reliable, weatherproof operation.
 - Never** use ‘electrical tape’ (e.g. black PVC tape) to weatherproof RF connections
 - No installation may have more than one (1) connection
 - All antenna cables **must** be carefully tied to the vehicle. Loosely vibrating cable will fatigue and the central conductor will break over time.
 - Make all cables removable to prevent them from being cut when the vehicle is being serviced.





HEXAGON
MINING



SAFEmine (part of Hexagon Mining)
Baarerstrasse 133, CH-6300 Zug
Switzerland
www.hexagon.com

Wear and damage to the RF and GPS antenna cables is not covered under warranty.



4.4.5. SMA Coaxial Cable Connectors

Waterproofing connection: The coaxial cables contain a white plastic separator between the screen shield and the center core conductor. This plastic is a dielectric material which has the property to absorb water. SMA connectors are not sealed and thus tend to permit water entry from rain and condensation. When the dielectric material in the coaxial cable begins to absorb the water, the cables signal transmission capacity is severely compromised. Signal loss and bad GPS reception are the consequences.

SAFEmine strongly recommends using sealing, so called self-amalgamating tape in order to waterproof the SMA connections. Do not use the common vinyl electric insulation tape since it does not provide a waterproof sealing for the connection.

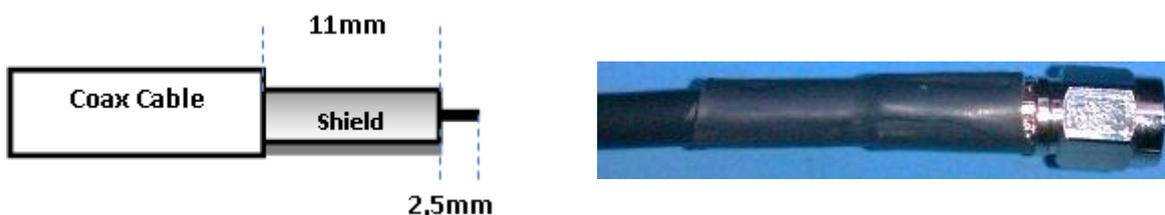
Please attain to these recommendations for any SMA connection installed outside the cabin:

- **Do not use** electrical tape or insulation tape. They tend to unwrap by themselves and do not provide a waterproof protection of the connection. See explanation below.
- **Protect** the connection with self-amalgamating or self-fusing tape instead. This seals the connector from the environment.
- As an alternative to Heat Shrink can be used over the whole connection. In harsh conditions it is recommended to use both the heat shrink and self-fusing tape.



Custom cable length: If the coaxial cables are being cut to length and confectioned with SMA connectors, please attain to the recommendations of the manufacturer as well as the following best practices recommended by SAFEmine:

- Do not use a knife to cut the cable. Damaging or scratching the shield screen or the center core would lead to signal losses and deteriorate the performance of the system.
- Use a 3-blade coaxial cable stripper tool instead.
- Adjust the stripper tool blades to the depth as recommended by the SMA connector manufacturer. See below for an example.
- Use solid core coaxial cables. See explanation below.
- Solder the center pin.



Solid core vs. stranded core: Although having a stranded inner conductor makes the coaxial cable more flexible and less prone to breaking, it is also makes confectioning the cable with SMA connectors more sensible to correct installation procedures of the center pin. Without the appropriate tools such as a 3-blade coaxial cable stripper and especially the center pin crimping pliers, it is almost impossible to consistently create high quality connections. Therefore SAFEmine recommends using solid core coaxial cable and soldering the center pin to the core if you're planning to cut the cables to length.

Please send your SAFEmine supporter the datasheets of the cables and SMA connectors prior to installation in order for assistance.

4.4.6. Antenna Cable Conduit

Through-hole mount antennas are delivered with an at least 30cm long cable conduit sleeve to prevent the antenna cabling to brake due to repeated bending fatigue when vibrating. The installation of the cable conduit is compulsory for every SAFEmine CAS installation using through-hole antennas. The correct installation will ensure the robustness of the CAS system. To do so please attend to the following rules:



- First, protect the RF cable in a braided sleeve for the whole length of the coaxial cable, from the antenna to the CAS unit.
- Use zip-ties at the beginning and the end of the cable to tie the braided sleeve to the coaxial cable
- Do not cut the left-over of the zip tie to ensure the coaxial cable does not move freely inside conduit.
- Insert the coaxial cable protected with the braided sleeve into the cable conduit.
- Attach the cable conduit mechanically to the nearest possible structure: antenna bracket, antenna pole, hand rail or chassis.
- The free, unattached length of the conduit should be 15cm long, but never longer than 30cm.
- Respect the bending radiuses for coaxial cabling!



Remember to follow the water-proofing rules described above before installing the sleeve and the conduit.



4.4.7. Through-Hole Mount Antennas (QF012, QF020, QF036)

The through-hole mount antennas are the recommended antennas for permanent installations due to their strong mechanical attachment to the vehicle. The following section describes the general recommendations for installation procedures specific to this type of antennas.

The through-hole mount antennas have the following properties:

- A threaded metal shaft, which receives a $\frac{3}{4}$ " – 20 threads nut.
- The shaft is hollow giving path to the pigtail of 2 or 3 approx. 10-15cm long coaxial cables.
- The cables are confectioned with standard male SMA connector for GPS and RF signal cables and a reversed male SMA for the WiFi signal cable.
- The shaft thread is $\frac{3}{4}$ " with 20 threads per inch and is $\frac{1}{2}$ " long. The through-hole mount antennas are shipped with the matching $\frac{3}{4}$ " Nut and a isolating nylon washer.
- The attached gasket provides a sealant to prevent moisture from entering through the mounting hole.



Do not use the triple antenna (QF036) for GPS, RF and GSM since RF and GSM signals will interfere and render the system non-operational. Instead use a combination of GPS+RF antenna (QF012) on the roof with a separate adhesive GSM/LTE antenna (QF034) in the cabin.

In order to mount the through-hole antenna the following operations **must** be performed:

- The antenna requires to be mounted on a horizontal **metal surface** which is in diameter 1-2cm larger than the diameter of the antenna. Any metallic surface larger than this is acceptable.
- If no such surface can be provided, mount an extra surface at least XXcm wide as mounting surface.
- A hole must be drilled or punched into the surface. The diameter of the hole must be at least 22mm (0.866") in order to fit the antenna and the compulsory insulating washer.
- The surface should also not be thicker than 12mm (1/2") in order for the threaded shaft to protrude through the mounting surface.

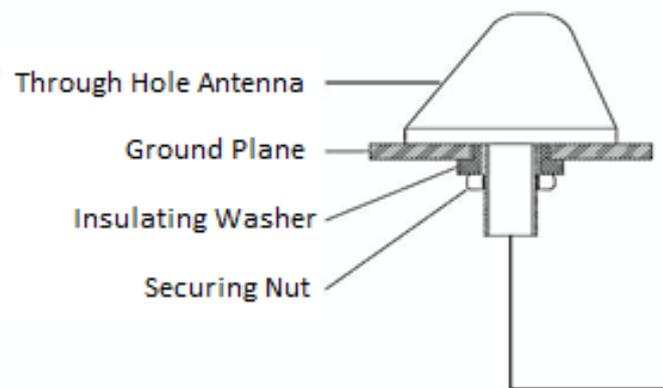


- In order to secure the antenna mounting with the provided insulating washer and nut it is necessary to have access to the backside of the mounting surface.

 **Metallic Surface:** It is compulsory to use a metallic surface as a mounting platform. The metallic surface provides an effective shield against ground reflections of the GPS signal and helps to improve RF connectivity. To omit the metallic mounting surface can result in poor GPS positioning and decreased range of RF communication.

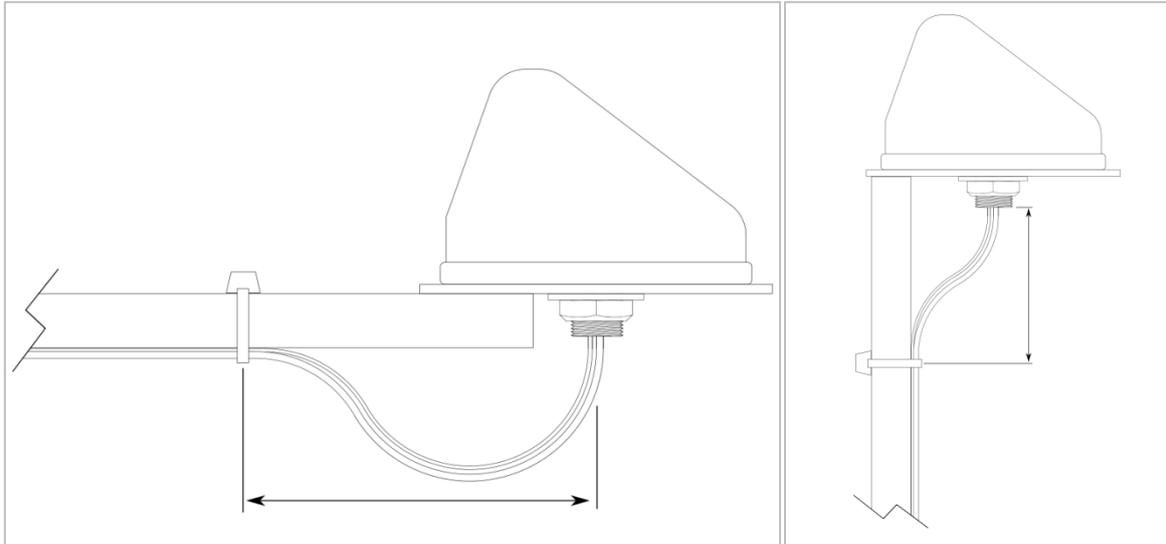
Finally to attach the antenna the following steps are necessary:

- **From the top side:**
 - After removing the nut and the washer from the threaded shaft feed the cables through the hole of the mounting surface.
 - Insert the threaded shaft through the hole until the antenna is sitting flush with the soft foam cushion on the metallic surface.
- **From the back side:**
 - Feed the cables through the insulating washer from the narrower end.
 - Slide the washer over the shaft such that the narrow part of the insulating washer sinks into the space between the shaft and the mounting hole.
 - Make sure the insulating washer lies flush on the back side of the mounting surface. If this is not the case, carefully reduce the height of the small neck of the insulation washer. Do not remove it completely since this would render the washer useless and the threaded shaft could electrically contact with the mounting surface.
 - Next slide the nut over the cables and screw it on the threaded shaft. The nut should be tightened with a torque of 5 ft-lb or 6.8 nm in order to properly seal the gasket. Tighten the nut with a wrench.
 - Finally, feed the cables to the receiver thru additional jumper cables.



 **Insulating washer:** The threaded shaft of the antennas must always be isolated from the vehicle in order to avoid ground loops. To achieve a reliable isolation between the antenna shaft and the metallic mounting surface it is compulsory to install the insulation washer. This washer possesses a small neck which isolates the inner hole surface from the threads on the antenna mounting shaft. Suitable insulating washers are available from SAFEmine and can be ordered separately if needed.

Please contact your SAFEmine support responsible if you have any questions regarding the best practices and potential pitfalls when installing through-hole mount antennas.



In the picture above, the cables in the cable conduit of the through-hole antenna should have a free cable portion of 15 to maximum 30 cm until the first attachment to the pole or frame. Keep a gentle curve of the cabling but don't permit the free portion of the cable to be too long. Otherwise the cabling is in danger of braking through bending fatigue.

4.4.8. *Magnetic Mount Antennas (QF024, QF026, QF037, QN555)*

These antenna types are the preferred solution for light vehicles, demonstrations, contractor vehicles and in general vehicles which do not provide the possibility to mount a through-hole antenna. Installation on heavy equipment such as haul trucks, excavators or dozers is not recommended, due to the strong vibrations these vehicles are exposed to.

The magnetic mount antennas are equipped with 3.5m cable harnesses, either with two cables for GPS and RF (QF024, QN555), two cables for GPS and GSM (QF026) or with three cables for GPS, RF and WiFi (QF037).

 **Do not use the triple antenna (QF037) for GPS, RF and GSM since RF and GSM signals will interfere and render the system non-operational.** Instead use a combination of GPS+RF antenna (QF024) on the roof with a separate adhesive GSM/LTE antenna (QF034) in the cabin.

The antennas can be located on any flat magnetic surface, preferably on top of the roof, where it has free view of the sky. Pay attention to install the antennas such that they are not covered by any electrically conducting surfaces as metal or carbon fiber nor should they be mounted immediately alongside such materials.

As the through-hole antennas, the magnetic mount antennas require a mounting surface with a diameter of at least 18cm. This ensures shielding from ground reflections of the GPS signal and significantly improves the radiation characteristics of the RF antenna.





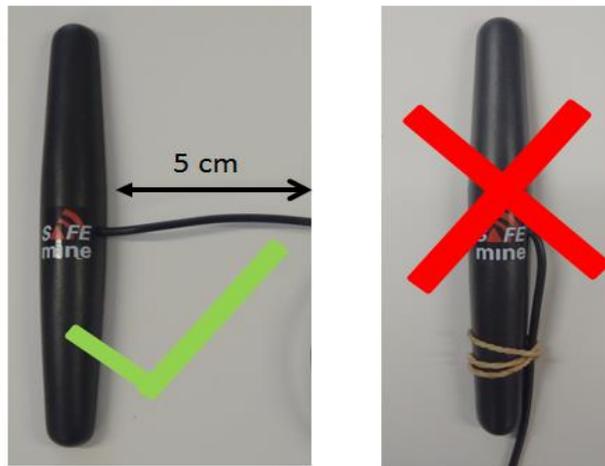
4.4.9. *Adhesive Mount Antennas (QF028, QF034)*

The adhesive mount antennas are designed to be attached to a non-conducting surface, preferably the front windshield. The QF024 antenna is a GSMonly antenna meant to be installed in the cabin with QC24X MainUnits in addition to a GPS+RF roof antenna (either QF012 or QF024). The QF034 is a combined GPS+GSM/LTE antenna which is dedicated to installations which use the QC220 MainUnit.

The antennas come with a 2.4m (8 foot) long coaxial cable and a male SMA connector.

The GSM/LTE antennas must be installed such that:

- In cabins with metallic roof, a minimum 1m distance is maintained from the SAFEmine GPS/RF antenna and any other antenna emitting in the 800MHz to 2.4 GHz range.
- If the roof is non-metallic increase the minimum distance to 2m.
- At least 5cm clearance is given from any metal structure (i.e. four fingers wide).
- The antenna is mounted inside the vehicle in a dry place.
- The antenna is mounted vertically.
- The cable of the antenna is perpendicular to the antenna and does not bend for the first 5cm.



4.4.10. *Bracket Mount Antennas (QF038)*

SAFEmine supplies bracket mounts for QF038 WiFi Stick Antennas. The bracket is used to mount the antenna on a rail or tubing. As with all SAFEmine equipment, electrical insulation between the metal structure and the metallic antenna parts must be ensured at all time in order to avoid ground current loops.

Please refer to your support responsible or write to support@safe-mine.com for further information.



4.5. GPIO Connections

The CAS system offers to interact with its environment through eight general purpose input/output ports. The outputs may drive (source or sink) 400mA each and at the same time. The inputs are designed to work on switches, providing either pull-up or pull-down configurations.

Due to the multi-purpose nature of the CAS GPIO input/outputs it is not possible to galvanically isolate them. If galvanic isolation is required install a protection relay in the signal path.

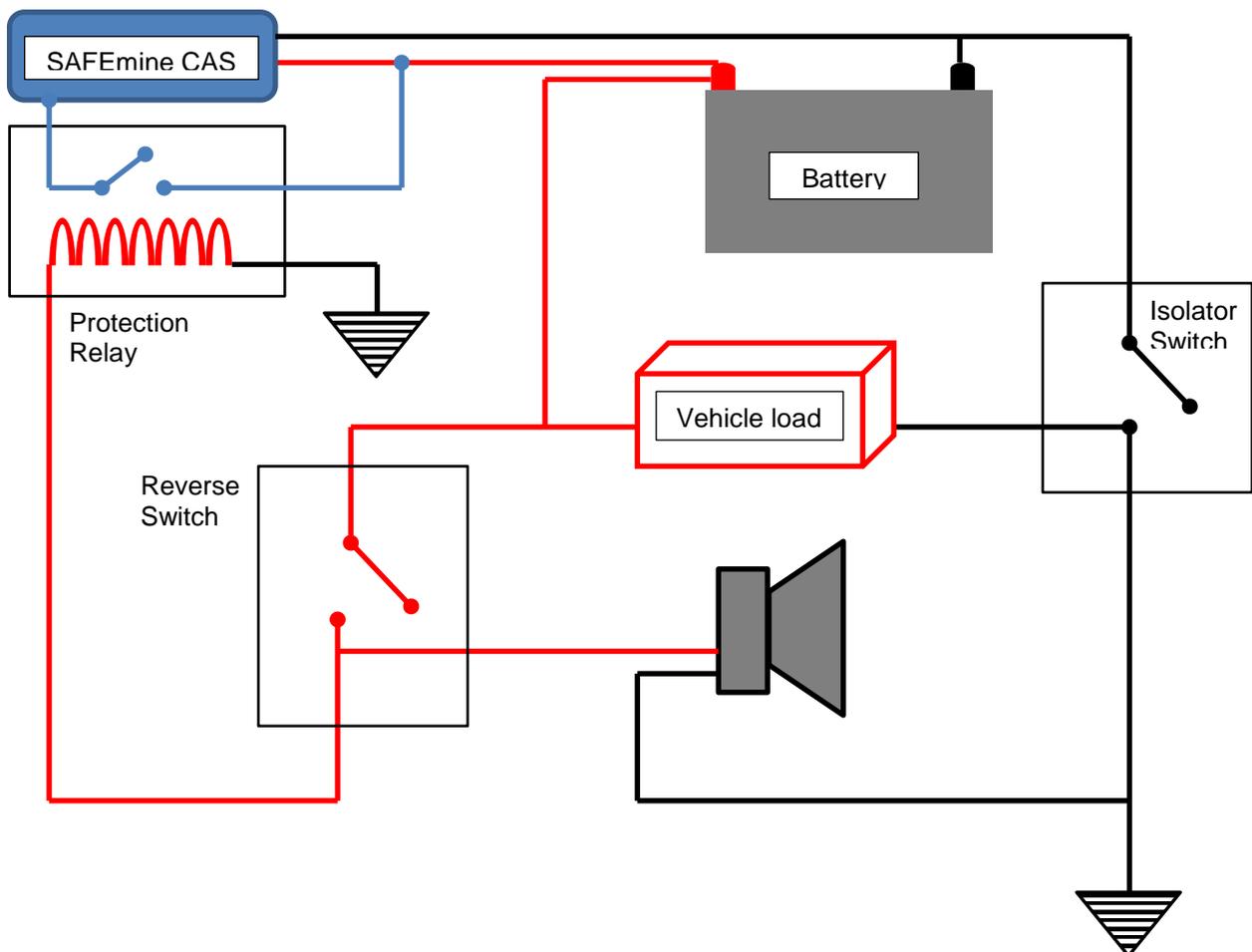
Further, always connect inputs/outputs to non-sensible systems. Since the CAS system is permanently powered, it must be made sure it can never feed current into a potentially dangerous subsystem.



For example: Always connect the reverse gear sense line to the switch side, which connects to the buzzer or the strobe for reversing. **Never connect on the relay coil side or on a driving output!**

It is compulsory to mount protection relays when the inner workings of signal sources are not completely understood or the receiving subsystem might act unexpectedly.

The following schematic shows the recommended connection to the reverse switch signal in a vehicle with negative isolation switch (as found in Caterpillar and alike).



This configuration prevents eventual currents flowing from the CAS reverse input to the vehicle systems when the isolator switch is opened or the negative connection of the CAS should become disconnected.



Appendix A FCC COMPLIANCE

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.

Per FCC Rules, changes or modifications not expressly approved by SAFEmine could void your authority to operate this equipment.

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Appendix B RF RADIATION

RF Radiation Hazard Warning

To ensure compliance with FCC and Industry Canada RF exposure requirements, this device must be installed in a location where the antennas of the device will have a minimum distance of at least 20 cm from all persons. Using higher gain antennas and types of antennas not certified for use with this product is not allowed. The device shall not be co-located with another transmitter.

Installez l'appareil en veillant à conserver une distance d'au moins 20 cm entre les éléments rayonnants et les personnes. Cet avertissement de sécurité est conforme aux limites d'exposition définies par la norme CNR-102 relative aux fréquences radio.

Appendix C IC COMPLIANCE

Industry Canada Notice and Marking

7.1.2 if detachable antenna

This radio transmitter RS9110N1122 and NRF905 has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

Antennatype	QF036	QF037
Mounting type	Through Hole	Magnetic
Weight	480g	620g
Impedance	50 Ohm Nominal	
WIFI gain	5 dBi	
RF gain	3 dBi	
GPS gain	5 dBi	

7.1.2 (applies to all transmitters)

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

7.1.3 - unlicensed

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.



Appendix D LEGAL STATEMENT

WARNING OF PERSONAL INJURY

As with all traffic awareness and collision avoidance devices, SAFEmine products may not detect all threats within the detection window. SAFEmine products are intended as an additional tool in determining potential traffic threats, supporting an alert and conscientious driver. SAFEmine products are not designed as a substitute for proper safe driving and visual traffic scanning procedures; a vigilant effective lookout is required at all times. SAFEmine products only warn the operator of the presence of other vehicles that are also fitted with SAFEmine products or warn of obstacles that are stored in the internal database. SAFEmine products do not give any guidance on avoiding action. The operator of the vehicle remains fully responsible for operating the vehicle and ensuring the safety of passengers, pedestrians and other traffic. Never use SAFEmine products for applications other than their intended and authorized use. Never use SAFEmine products as emergency stop device or in any other application where failure of the products could result in personal injury. Before installing, handling, using or servicing SAFEmine products, consult the data sheet, manuals and application notes and make yourself thoroughly familiar with the operations and limitations. Failure to comply with these instructions could result in serious injury or death.

LIMITED WARRANTY

EXCEPT FOR THE WARRANTIES EXPRESSLY SET FORTH HEREIN, SAFEMINE MAKES NO WARRANTIES, EITHER EXPRESS OR IMPLIED, WITH RESPECT TO THE PRODUCT. ANY AND ALL WARRANTIES, INCLUDING WITHOUT LIMITATION, WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, ARE EXPRESSLY EXCLUDED AND DECLINED. SAFEMINE is only liable for defects of this product arising under the conditions of operation provided for in the data sheet and proper use of the goods. SAFEMINE explicitly disclaims all warranties, express or implied, for any period during which the goods are operated or stored not in accordance with the data sheet. The warranty voids in the case of the following cases: any opening of the housing, inappropriate operations or installation (see the restrictions in the respective manuals) and intellectual property violations.

SAFEmine Ltd.'s entire liability and customer's exclusive remedy for SAFEmine products that fail to conform to SAFEmine Ltd.'s limited warranty, shall be, at SAFEmine Ltd.'s sole option, either repair or replacement of the nonconforming products, or, if neither is practicable, a refund of the fees paid by customer to SAFEmine Ltd. for such products. The warranty for the repaired or replaced product is limited to the scope and remaining duration of the original warranty for the nonconforming product.

LIMITED LIABILITY

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If the customers uses SAFEmine products for any unintended or unauthorized application, the customer shall defend, indemnify and hold harmless SAFEmine Ltd. and its officers, employees, subsidiaries, affiliates and distributors against all claims, costs, damages and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if SAFEmine Ltd. shall be allegedly negligent with respect to the design or the manufacture of the product.



INDEMNIFICATION

Customers agree to indemnify and hold harmless SAFEmine Ltd., its subsidiaries, and affiliates, and their respective successors and assigns, from and against all third party claims, loss, damage or expense, and any other liabilities whatsoever, including without limitation, reasonable counsel fees, arising from or by reason of any actual or claimed damages, and/or injuries, or any litigation based thereon, which may be incurred by SAFEmine Ltd. with respect to any of the SAFEmine products covered by the order, including use, and such obligation shall survive acceptance of the SAFEmine products and payment therefore by the customer.

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