Vehicle Safety Controller

Rugged Wireless Receiver with Dual Emergency Stop Inputs and Outputs, USB, RS232, and CAN Integration

HRI's Safe Remote Control System is a medium to long-range wireless controller designed from the ground up to enable the safe operation of remote and automated systems. It provides a rugged, ergonomic, and easy to understand controller with a flexible receiver that both implement HRI's proprietary SafetySense™ technology to ensure both consistent and reliable control.

1. Applications

- Control of remote, tele-operated, semi- or fully autonomous robotic systems where safety and usability are critical.
- Monitoring of fixed or mobile industrial systems requiring sophisticated control and reliable wireless emergency stop capabilities.

2. Key Features (Vehicle Safety Controller – VSC)

- SafetySense™ wireless communications
  - Frequency bands include 900 MHz (2+ km LOS), 2.4 GHz (200+ m LOS) (other bands available)
  - Encryption available upon request
- USB, RS-232 serial, and CAN bus support for flexible system integration options
- Second generation SafetySense™ architecture for high reliability, no single point of failure safety implementation
- Dual wired emergency stop loop with active diagnostics
  - Designed to meet ISO 13849 Category 3 Performance Level d
- Master enable relay output for direct stop of motion control equipment
  - Internal Master enable fault detection
- 9 VDC to 36 VDC power input
- USB interface for programming and configuration
- -40°C to 70°C operation
- Multiple Connector Options
  - Sealed Mini-USB AB, Ecomate RM for Power, Estop I/O, RS232, or CAN interfaces, and RP-SMA antenna connector
  - MIL-DTL-38999 6 pin for USB, MIL-DTL-38999 19 pin for Power, Estop I/O, RS232, or CAN interfaces, and RP-SMA antenna connector
- IP66 (NEMA 4X) rated enclosure
- C and python drivers available to accelerate system software development

3. SafetySense™ Technology

SafetySense™ Technology consists of major system-level technologies that work together to provide the integrator the ability to design systems with consistent and reliable remote operations.

The VSC contains dedicated hardware that is monitoring its remote links, local safety inputs, local safety outputs, as well as its internal health. Dual highly-reliable programmable controllers run frequent diagnostics on themselves as well as their partner to ensure any internal or external faults are detected before a demand on the safety system occurs.

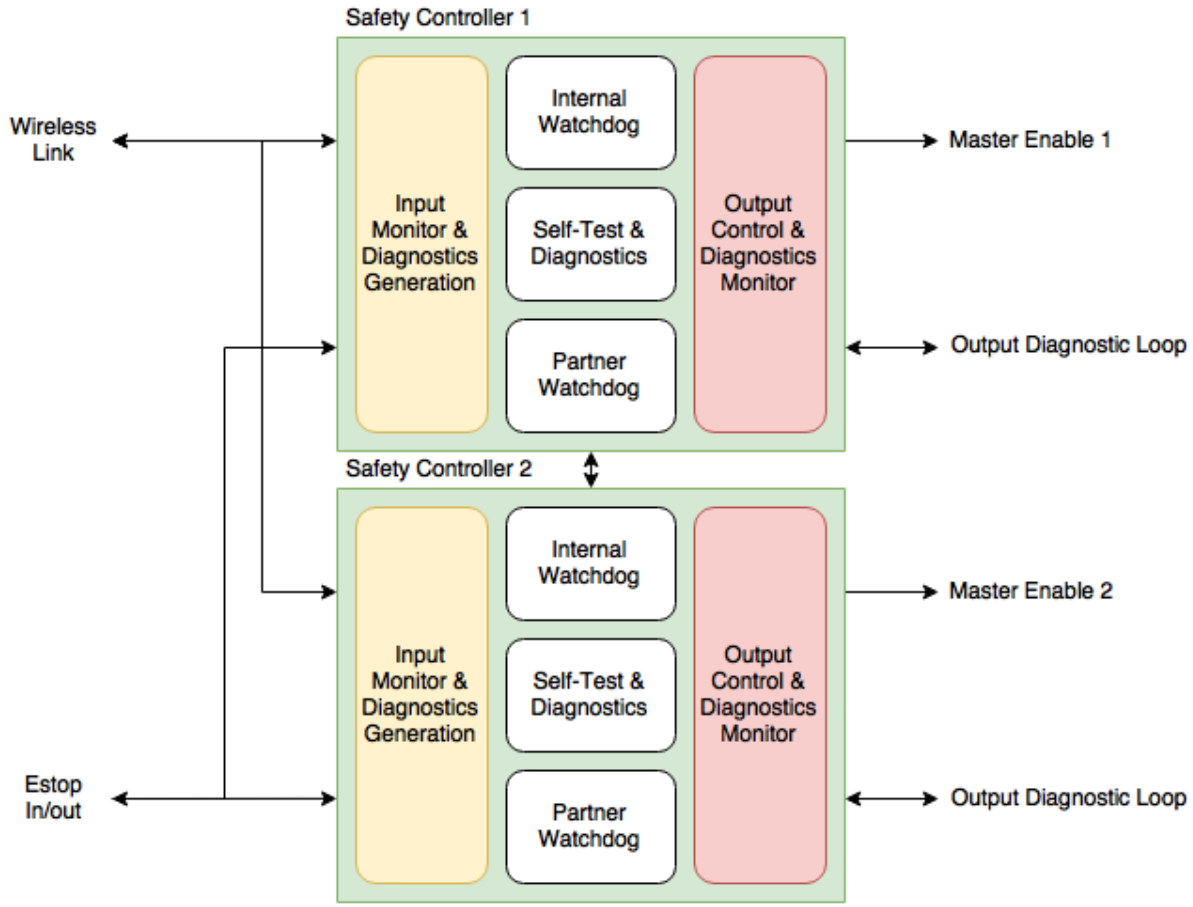

Figure 1 – Safety Architecture

The figure above illustrates the internal structure of the VSC. It is designed from the ground up to ensure that no single point of failure (hardware or software) exists that could cause an unsafe condition to not be caught and indicated by the Master Enable. It is important that system designers pay careful attention in the integration of the VSC with their drive system to ensure that motion will be prevented when the system de-asserts the Master Enable signals.

4. Specifications (Vehicle Safety Controller – VSC)

The Vehicle Safety Controller is an advanced receiver for several of HRI's wireless control and safety systems. It incorporates many of the SafetySense™ technologies described above.

4.1. Absolute Maximum Ratings[1]

Parameter	Minimum	Maximum	Unit
PVin	GND	42	V
Output Voltage	GND	PVin	V
MasterEnable 0 & 1 to Estop, PVin, GND or Data signals		1000	Vrms
Operational Temperature	-40	+70	°C
Storage Temperature	-40	+85	°C
Input Voltage	GND	PVin	V

1 – Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Table 1 – Absolute Maximum Ratings

4.2. Recommended Operating Conditions

Parameter	Minimum	Typical	Maximum	Unit
PVin High Operating Voltage	9	12	36	V
PVin Input Power		1	8[1]	W
PVin Operating Current			1.5	A
MasterEnable 0 & 1 Output Voltage (AC)			250	VAC
MasterEnable 0 & 1 Output Voltage (DC)			50	VDC
MasterEnable 0 & 1 Current			4	A
EStopLoop 0 & 1 Output	GND		5	V
Estop 0 & 1 Input Voltage Maximum	GND		36	V
Estop 0 & 1 Input High Voltage	2.3			V
Estop 0 & 1 Input Low Voltage			1.0	V
LED 0-2 Voltage	GND		5	V
LED 0-2 Current			50	mA

1 – Maximum depends on primarily on RF power output.

Table 2 – Recommended Operating Conditions

4.3. Wireless Specifications

The VSC-008 can be configured with several different radios based on frequency requirements and local regulatory compatibility. Prior to ordering and deployment, please consult your local regulations to ensure the proper radio is installed.

4.3.1. 902-928MHz North America ISM Radio (Radio Code -901)

Parameter	Minimum	Typical	Maximum	Unit
Transmit Power		140	1000[1]	mW
Receive Sensitivity	-108			dBm

Frequency	902		928	MHz
Channel Size		250		kHz
Number of Channels			105	
Error Detection		32 bit CRC		
Spread Spectrum		FHSS		
Data Security		AES 128		Optional

1 – Maximum depends on local regulations. Inquire for details.

Table 3 – 902-928 MHz North America Radio Specifications

4.3.2. 915-928MHz Australia & New Zealand ISM Radio (Radio Code -903)

Parameter	Minimum	Typical	Maximum	Unit
Transmit Power		140	1000[1]	mW
Receive Sensitivity	-108			dBm
Frequency	915		928	MHz
Channel Size		250		kHz
Number of Channels			52	
Error Detection		32 bit CRC		
Spread Spectrum		FHSS		
Data Security		AES 128		Optional

1 – Maximum depends on local regulations. Inquire for details.

Table 4 – 915-928MHz Australia & New Zealand Radio Specifications

4.3.3. 2.4GHz ISM Radio (Radio Code -2401)

Parameter	Minimum	Typical	Maximum	Unit
Transmit Power – 2.4GHz		100	500[1]	mW
Receive Sensitivity	-107			dBm
Frequency	2.4000		2.4835	GHz
Channel Size		250		kHz
Number of Channels			105	
Error Detection		32 bit CRC		
Spread Spectrum		FHSS		
Data Security		AES 128		Optional

1 – Maximum depends on local regulations. Inquire for details.

Table 5 – 2.4GHz Radio Specifications

4.4. Data Interfaces

The VSC's integration interface is USB, RS232, or CAN. The communication specifications (data rates and protocol) are described in the system user manual. The dual Master Enable outputs should be used to prevent any motion of the system under control when the VSC receives an emergency stop from either the connected remote device or its wired emergency stop input. The Master Enable outputs are open drain type, designed to drive the coil of a pair of safety relays. The emergency stop inputs are relative to the PVin. A single ground reference should be maintained for all power and reverence voltages.

Parameter	Minimum	Typical	Maximum	Unit
CAN H/L Voltage	-2		7	V
CAN H/L baud rate	40	250	1000	kbps
CAN H/L high level input voltage	2			V
CAN H/L low level input voltage			0.8	V
CAN H/L high level output current - driver	-40			mA
CAN H/L high level output current - receiver	-8			mA
CAN H/L low level output current - driver			48	mA
CAN H/L low level output current - receiver			8	mA
CAN H/L positive going input threshold		750	900	mV
CAN H/L negative going input threshold	500	650		mV
CAN H/L input resistance	25	35	50	kΩ

Table 6 - CAN Interface Specifications

Parameter	Minimum	Typical	Maximum	Unit
RS232 TX high level output voltage	5	5.4		V
RS232 TX low level output voltage	-5	-5.4		V
RS232 RX high level output voltage	5	5.4		V
RS232 RX positive going input threshold		1.5	2.4	V
RS232 RX negative going input threshold	0.6	1.2		V
RS232 RX input resistance	3	5	8	kΩ
RS232 baud rate		115200		bps

Table 7 – RS232 Interface Specification

4.5. I/O Connector Pinout

The 19-pin I/O connector is where the majority of the system integration is done. Most applications will only need this connector, leaving 6-pin USB connector capped.

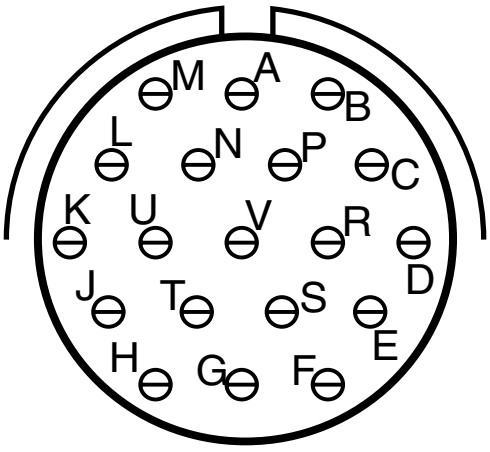

Figure 2 - VSC I/O connector pinout

NOTE: Connectors are designed to be hand tightened only. Use of a wrench or other tool will cause damage to the connector or cabling.

VSC-009 Pin	VSC-006 Pin	Signal Name	Type	Wire Color on Breakout	Description
A	A	MasterEnable0_COM	O	White/Blue	Master Enable 0 common
B	B	NA	NA		Reserved. Do Not Connect.
C	C	Estop In 0	I	Brown	Normally low Estop input (high = active estop condition).
D	D	Estop In 1	I	Violet	Normally High Estop input (low = active estop condition).
E	E	LED0	O	Gray	Status LED output. Refer to green LED behavior in user manual.
F	F	CAN_L	I/O	Yellow	CAN low data interface
G	G	CAN_H	I/O	Orange	CAN high data interface
H	H	MasterEnable1_COM	O	White/Black	Master Enable 1 common
J	J	RS-232 TX	O	White/Orange	RS-232 transmit data interface
K	K	RS-232 RX	I	White/Yellow	RS-232 receive data interface
L	L	Estop Out 0	O	White/Brown	Estop 0 loop output. Connect to Estop In 0 through one or more normally open emergency stop switches.
M	M	Estop Out 1	O	White/Violet	Estop 1 loop output. Connect to Estop In 1 through one or more normally open emergency stop switches.
N	N	MasterEnable1_NO	O	White	Normally open MasterEnable0 contact de-asserted = open = active estop condition asserted = closed (pulled low) = no estop condition
P	P	LED1	O	Pink	Status LED output. Refer to green LED behavior in user manual.
R	R	RS-485_P	I/O	White/Gray	Reserved for future use. Do Not Connect.
S	S	MasterEnable0_NO	O	Blue	Normally open system enable output de-asserted = open = active estop condition asserted = closed (pulled low) = no estop condition (run)
T	T	RS-485_N	I/O	White/Green	Reserved for future use. Do Not Connect.
U	U	PVin	NA	Red	Power input
V	V	GND	NA	Green	

Table 8 – VSC I/O connector pinout and signal descriptions

4.6. USB Connector Pinout

4.6.1. VSC-009 - 38999

The 6-pin USB connector is used primarily for configuration and firmware upgrades or system communication if the USB-CDC interface is utilized.

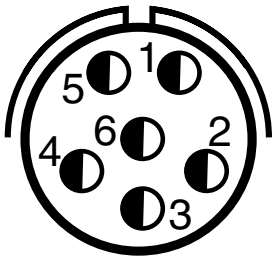

Figure 3 - VSC USB connector pin location

NOTE: Connectors are designed to be hand tightened only. Use of a wrench or other tool will cause damage to the connector or cabling.

Pin	Signal Name	Type	Description
1	+5V	Vcc	USB power input
2	NA	NA	Reserved. Do Not Connect.
3	NA	NA	Reserved. Do Not Connect.
4	USB D-	I/O	USB data negative differential signal
5	USB D+	I/O	USB data positive differential signal
6	GND	Vss	USB ground

Table 9 –VSC USB (VIC-004) connector pinout and signal descriptions

4.6.2. VSC-006 – USB Mini-AB

The standard USB Mini-AB connector is used primarily for configuration and firmware upgrades or system communication if the USB-CDC interface is utilized.

4.7. Mechanical Specifications

4.7.1. VSC-009 – 38999

Parameter	Minimum	Typical	Maximum	Unit
Ingress Protection	IP66[1]			
Weight		1.0		lbs
Antenna Connector		RP-SMA Female		
Data Connector		38999 Series III TV 6p (Amphenol part # D38999/24WA35PN)		
I/O Connector		38999 Series III TV 19p (Amphenol part # D38999/24WD19PN)		

1 – When connected or dustcap installed

Table 10 –VSC-009 Mechanical Specifications

4.7.2. VSC-006 – Ecomate RM

Parameter	Minimum	Typical	Maximum	Unit
Ingress Protection	IP66[1]			
Weight		1.0		lbs

Antenna Connector		RP-SMA Female		
Data Connector		USB Mini-AB		
I/O Connector		Amphenol Ecomate RM (Amphenol part # RTO01619PNH)		

1 – When data connector is connected

Table 11 – VSC-006 Mechanical Specifications

4.8. Mechanical Drawing

4.8.1. VSC-009 – 38999

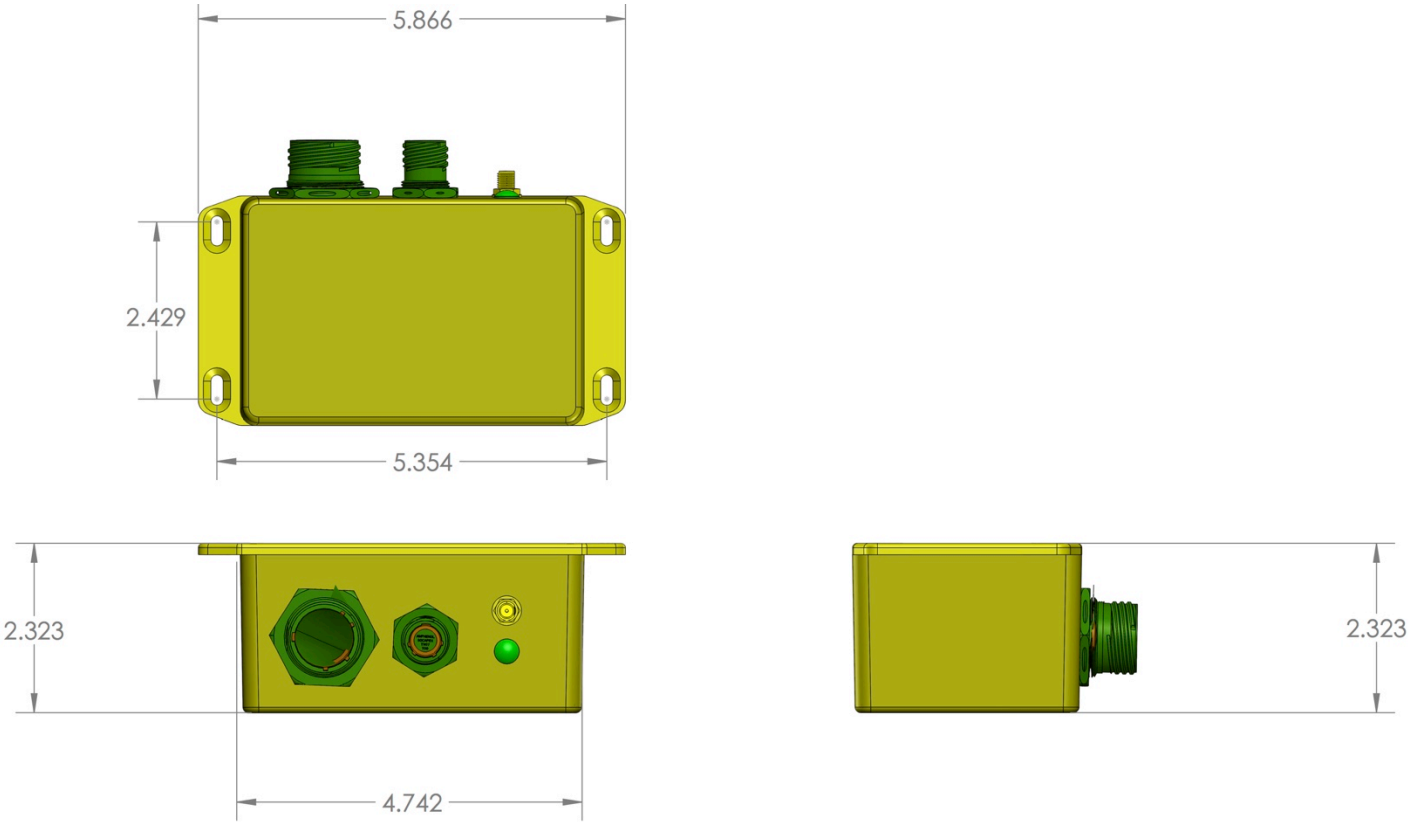

Figure 4 – VSC-009 Mechanical Drawing (All Dimensions in Inches)

4.8.2. VSC-006 – Ecomate RM

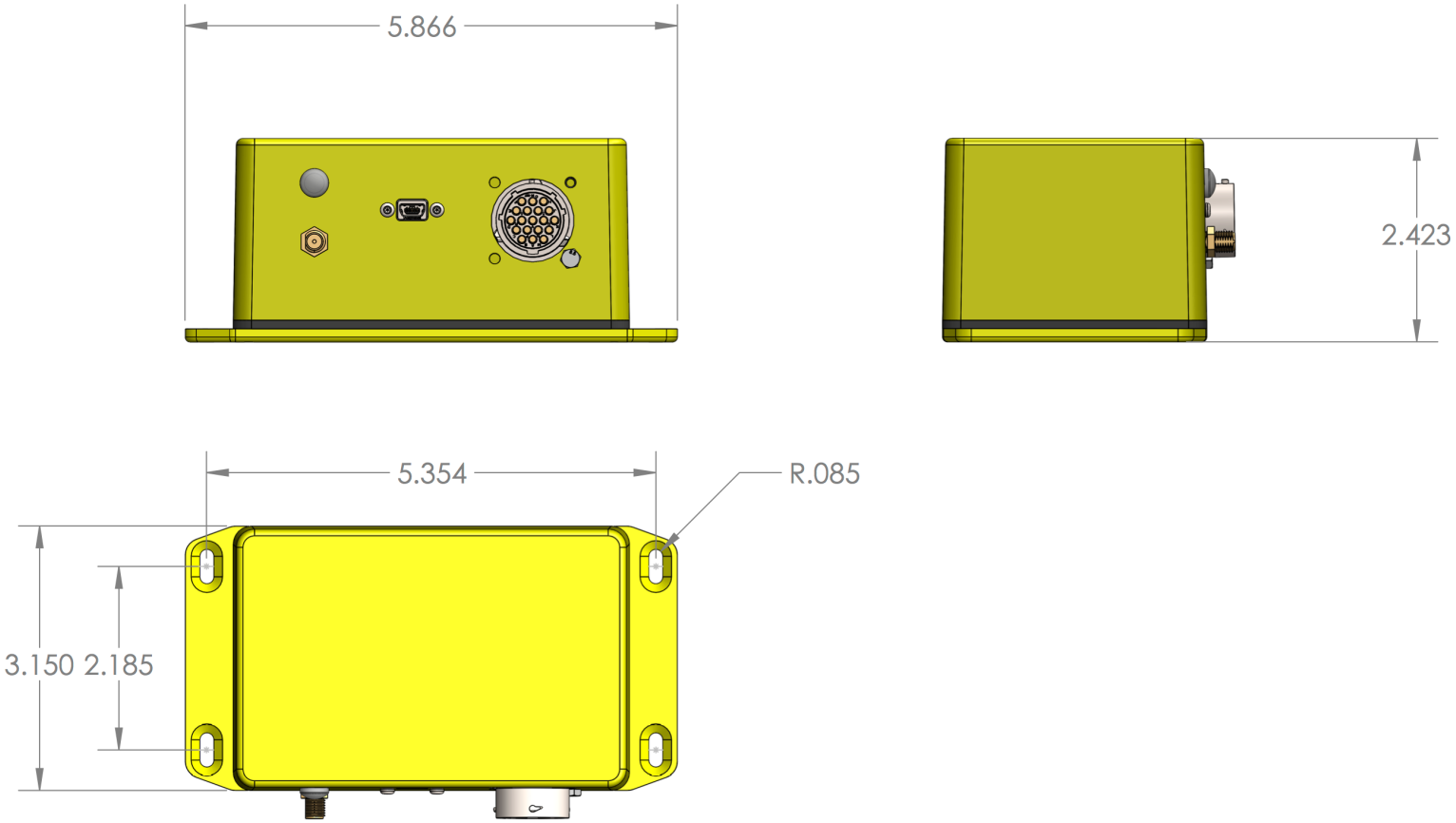

Figure 5 – VSC-006 Mechanical Drawing (all dimensions in inches)

5. Installation

5.1. Hardware Integration

The I/O cable described in section 4.5 provides the connections required for most integration into systems with a user computer, wired emergency stops, and utilizing the Master Enables.

Estop_In_0/Estop_out_0 and Estop_In_1/Estop_out_1 are intended to be connected as shown through a standard emergency stop switch. These signals are internally biased to their fault state, so if this wired safety input is not used it must be bypassed externally as shown below. It is critical that the Estop_In_0 and Estop_In_1 signals are treated properly. If one or both signals are treated improperly or left unconnected, the VSC will treat this as a fault condition and de-assert the Master Enable signals.

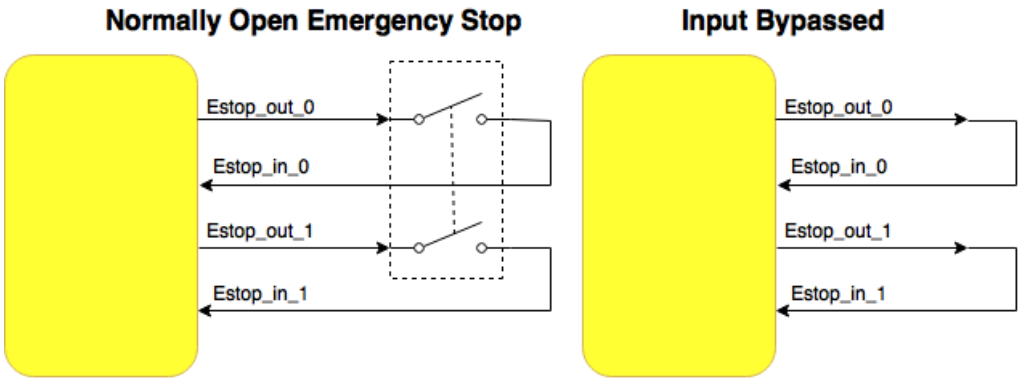

Figure 6 – Emergency Stop Input Wiring

Access to the internal safety relays are given through the MasterEnable_NO and MasterEnable_COM signals. One normally open contact of each of the two relays is provided for control of external loads (motors, contactors, or relays) or participation in an existing wired emergency stop loop. This architecture makes the VSC integrate similarly to an additional wired normally open emergency stop button.

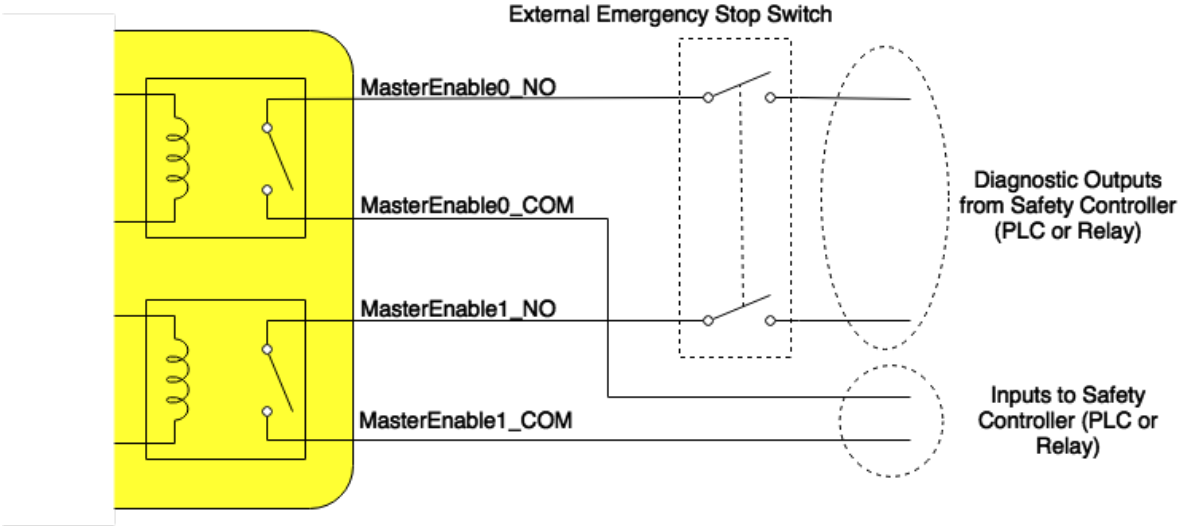

Figure 7– Master Enable Connection to Emergency Stop Loop

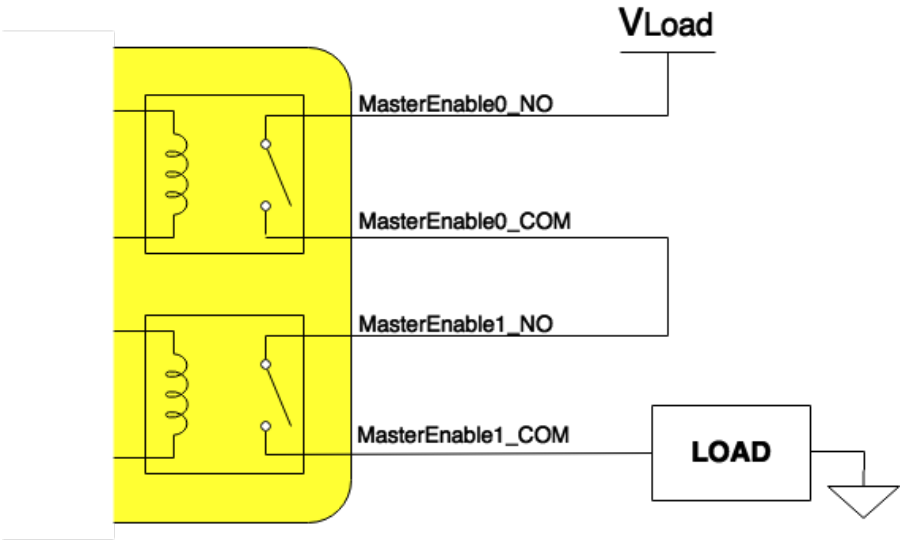

Figure 8– Master Enable Connection to External Load

5.2. Interfacing (RS232 / USB)

When using an RS232 or USB version of the VSC, all command and control communication is in the HRI Packet Protocol. The VSC USB interface is implemented as a CDC device and on most operating systems it will show up as a serial port (*/dev/tty.usbserial*, */dev/ttyACM0*, COM1, etc). There are no differences in software integration when using the RS232 connection or the USB connection. An example C application is provided that uses the HRI Packet Protocol to communicate with the VSC over a serial device. The example shows to how provide heartbeat and feedback messages to the VSC while receiving joystick, heartbeat and GPS messages from the VSC. Detailed integration information is described in the system user manual. Up to date documentation and sample code can be found at http://docs.hri.io.

5.3. Interfacing (CAN-J1939)

When using the CAN version of the VSC, all command and control communication is over the CAN Bus interface using J1939 Protocol. The VSC uses the SAE J1939 basic joystick messages and extended joystick messages to transfer information about the measured status of the X, Y and Z-axis of the joysticks, and the state of buttons. The SRCS uses custom SAE J1939 messages to transfer the heartbeat and key-value pair information. Detailed integration information is described in the system user manual. An example python application is available that demonstrates the parsing and transmission of these messages. Up to date documentation and sample code can be found at http://docs.hri.io.

6. Regulatory Information

6.1. Power Output

The VSC-009-9XX is capable of transmitting at up to 1W. It is recommended that the transmit antenna be kept at least 23cm away from nearby persons to satisfy FCC RF exposure requirements.

The VSC-009-24XX is capable of transmitting at up to 500mW. The antenna used must provide a separation distance of at least 20cm from all persons and must not be co-located or operate in conjunction with any other antenna or transmitter.

6.2. FCC Notifications

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.

6.3. IC Notifications

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

Ce dispositif est conforme aux norms permis-exemptes du Canada RSS d'industrie. L'opération est sujette aux deux conditions suivates: (1) ce dispositive peut ne pas l'interférence, et (2) ce dispositif doit accepter n'importe quelle interference, y compris l'interférence qui peut causer le fonctionnement peu desire du dispositif.

7. Ordering Information

Part Number	Description
VSC-009-(F)	Vehicle Safety Controller with 38999 Connectors and Integrated Safety Relays (F) = Radio Selection 901: 902-928MHz FHSS North America 1W 903: 915-928MHz FHSS Australia/New Zealand 1W 2401: 2.4GHz FHSS 500mW (inquire for higher power) ** Inquire about other frequency bands
VSC-006-(F)	Vehicle Safety Controller with Ecomate RM Connector and Integrated Safety Relays (F) = Radio Selection 901: 902-928MHz FHSS North America 1W 903: 915-928MHz FHSS Australia/New Zealand 1W 2401: 2.4GHz FHSS 500mW (inquire for higher power) ** Inquire about other frequency bands
VIC-004	USB interface cable with 6p 38999 for VSC-009
VIC-003	36 inch pigtail I/O cable with 19p 38999 for VSC-009
100-0148	36 inch pigtail I/O cable with 19p Ecomate RM for VSC-006

Table 12 – VSC Orderable Part Numbers

8. Limited Warranty

All products sold by Humanistic Robotics, Inc are subject to the warranty provisions of the Humanistic Robotics Order Confirmation terms and conditions and are warranted against defects in material and workmanship for a period of one (1) year from the date of shipment. If you believe any Humanistic Robotics, Inc product you have purchased has a defect in material or workmanship or has failed during normal use within the warranty period, please contact Humanistic Robotics, Inc for assistance. If product repair or replacement is necessary, the Customer will be solely responsible for all shipping charges, freight, insurance and proper packaging to prevent breakage in transit, whether the product is covered by this warranty or not.

This warranty does not apply to defects resulting from any Customer actions, such as mishandling, improper interfacing, operation outside of design limits, misapplication, improper repair, or unauthorized modification. No other warranties are expressed or implied. Humanistic Robotics, Inc specifically disclaims any implied warranties of merchantability or fitness for a specific purpose and all warranties arising from course of dealing and/or trade usage. Humanistic Robotics, Inc.'s liability shall be limited to the actual purchase price of any defective unit or units of equipment to which a claim is made, and shall in no event include the Customer's manufacturing costs, lost profits or goodwill, or any other direct, indirect, special, incidental, consequential or punitive damages whether based on contract, tort or other legal theory. Humanistic Robotics, Inc shall not be liable for normal manufacturing defects or customary variances from specifications.

Products sold by Humanistic Robotics, Inc are not designed, intended or authorized for use in applications intended to sustain or support life, in any nuclear facilities or any other application where the failure of the product could create a situation where catastrophic property damage, personal injury or death may occur. In the event that the Customer purchases or uses any Humanistic Robotics, Inc products for any such unintended or unauthorized application, the Customer shall indemnify and hold harmless Humanistic Robotics, Inc and its officers, directors, employees, agents, affiliates, successors and assigns against all claims, costs, damages and expenses (including reasonable attorneys' and expert witness' fees) arising out of or in connection with, directly or indirectly, any claim for property damage, personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Humanistic Robotics, Inc was negligent regarding the design or manufacture of the subject product.

9. Revision History

Version	Date	Changes
-01	7/7/2017	Initial Release
-02	9/25/2017	Updated LOS range for 2.4GHz radio

Table 13 – Document Revision History

Humanistic Robotics, Inc.
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