

# Technical Manual

## WAVE Transceiver with precise localization capability MTX-9450 and TRX-9450

**This device is based on the IEEE WAVE Standards**

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## Information about this document

### Audience

This document is addressed to **qualified staff** only.

Qualified staff have the appropriate knowledge in the scope of electrical engineering and have been instructed and authorized by Kapsch.

### Preparations

This Technical Manual shall be carefully read before installation.

## Text conventions

Visual aids and standard text formats in this manual help the reader to locate and identify information easily.

Typographical formats:

Table 1  
Text formats and their meaning

Style	Used for
<b>bold</b>	Accentuations
<i>italics</i>	Labelling and cross-references
CAPITAL LETTERS	Acronyms

## Important text elements

This manual contains specific Caution and Warning statements. These shall be interpreted as follows:

### Attention



**Attention:** This warning indicates that the device may be affected by Electrostatic Discharge. Appropriate precautions must be made to avoid damage to the device.

### Caution



**Caution:** A caution sign indicates concerns about a procedure which may lead to equipment damage or violation of regulatory requirements.

### Warning



**Warning:** indicates a potential danger that requires correct procedures or practices in order to prevent injury to humans or damage to the equipment.

## Abbreviations

<b>DL</b>	Downlink direction (Information from TRX)
<b>DSRC</b>	Dedicated Short Range Communication
<b>EIRP</b>	Equivalent Isotropic Radiated Power
<b>MLFF</b>	Multi Lane Free Flow
<b>MTX</b>	Master Transceiver
<b>OBU</b>	On Board Unit
<b>RSU</b>	Roadside Unit
<b>TCM</b>	Transceiver Connection Module
<b>TIM</b>	Transceiver Interface Module
<b>TRC</b>	Transceiver Controller
<b>TRP</b>	Transponder Unit
<b>TRX</b>	Transceiver
<b>UL</b>	Uplink direction (Information to TRX)

## Warning to users in the United States

### Local Regulations

The hardware referred to in this document allows selection of frequency bands and transmit power levels that may not comply with the regulatory body that governs spectrum policy where the hardware is being used.

### License Required

The operator is required apply for and obtain a 47 CFR Part 90 geographic area license from the FCC that has specified eligibility requirements to operate this device in the United States (47 CFR Part 90.375). See product label for FCC ID number.

Individual devices have to be registered. Such licenses serve as a prerequisite to registering individual devices located within the licensed geographic area. Licensees must register each installation in the Universal Licensing System (ULS) before operating an Roadside Unit (RSU).

For further information about DSRC regulations in the US please refer to

[http://wireless.fcc.gov/services/index.htm?job=service\\_home&id=dedicated\\_src](http://wireless.fcc.gov/services/index.htm?job=service_home&id=dedicated_src)

## Regulatory Information

### Notice

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.

### Notice

Changes or modifications made to this equipment not expressly approved by Kapsch may void the FCC authorization to operate this equipment.

### Class B digital device

**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.

### Radio frequency radiation exposure Information

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance of 20 cm (8 inches) between the radiator and a human body. Failure to do so could result in bodily injury or death.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.



## Safety Instructions

### Overvoltage Protection



**Caution:** The TCM/TIM overvoltage protection module must be used.

### Handling of Cables



**Caution:** Cables shall not be bent to a smaller radius than specified by the cable manufacturer. For cables listed in this manual the bent radius shall be larger than 5 inch (12cm)

### Grounding



**Caution:** It is necessary to connect the device to ground with a low impedance connection.

### Note to GPS System Installer

This reminder is provided to call the systems installer's attention to Section 820.93 of the NFPA 70® National Electrical Code ® 2008 Edition, which provide guidelines for proper grounding and, in particular, specify that the coaxial cable shield shall be connected to the grounding system of the building, as close to the point of cable entry as practical.

## Maintenance Instructions

The Localization Transceivers MTX-9450 and TRX-9450 need no regular electrical maintenance.

## Inspection Instructions



**Warning:** Regular inspection of installed equipment is mandatory and shall be in accordance with the local safety regulations for equipment installed on the roadside.

## Environmental Information

### **Recycling**

Your equipment set consists of material that can be recycled by specialized companies. Please observe the local regulations regarding the disposal of packaging material and waste electronic equipment.

### **Environmental requirements**

The transceiver is protected against environmental influences by NEMA 4X enclosure. No additional protection measures are required for roadside open air installations.

## Visual Inspection

Always check the shipment for completeness and possible damage. If the content is incomplete or damaged, a claim should be filed with the carrier immediately and contact your local Kapsch office.

## Installation Instructions

For information regarding applications for and installation of the products described in this manual, please see the application notes.

# General Information

## Definitions

**Master Transceiver**

The Master transceiver performs communications with an OBU autonomously. It basically includes the functionality of radio module and controller software to perform the communication with the OBU. It can be used as a standalone device or in conjunction with one slave transceiver.

**(Slave) Transceiver**

Slave transceivers are able to perform communications with OBUs by the use of a transceiver controller. The communication is initialized and controlled by the transceiver controller, and forwarded by the transceiver. In this application the transceiver acts as a wireless bridge. Multiple transceivers may be combined in a modular architecture to cover specific communications areas.

**Transceiver Controller**

The transceiver controller performs the application by using the slave transceiver as a wireless network bridge. The transceiver controller further provides the interface to the host e.g. lane controller, central system.

**Communication zones of the transceivers**

The size of the communication zone is defined as the space within communication with another device (e.g., OBU) is reliable. The size of the communication zone is mostly influenced by the mounting height and mounting angle of the transceiver, the antenna utilized and the maximum power level used.

## System Overview

The 5.9 WAVE Transceiver family with precise localization capability implemented in roadside systems supports reliable data exchange with standard compliant Onboard Units (OBUs).

*Figure 1*  
*WAVE Localization Transceiver*



## Performance Overview

- WAVE/802.11p compliant DSRC transceiver with precise localization functionality
- Compatible with WAVE/802.11p compliant OBUs
- Products operate in single - lane- and multi – lane environments
- Weather proof, robust and compact housing

## System Architecture

The 5.9 WAVE Localization Transceiver family supports 2 types of architectures.

- Modular Architecture (*see the following chapter*)
- Compact Architecture (*see page 15*)

### Modular Architecture

#### Scope

This architecture has the highest flexibility for different system setups. It can be scaled from 1 up to 8 lanes.

#### System structure

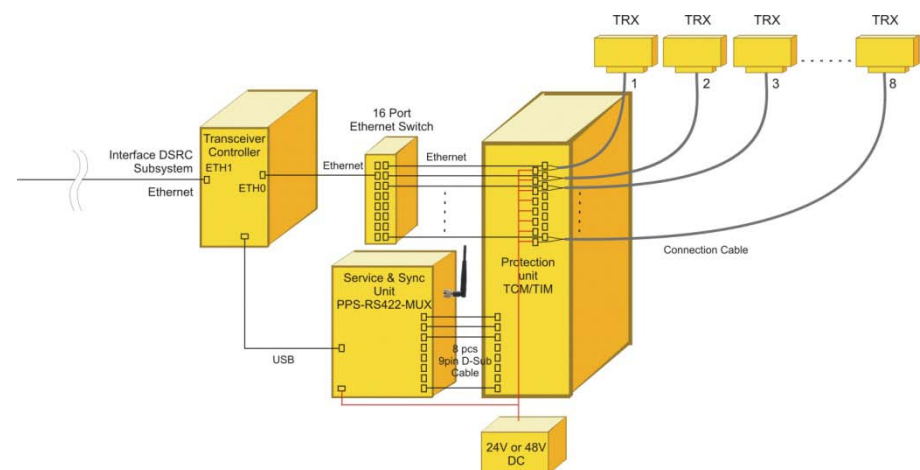
The system consists of 1 transceiver controller and up to 8 transceivers.

- The system interface is based on Ethernet
- The transceivers have to be supplied with an external 24 or 48V DC power supply unit.
- Each Transceiver is internally protected against surges on data and power lines
- The PPS-RS422-MUX is used for synchronization and service purposes of the TRX



**Caution:** At the roadside cabinet a TCM/TIM over-voltage protection unit must to be used to protect the controller against surges.

Figure 2  
System variant  
“Modular Architecture”



#### TRX 1 to 8

The following types of Transceivers are available for the modular architecture.

Table 2  
Transceivers for the system  
variant “Modular Architecture”

System	Type	Kapsch Part No.	Description
Modular	TRX-9450	34026470000	Slave Transceiver

**Installation**

See applications notes.

**Connection Cable**

Max. Length 260feet (80m)

See chapter "Connection Cable (Ethernet + Power Supply)" on page 19.

**Transient Protection Unit**

The transient protection unit consists of the two modules.

Table 3

Available TCM and TIM modules

Module	Description	Kapsch Part No.
TCM-0902	Module holder for up to two TIM modules	34019410000
TCM-0904	Module holder for up to four TIM modules	34018320000
TIM-5310*	Overvoltage Protection Unit (48V / 2.5A fuse, type slow blowing)	34026560000

\* Quantity: 1 TIM module per transceiver

**Service and****Synchronization Unit**

For more detailed information see the technical manual of the transient protection unit (Doc. No. 1000002917 or 1000003873).

Table 4

Available PPS-RS422-MUX modules

Module	Description	Kapsch Part No.
PPS-RS422-MUX-2	Service and Synchronization Unit up to 2 TRX	34026530010
PPS-RS422-MUX-8	Service and Synchronization Unit up to 8 TRX	34026530000

**Power supply**

The power supply must be mounted inside the roadside cabinet. The power supply for the transceivers has to fulfill the requirements for a SELV-circuit (Safety Extra Low Voltage). The supply voltage has to be 24 or 48V DC. A UL compliant industrial power supply must be used.

Table 5

Recommended power supplies

Manufacturer	Type	Description	Kapsch Part No.
TRACO	TSL240-124	24V DC / 10A / 240W	1000000904
TRACO	TSL240-148	48V DC / 5A / 240W	1000000160

**Transceiver Controller**

The Transceiver controller must be mounted inside the roadside cabinet.

Table 6

Available Transceiver Controllers  
TRC-1040-IPC

Type	Description	Kapsch Part No.
TRC-1040-IPC	Transceiver Controller for WAVE	

For more detailed information see the technical manual of the transceiver controller.

## Compact Architecture

### Scope

This architecture is used for setups with minimum of auxiliary equipment needed on the roadside. The transceiver includes all functionality to run the complete application.

### System structure

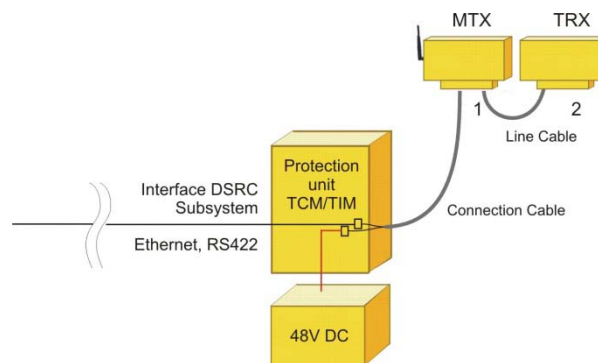
The system is scalable up to 2 lanes and is based on a master slave principle, where the MTX acts as a master.

- The transceivers have to be supplied with an external 24-48V DC power supply unit.
- Each Transceiver is internally protected against reverse polarity and surges.



**Caution:** An over-voltage protection unit has to be used to protect the auxiliary equipment against

Figure 3  
System variant “Line application with Master-Transceiver”



### Transceivers

The following types of Localization Transceivers are available for the “compact architecture”.

Table 7  
Localization Transceivers for the system variant “Line application with Master-Transceiver”

System	Type	Part No.	Description
Compact	MTX-9450	34026470100	Master Transceiver
	TRX-9450	34026470000	Slave Transceiver

### Installation

See application notes

### Connection Cable

Length: from, 33feet (10m) up to 260feet (80m).  
See chapter “Connection Cable (Ethernet + Power Supply)” on page 19.

### Line Cable

The maximum length is limited to 80m.

For standard cables please refer to *chapter* Line Connection Cable (Ethernet + Power Supply) on page 21

### Transient Protection Unit

A transient protection unit which consists of the two modules TCM and TIM must be used at the roadside.

Table 8  
Available TCM and TIM modules

Module	Description	Kapsch Part No.
TCM-0902	Module for up to two TIM modules	34019410000
TIM-5310*	Module for Line application (48V / 2.5A fuse, type slow blowing)	34026560000

\* Quantity: One (1) TIM module per TRX

For more detailed information see the technical manual of the transient protection unit (Doc. No. 1000002917 or 1000003873).

### Power supply

The power supply must be mounted in the roadside cabinet. The power supply for the transceiver has to fulfill the requirements for a SELV-circuit (Safety Extra Low Voltage). The recommended supply voltage is 48V DC. A UL compliant industrial power supply must be used.

Recommended power supplies see Table 5 on page 14.



# Installation

The described mounting applies to all transceivers specified in this documentation.

## Mounting position and height

- The antenna should point towards the direction of traffic flow.
- The mounting device offers the possibility to adapt to different environments, for example mounting under a ceiling is possible.

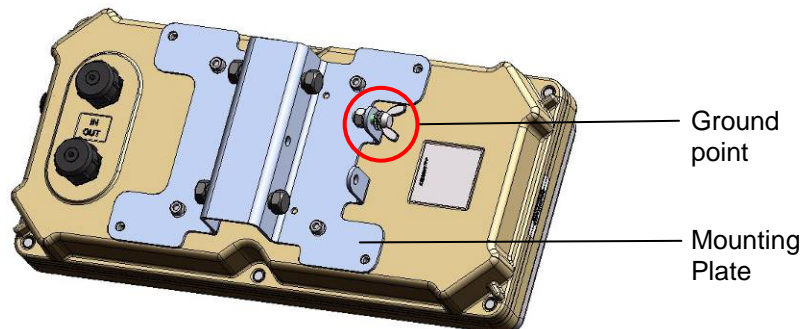


**Warning:** When mounting the bracket to a bridge, a gantry or a wall the appropriate safety regulations must be followed.

## Mounting plate for MTX-9450 and TRX-9450

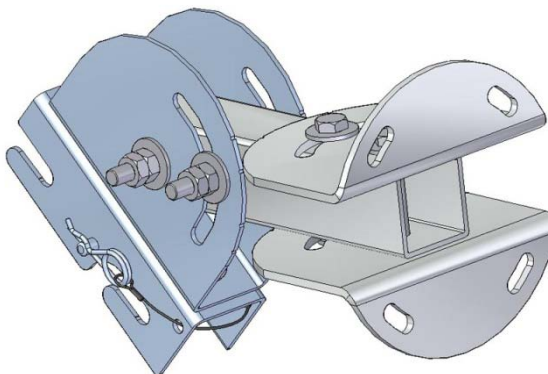
The mounting plate is part of the transceiver and must not be removed.

Figure 4  
Mounting plate for MTX-9450 and  
TRX-9450



## Bracket for MTX-9450 and TRX-9450

Figure 5  
Bracket for MTX-9450 and  
TRX-9450



Module	Description	Kapsch Part No.
Bracket for MTX/TRX	Bracket for installation of MTX/TR	34017690000



**Warning:** Installation of the MTX-9450/TRX-9450 product must be performed by trained Kapsch approved staff.

# Electrical Installation

## Recommendation for cabling

**Remark:** The cables must be protected against mechanical damage. Optimal protection offers a protective cable guard. Cables must be fixed with cable strap in such a way that the maximum protection against mechanical damage is provided.

## Connection Cable (Ethernet + Power Supply)

Table 9  
Available lengths of  
Connection Cable

Part number	Cable length
34015780100	33 feet (10m)
34015780140	46 feet (14m)
34015780180	59 feet (18m)
34015780220	72 feet (22m)
34015780260	85 feet (26m)
34015780300	98 feet (30m)
34015780500	164 feet (50m)

Other lengths are available on request.

Figure 6  
Connection Cable  
(Ethernet + Power Supply)

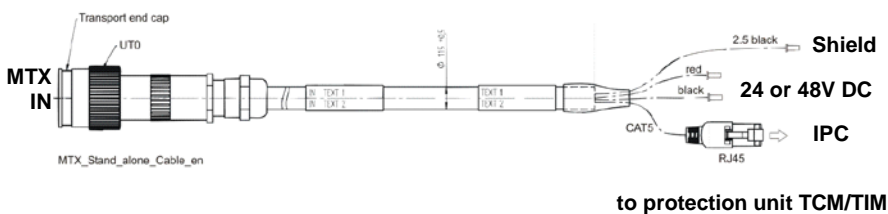
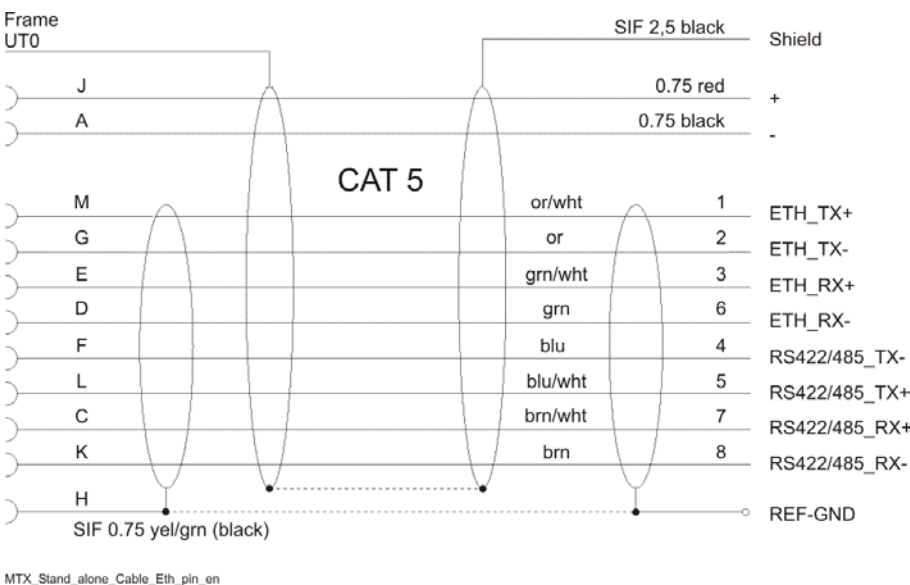


Figure 7  
Connector pin assignment  
Connection Cable  
(Ethernet + Power Supply)



## Signals at connector “IN” of MTX-9450/TRX-9450

Table 10

Signals at connector “IN” of  
MTX-9450/TRX-9450

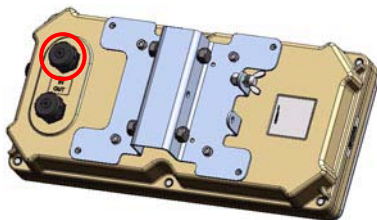
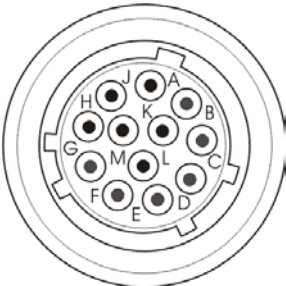
Connector	Pin	Signal	Description
MTX-9450/TRX-9450 “IN”    UT0 Connector male   Stecker_UT0_00	M	ETH_TX+	Ethernet:
	G	ETH_TX-	Positive / negative line, isolated, Transmit-line from transceiver to TRC-1040-E.
	C	RS422/485_RX+	Service:
	K	RS422/485_RX-	Receive-line to transceiver. RS422/485: Positive / negative line, 5Vp-p,
	L	RS422/485_TX+	Service:
	F	RS422/485_TX-	Transmit-line from transceiver, isolated. RS422/485: Positive / negative line, 5Vp-p.
	E	ETH_RX+	Ethernet:
	D	ETH_RX-	Positive / negative line, isolated, Receive-line from TRC-1040-E to transceiver.
	H	REF-GND	REF-GND, reference ground for RS485: Connected with internal galvanic isolated GND via choke.
	J	+	Power line:
	A	-	24V-48V DC, input

Table 11  
Available cable lengths  
Line Connection Cable

Line Connection Cable (Ethernet + Power Supply)

Part number	Cable length [m]
34017450050	16 feet (5m)
34017450070	23 feet (7m)
34017450100	33 feet (10m)
34017450150	49 feet (15m)

Other lengths are available on request.

Figure 8  
Line Connection Cable  
(Ethernet + Power Supply)

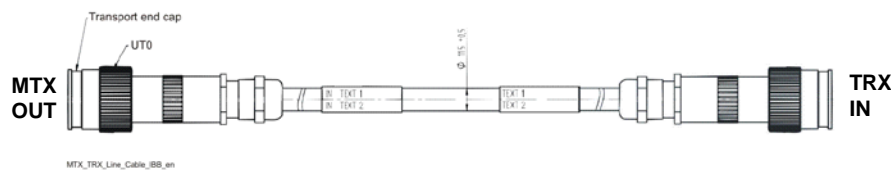
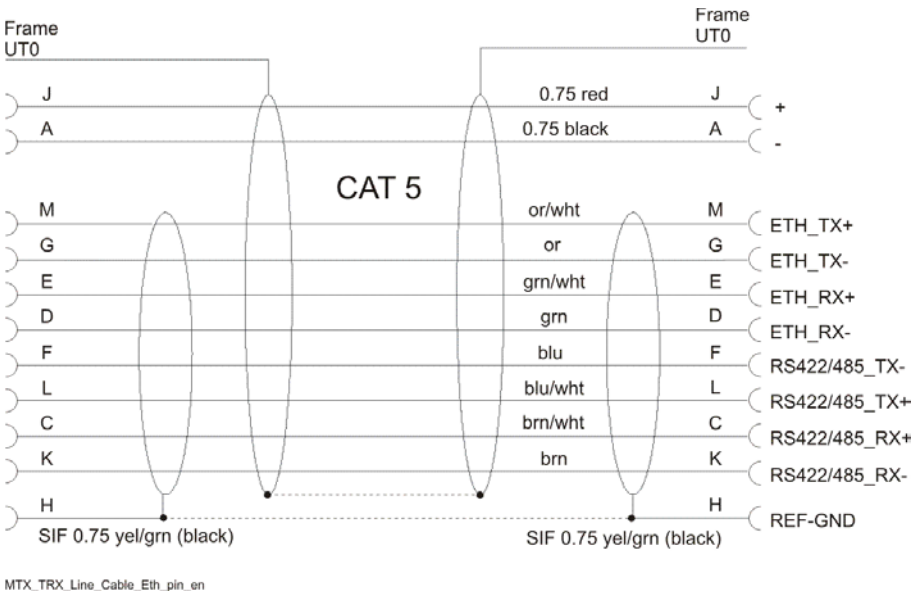


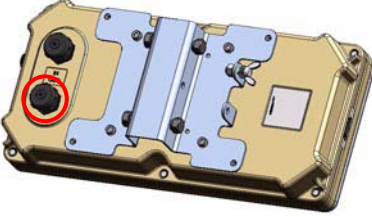
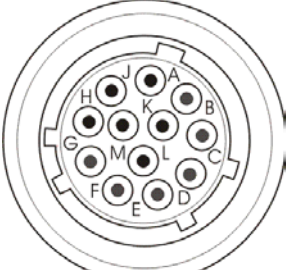
Figure 9  
Connector pin assignment  
Line Connection Cable  
(Ethernet + Power Supply)



## Signals at connector “OUT” of MTX-9450

Table 12

Signals at connector “OUT” of  
MTX-9450

Connector	Pin	Signal	Description
MTX-9450 “OUT”    UT0 Connector male   Stecker_UT0_00	M	ETH_TX+	Ethernet:
	G	ETH_TX-	Positive / negative line, isolated, Transmit-line from transceiver to TRC-1040-E.
	C	RS422/485_RX+	Service:
	K	RS422/485_RX-	Receive-line to transceiver. RS422/485: Positive / negative line, 5Vp-p,
	L	RS422/485_TX+	Service:
	F	RS422/485_TX-	Transmit-line from transceiver, isolated. RS422/485: Positive / negative line, 5Vp-p.
	E	ETH_RX+	Ethernet:
	D	ETH_RX-	Positive / negative line, isolated, Receive-line from TRC-1040-E to transceiver.
	H	REF-GND	REF-GND, reference ground for RS485: Connected with internal galvanic isolated GND via choke.
	J	+	Power line:
	A	-	24V-48V DC, output

# Product Specifications

## Transceivers MTX-9450 and TRX-9450

### Mechanical characteristics

Dimensions [LxWxH]	16.5 in x 7.9 in x 3.4 in (420mm x 200mm x 86mm)
Weight without bracket	<16 pounds (<7 kg)
Material of housing	Alloy die casting, Radom: Polycarbonate
Wind load	70 km/h (43.5 mph) – 34.5 N 120 km/h (74,6 mph) – 100 N 140 km/h (87.0 mph) – 137.5 N 160 km/h (99.4 mph) – 180 N

### Electrical characteristics and conditions

#### Interface Specification

Rated Input Voltage	Nom. 24V DC up to 48V DC
Input Voltage Range	Min: 21.6V DC (=24V – 10%) permanent Max: 52.8V DC (=48V + 10%) permanent
Protection	The Transceiver is internally protected against reverse polarity of the input voltage and internally fused with 3A (type slow blowing). The fuse cannot be changed by the user.
Power consumption at maximum transmit power	MTX 24W typical TRX 24W typical

### RF Interfaces

#### Radio 1

Frequency range	5.850GHz - 5.920GHz
Channels	Channels: 172,174,176,178,180,182,184
Data Rates	3MBit/s – 27MBit/s
Antenna Polarization	Right hand circular
Radiated power	≤ 33dBm EIRP
External Antenna N-Connector (MTX only)	≤20dBm conducted

#### Radio 2

Frequency range	5.850GHz - 5.920GHz
Channels	Channels: 172,174,176,178,180,182,184
Data Rates	3MBit/s – 27MBit/s
Antenna Polarization	Right hand circular
Radiated power	≤ 20dBm EIRP
External Antenna N-Connector (MTX only)	≤ 10dBm conducted

**GPS Interface**

Connector Type	N-Connector female
Antenna Type	Active GPS Antenna

**Environmental conditions**

Temperature (operation)	-30°C ...+55°C (ASTM Type 2) -22F ... 131F
Temperature (storage)	-40°C ...+70°C -40F ... 158F
IEC protection rating	NEMA 4X
Oscillation	3.5mm / (1...9)Hz 10m/s <sup>2</sup> / (9...150)Hz
Shock	150m/s <sup>2</sup> / 11ms

**Compliance**

47 CFR Part 90 M  
47 CFR Part 15 B  
UL-60950-1, 2<sup>nd</sup> edition  
UL-60950-22, 2<sup>nd</sup> edition  
CSA C22.2 No. 60950-1-07, 2<sup>nd</sup> edition  
UL: E323290





# Conformity

## Standards

Table 13  
Standards

Ref.	Standard	Description
[1]	ASTM E2213 - 03	Standard Specification for Telecommunications and Information Exchange Between Roadside and Vehicle Systems — 5 GHz Band Dedicated Short Range Communications (DSRC) Medium Access Control (MAC) and Physical Layer (PHY) Specifications
[2]	IEEE 802.11™a-2007	IEEE Standard for Information technology— Telecommunications and information exchange between systems— Local and metropolitan area networks— Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications
[3]	IEEE 802.11™p	IEEE Standard for Information technology— Telecommunications and information exchange between systems— Local and metropolitan area networks— Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 7: Wireless Access in Vehicular Environments
[4]	IEEE 1609.4™	Draft Standard for Wireless Access in Vehicular Environments (WAVE) - Multi-channel Operation
[5]	IEEE 1609.3™	Draft Standard for Wireless Access in Vehicular Environments (WAVE) – Networking Services

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