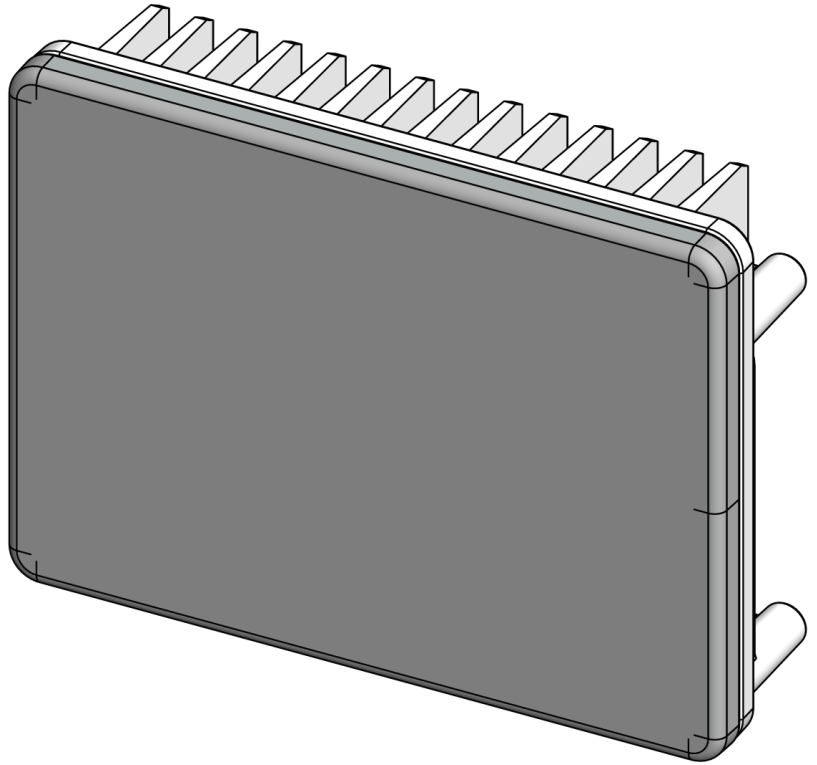




zPRIME 3.0

Ultra-Resolution Software-Defined Imaging Radar™

User Manual

July 2025

1 Introduction and Legal	4
1.1 General Disclaimer	4
1.2 Regulatory Compliance	4
2 Product Overview	6
2.1 zPRIME 3.0 Introduction	6
Key Features	6
Typical Applications	7
Hardware Model Variants	7
2.2 Radar Operating Principle	8
3 Setup and Integration	9
3.1 Kit Contents	9
3.2 Connection Guide	10
Connecting zPRIME 3.0 to 1000BASE-T1 systems (automotive ethernet)	10
Connecting zPRIME 3.0 to RJ45 systems (regular ethernet)	11
3.3 Electrical and Connector Specification	12
Radar-Side Socket Specification	12
Radar-Side Socket Pinout	12
Cable Specification	13
Input Voltage Requirements	14
Power and Current Consumption	14
3.4 Mounting and Installation	15
Mechanical Drawing and 3D CAD/STEP Files	15
Impact of Mounting on Radar Performance	16
FOV Considerations and Keepout Zones	16
Fascia Covers, Bumpers, and User-Attached Radomes	18
Thermal Guidelines	18
Ingress Protection	19
4 Radar Operation	20
4.1 Operational Overview	20
4.2 Network Topology	22
Ubuntu Network Configuration	23
Windows 11 Network Configuration	23
MacOS Network Configuration	25
4.4 Verifying Network Connection	26
4.4 Point Cloud Viewer and Management Webpage	27
Basic Operations	28
User Interface Functions	28
Radar Settings Configuration via Webpage	29



5 HTTP REST API Guide	30
Rest API Endpoint Diagram	31
API Endpoint Quick Guide	32
5 Data Format and Interpretation	33
5.1 Receiving and Deserializing Radar (Point Cloud) Data	33
UDP Transfer Scheme	34
Packet Struct	35
Sample Radar Data UDP Parser Code	36
Extracting 4D Point Cloud	36
Extracting Radar Odometry	36
Extracting Clusters	37
Extracting Tracks	37
5.2 Receiving and Unpacking 6-Axis IMU Data	38
IMU Data Struct	38
Sample IMU Data UDP Parser Code	39
5.3 Coordinate Systems	39
5.4 PTP Time Synchronization	41
PTP Network Connection Topologies	41
PTP Timestamping & Triggering	42
6 Troubleshooting and Maintenance	43
6.1 Basic Diagnostics, Common Issues, and Fixes	43
6.2 Firmware Updates	43
7 Appendix	44
7.1 Technical Specifications	44
8 Revision History	44

1 Introduction and Legal

1.1 General Disclaimer

Notice to Users:

The zPRIME 3.0 radar sensor is a high-performance imaging radar intended for integration into commercial, industrial, and autonomous platforms. This product must be installed, configured, and operated by qualified personnel familiar with radar systems, safety practices, and applicable regulations.

zPRIME 3.0 is designed for use in non-life-critical applications unless specifically certified for safety-critical systems. Users must independently validate the radar's suitability for their intended use. Integration, testing, and certification for end-use compliance are the responsibility of the system integrator.

Specifications, software features, and documentation are subject to change without notice. The manufacturer accepts no liability for any loss or damage resulting from reliance on this document.

Hazard Disclaimer:

The zPRIME 3.0 emits millimeter-wave electromagnetic radiation in the 76-81 GHz band. While compliant with applicable emission limits, it should not be operated in proximity to sensitive RF equipment without proper evaluation.

1.2 Regulatory Compliance

zPRIME 3.0 radar sensors are designed to meet regulatory requirements across major global markets. Certification or conformity details may vary by model and configuration.

USA:



FCC ID: 2BFPN-ZPRM3

This device complies with FCC rules under Part 95 Subpart M for vehicular radar systems operating in the 76-81 GHz frequency band. Operation is subject to the following two conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.

FCC RF Exposure Statement

This device complies with FCC radiation exposure limits set forth for an uncontrolled environment.

This equipment should be installed and operated with a minimum distance of 23 cm between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

	KC Wireless Specification
Frequency Band	76-77, 77-81, or 76-81GHz depending on region
Bandwidth	< 4GHz
Transmit Power (TX Power)	< 10dBm + 50% per TX



Modulation Scheme	RFTDMA, Zadar Proprietary
Antenna Configuration	TX: 12 RX: 16 MIMO
Field of View	Horizontal: +/- 60° / Vertical +/- 12°
Range Resolution	3.4cm or greater depending on mode
Velocity Resolution	0.14m/s or greater depending on mode
Maximum Detection Range	1,000m or less depending on mode

2 Product Overview

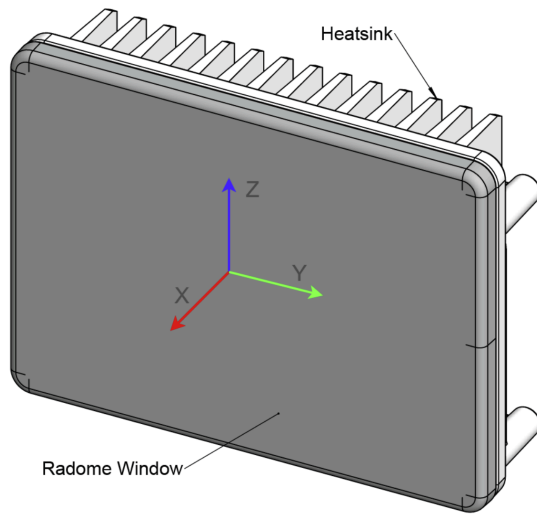


Figure 1. Front View with Coordinate System

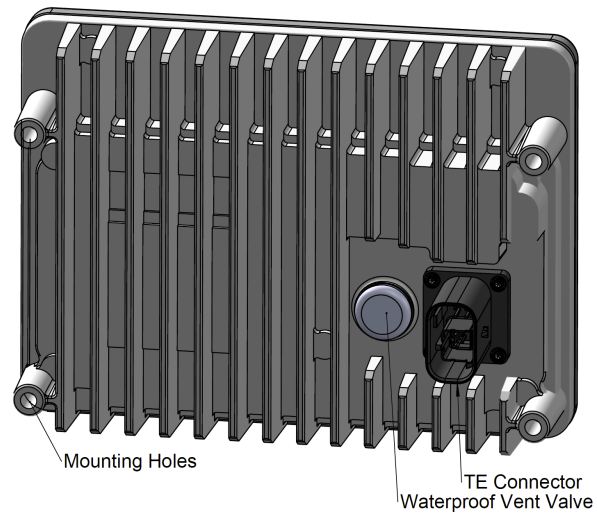


Figure 2. Back View

2.1 zPRIME 3.0 Introduction

zPRIME 3.0 is the industry leading third generation ultra-high-resolution 4D Software-Defined Imaging Radar (SDIR™). zPRIME is designed for demanding perception and safety applications in autonomous systems, industrial automation, and intelligent infrastructure.

zPRIME delivers a rich 4D point cloud with high resolution, range, and reliability for critical sensing applications. Engineered for both indoor and outdoor operation in all weather conditions, zPRIME is built for a long service life.

Key Features

- **True 4D imaging radar:** zPRIME provides true resolution in both Azimuth and Elevation, clearly distinguishing bridges, power lines, and tree canopies.
- **Ultra high static angular resolution:** a custom high resolution beamforming engine separates objects that occupy the same range-doppler cell within 0.35°.
- **Extended detection range:** detect humans up to 350m, vehicles up to 800m, and trucks beyond 1,000m.
- **Ultra-wide field of view:** all models offer 120° horizontal FOV with vertical FOV up to 90°.
- **High frame rate:** 20Hz standard frame rate with special Software-Defined modes up to 50Hz
- **All-weather performance:** operates reliably in rain, dust, fog, and snow under all lighting conditions

- **Software-Defined Imaging Radar™**: supports software-configurable adaptive transmission modes and processing modes for flexible on-the-fly reconfiguration. SDIR™ features depend on model configuration.
- **Standardized data output**: supports HTTP API for sensor configuration and UDP/Protobuf data output
- **Regular firmware updates**: zPRIME 3.0 performance and features improve on a continuous basis

Typical Applications

- Autonomous vehicles, mobile robots, and industrial vehicles
- Agricultural automation, driverless tractors
- Heavy equipment automation and safety
- Railway and mining automation
- Marine automation and collision avoidance
- Intelligent traffic infrastructure
- Site security and surveillance
- Robotics and SLAM in GPS-denied environments

Hardware Model Variants

Antenna Configuration	Interface	Part Number	Vertical FOV / Approximate Car Detection Range	Horizontal FOV
zPRIME 3.0 Long Range	1000BASE-T1	ZPRM3-T1-77-LR	24° V-FoV / $\approx$ 800 m	120°
zPRIME 3.0 Wide	1000BASE-T1	ZPRM3-T1-77-W	50° V-FoV / $\approx$ 400 m	120°
zPRIME 3.0 Ultra-Wide	1000BASE-T1	ZPRM3-T1-77-UW	90° V-FoV / $\approx$ 250 m	120°

- For all other specifications, please consult the appendix.
- Special hardware variants of zPRIME exist for customer-specified applications including ultra-long range, explosion proof, and marine variants. For these variants contact Zadar support for customized documentation.

 **All zPRIME models share the same core processing platform and software interface, allowing seamless integration across use cases.**

2.2 Radar Operating Principle

zPRIME uses **Frequency-Modulated Continuous-Wave (FMCW)** radar technology to detect and track objects in its environment in 4D with high precision.

By transmitting this FMCW signal to the environment, the received signal can be used to estimate:

1. Range (distance) to the target
2. Radial velocity (doppler velocity)
3. Azimuth angle
4. Elevation angle
5. Reflectivity (Radar Cross-Section) of the target

Zadar Labs has developed a family of innovative sensors using FMCW radar technology designed to meet the demands of modern autonomy, safety, and security applications that require advanced radar-based perception.

To meet these goals, Zadar has innovated at every level of the radar system spanning both hardware and software. This includes RF frontend, antenna design, signal processing, data processing, and radar perception and this is what allows zPRIME to deliver performance generations beyond available industry standard radar technology.

3 Setup and Integration

3.1 Kit Contents

The base zPRIME sensor includes:

- zPRIME 3.0 Sensor in your specified hardware-configured FOV (LR, W, or UW)
- 5 Meter Power & Data Cable
 - 1000BASE-T1 automotive ethernet with MATENet connector
 - 12V power

The radar evaluation kit additionally includes:

- 90° Mounting Bracket
 - Hardware and tools included
- 1000BASE-T1 to RJ45 ethernet converter with PoE Capability
 - Used to convert automotive ethernet to standard ethernet
 - Supports inline power-over-ethernet capability for infrastructure deployments
- 12V DC Power Supply, Worldwide Capable

Additional accessories are separately available:

- 90° Mounting Bracket (Zadar P/N BKT-90-ZPRM3-1)
- Flush Mounting Bracket (Zadar P/N BKT-FL-ZPRM3-1)
- Swivel Radar Kit for Surveillance Applications (Zadar P/N MNT-KIT-ZPRM3-1)
 - Comes with universal brackets suitable for pole mount, wall mount, and corner mount use cases

3.2 Connection Guide

The primary zPRIME interface is 1000BASE-T1 gigabit automotive ethernet. Systems that use standard RJ45 Gigabit Ethernet (1000BASE-T) can use the available RJ45 conversion box to adapt between the two standards.

Automotive ethernet specifications:

Parameter	Value
Default IP Address (can be configured)	192.168.0.10
Default Subnet	255.255.255.0
Automotive Ethernet Configuration	1000BASE-T1 Slave Device
MAC Address	Printed on device

Connecting zPRIME 3.0 to 1000BASE-T1 systems (automotive ethernet)

zPRIME 3.0 supports direct connection for 1000BASE-T1 systems. Data is supplied over TE MATEnet and power is supplied over 12V DC.

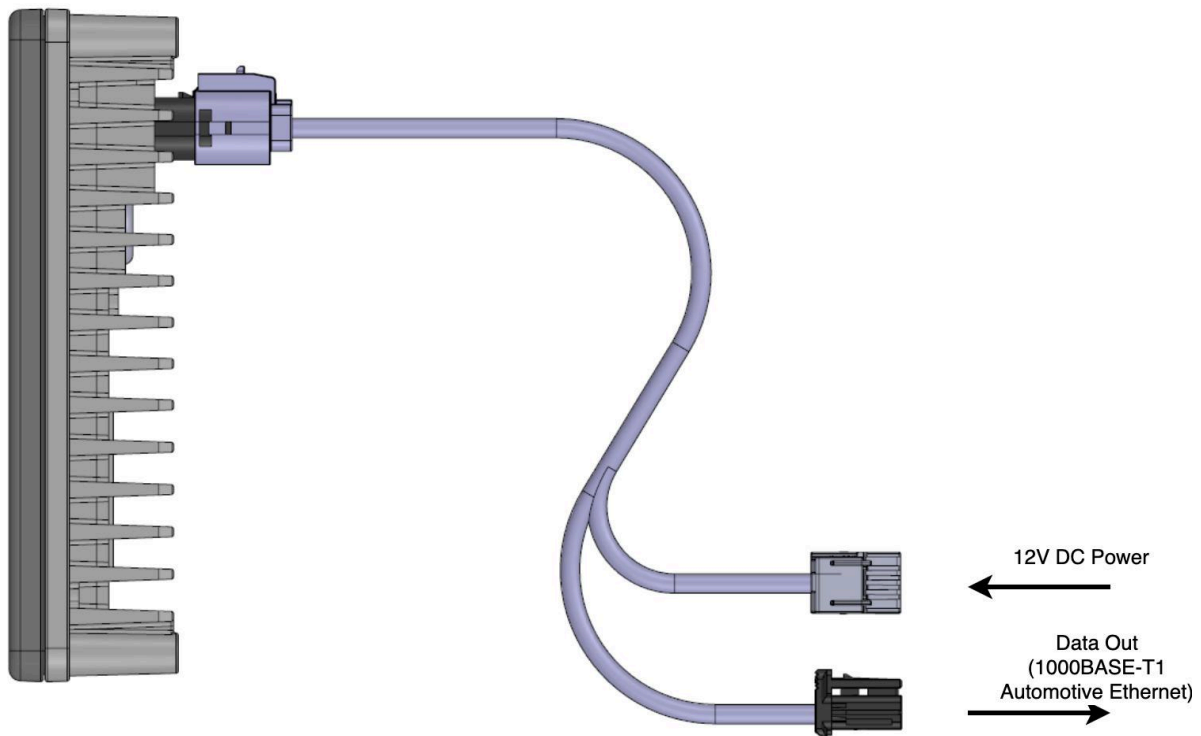


Figure 4. zPRIME with supplied cable assembly

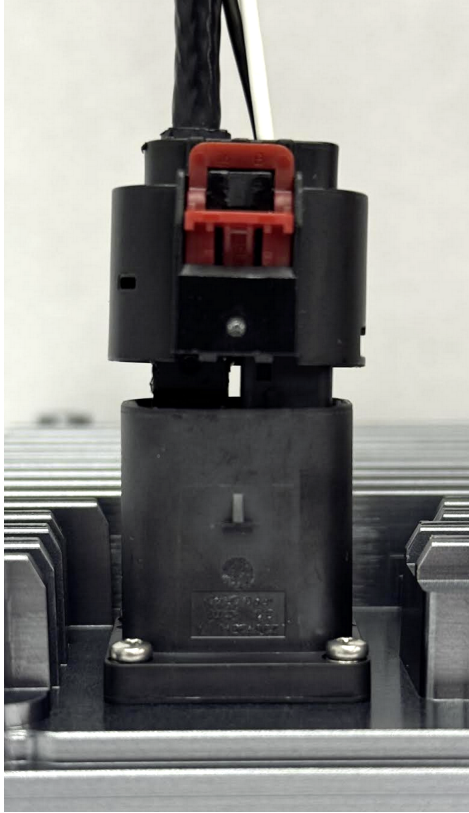


Figure 5. Not connected, red CPA tab disengaged

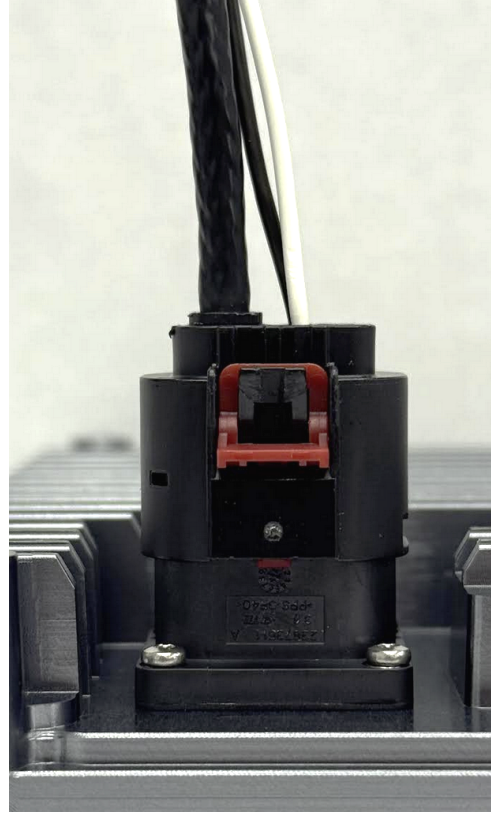


Figure 6. Connected, fully seated and CPA tab engaged

To connect zPRIME:

1. Disconnect power sources
2. Align plug, then push the plug into the socket until the black locking latch audibly clicks
3. Push the red CPA towards the socket until the CPA audibly clicks
4. The cable is now connected, sealed, and protected against accidental disconnection

To disconnect zPRIME:

1. Disconnect power sources
2. Pull the red CPA away from the socket until the CPA audibly clicks and disengages
3. Depress the black locking latch firmly and pull plug from socket.

👉 Pull via plastic housing only- do not pull plug via wires or damage may result. The weatherproof connector is tightly installed and is difficult to disconnect. When the black locking latch is fully depressed, the connector will disconnect easily. Never force the connector apart!

Connecting zPRIME 3.0 to RJ45 systems (regular ethernet)

[User Manual will be updated when the T1 to RJ45 converter is available]

3.3 Electrical and Connector Specification

Radar-Side Socket Specification

zPRIME ships with an 8-pin hybrid data+power connector, part number 1-2387351-1 manufactured by TE Connectivity. This connector requires the cable end to be installed in order to provide IP69K sealing performance.

Radar-Side Socket Pinout

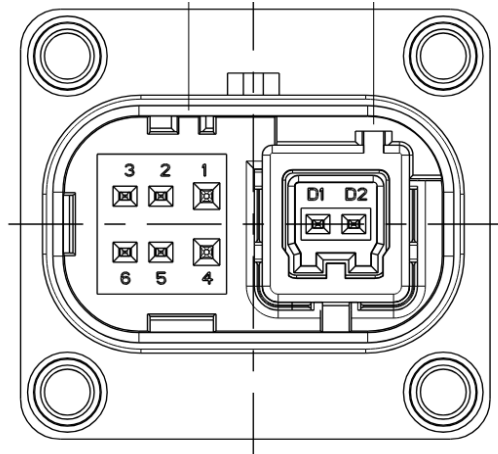


Figure 7. Radar Socket Pinout TE 1-2387351-1

Pinout, 6 pins hybrid power/signal

CNT1 Pin	Signal	Description
Pin 1	VCC	Power supply for radar, nominal 12-24V
Pin 4	GND	Ground for radar
Pin 2	CANH/GPIO (reserved)	Reserved for future CAN bus implementation
Pin 3	CANL (reserved)	Reserved for future CAN bus implementation
Pin 5, 6	Do not connect	Reserved for future use, do not connect

Pinout MATEnet 1000BASE-T1 automotive ethernet

CNT1 Pin	Signal	Description
D2	MDI-P	1000BASE-T1 Positive Signal
D1	MDI-N	1000BASE-T1 Negative Signal

Cable Specification

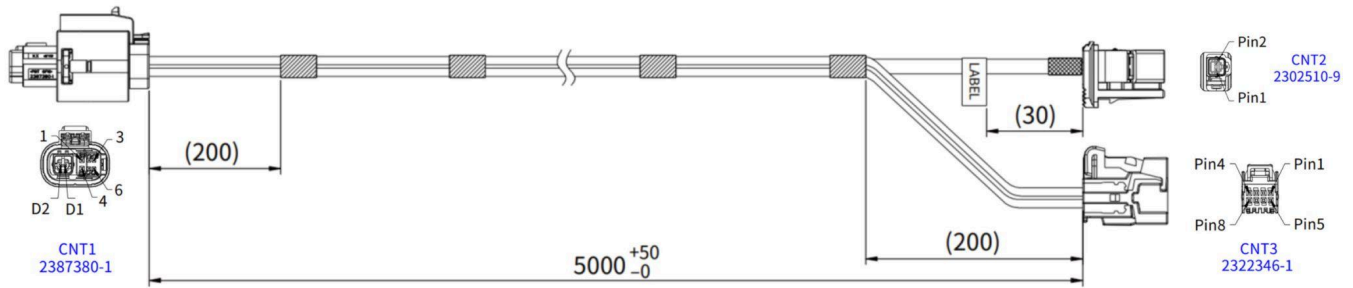


Figure 8. Cable Drawing (Zadar P/N 40-0-0101-0)

Cable Component Specification

Parameter	Value
Cable length	5 meter standard*
CNT1	Cable/Plug Side: 2387380-1
	Mating Socket Side: 1-2387351-1
CNT2	Cable/Plug Side: 2302510-9
	Mating Socket Side: 2304372-1
CNT3	Cable/Plug Side: 2322346-1
	Mating Socket Side: 2311621-1

* Alternative lengths are available for special order. Minimums and lead times apply.

Cable Pinout Power/Data

CNT1 Pin	CNT3 Pin	Signal	Wire Color	Cross Section
Pin 1	Pin 4	VCC	Red	0.35 mm ²
Pin 4	Pin 8	GND	Black	0.35mm ²
Pin 2	Pin 1	SIG1	Yellow	0.22mm ²
Pin 3	Pin 2	SIG2	Green	0.22mm ²

Pinout 1000BASE-T1 Automotive Ethernet Twisted Pair

CNT1 Pin	CNT2 Pin	Signal	Wire Color	Cross Section
D2	Pin 1	MDI-P	White	-
D1	Pin 2	MDI-N	Green	-

Input Voltage Requirements

PARAMETERS		TEST CONDITION	MIN	TYP	MAX	UNIT
VIN	System power supply	Measured at radar input connector. ⁽¹⁾	8	12	27	V
Transient Immunity Compliance		ISO 7637-2, ISO 61000				

(1) In use, cable IR drop at peak radar current consumption must be accounted for. Radar operation is not guaranteed if input voltage at input connector drops below the minimum input voltage.

Power and Current Consumption

PARAMETERS		TEST CONDITION	TYP	MAX	UNIT
P _{avg}	Typical average power consumption during operation, 50% duty cycle*	VIN = 12V	20		W
P _{pk}	Peak power consumption during transmission period	VIN = 12V	28	30	W
P _{idle}	Idle power consumption, no active transmission	VIN = 12V	7		W
I _{pk}	Maximum input current	VIN = 12V		2.5	A

* Average power consumption varies based on the duty cycle of the configured radar transmission mode. Numbers are based on typical operating modes.

3.4 Mounting and Installation

Mechanical Drawing and 3D CAD/STEP Files

Parameter	Value
Exterior dimensions (width/height/depth) not including connector	140 x 104 x 35 mm
Exterior dimensions (width/height/depth) including connector	140 x 104 x 46.1 mm
Unit mass	520 g
IP Rating	IP69K
Material, rear housing	ADC12
Material, front cover	Polycarbonate/PBT-GF30

👉 All dimensions are in mm. CAD files are available in our [product information folder](#).

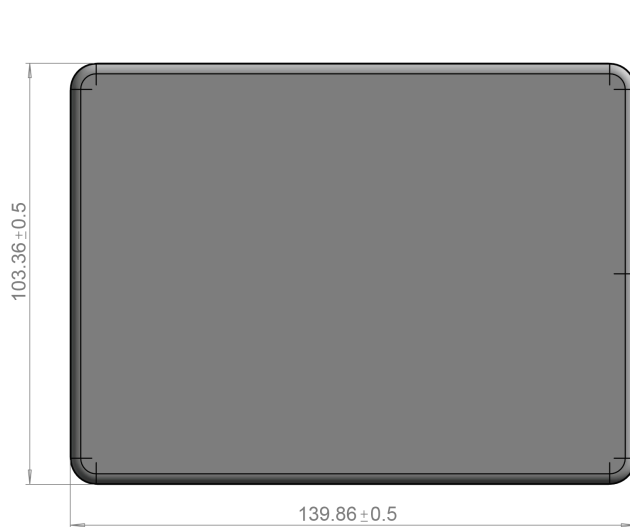


Figure 9. Front Dimensions

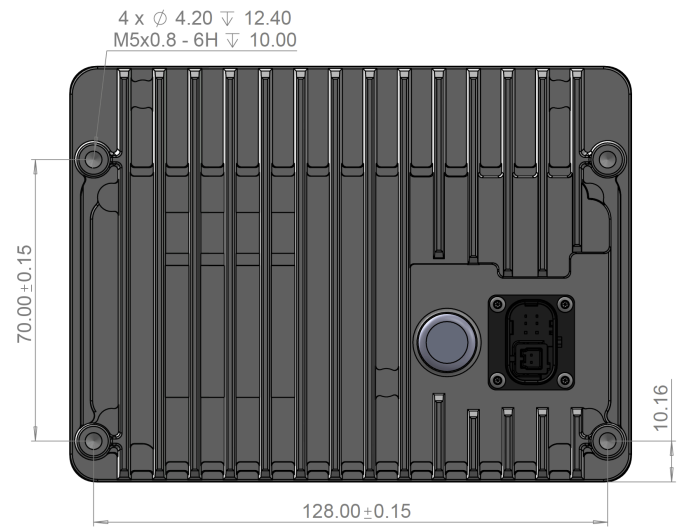


Figure 10. Rear Dimensions

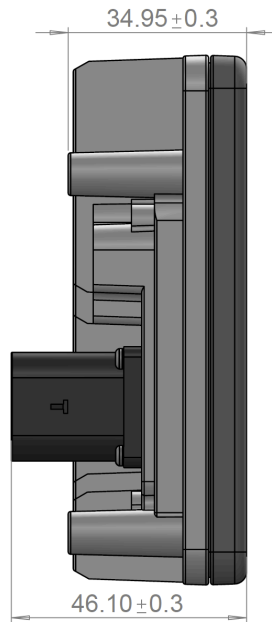


Figure 11. Left Side Dimensions

Impact of Mounting on Radar Performance

Radar mounting location may have an impact on radar performance, where performance could include maximum detectable range, field of view, and noise in the point cloud. Your intended mounting location should be evaluated according to the following criteria to ensure maximum radar performance. All Zadar performance specifications have been evaluated in conditions satisfying the following guidelines.

FOV Considerations and Keepout Zones

The recommended keepout FOV of the radar is included in the following table. We recommend that no metal objects and RF reflectors interfere with the radar keepout FOV. Close-range radar covers, housings, mounting brackets and the like within the keepout FOV should be made out of non-reflective materials such as plastic.

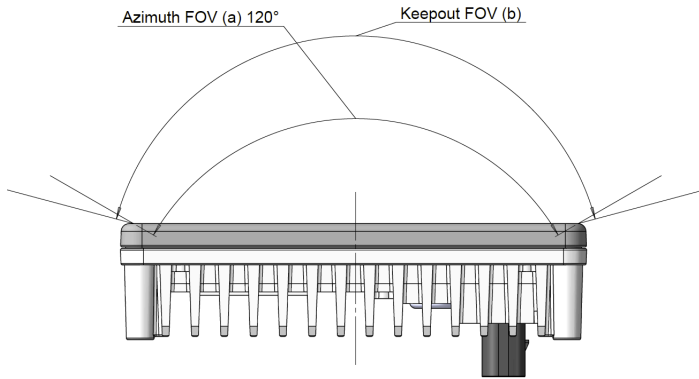


Figure 13. Azimuth Keep-Out

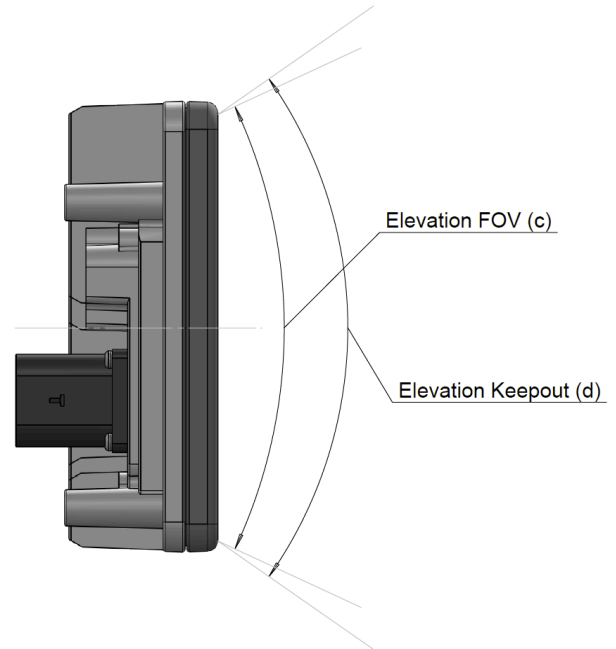


Figure 14. Elevation Keep-Out

		Azimuth		Elevation	
Model	Part No.	FOV (a)	Keep Out (b)	FOV (c)	Keep Out (d)
Long-Range	ZPRM3-T1-77-LR	±65°	±75°	±12°	±25°
Wide	ZPRM3-T1-77-W	±65°	±75°	±25°	±35°
Ultra-Wide	ZPRM3-T1-77-UW	±65°	±75°	±45°	±55°

Fascia Covers, Bumpers, and User-Attached Radomes

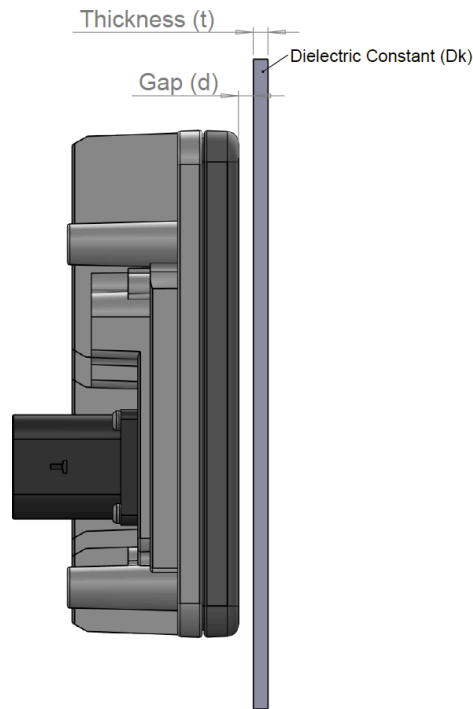


Figure 15. Appropriate Radome Design

Placing an enclosure, cover, or bumper in front of the radar will act as an additional radome. This will affect sensor performance in terms of maximum range and point cloud noise. As the radar's transmitted signal must travel through the additional material, the sensor's performance across FOV will depend on the material, paint type, thickness, and distance from the radar. The material should be plastic, but certain materials and paints perform better than others in terms of dielectric loss.

Good material selection and design will minimize the impact of adding an additional radome. Hence, we recommend proceeding carefully if the user chooses to install the radar behind a surface. If installing a bumper or cover is required in your application, we recommend benchmarking performance with and without the additional cover. Zadar support can help with good radome design.

Thermal Guidelines

zPRIME is rated for operation up to 85°C ambient in still air. The unit has internal temperature monitoring and will shut off if an over-temperature event occurs. Thermal performance may be degraded if the heatsink is obstructed or covered.

👉 Based on environmental conditions and operational mode, zPRIME can run hot to the touch. The radar will monitor its own temperature to keep it within limits.

Ingress Protection

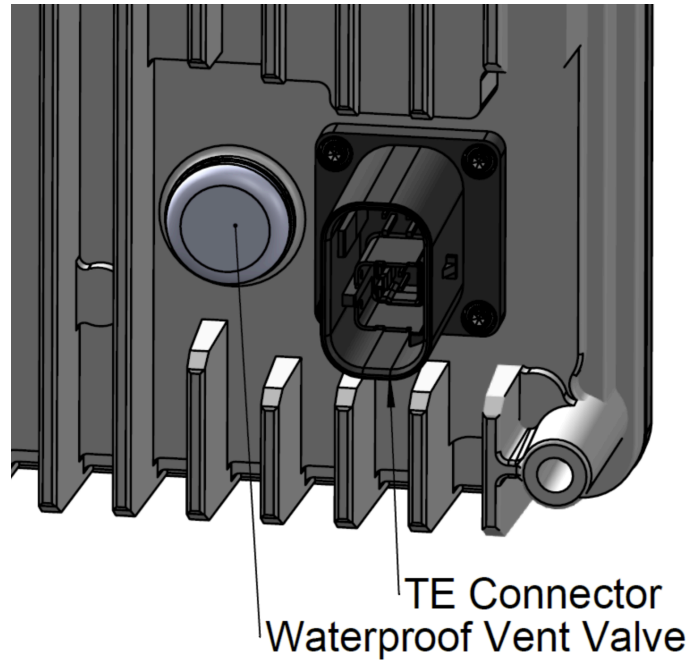


Figure 16. Vent Location

zPRIME sensors are fully sealed and are IP69K rated when the cable is installed. The cable must be installed to guarantee protection against water and dust ingress.

zPRIME sensors include a moisture vent on the back to improve reliability under cyclic temperature, humidity, and pressure variations. Avoid direct jets of water on this vent or the ingress protection may be compromised.

4 Radar Operation

4.1 Operational Overview

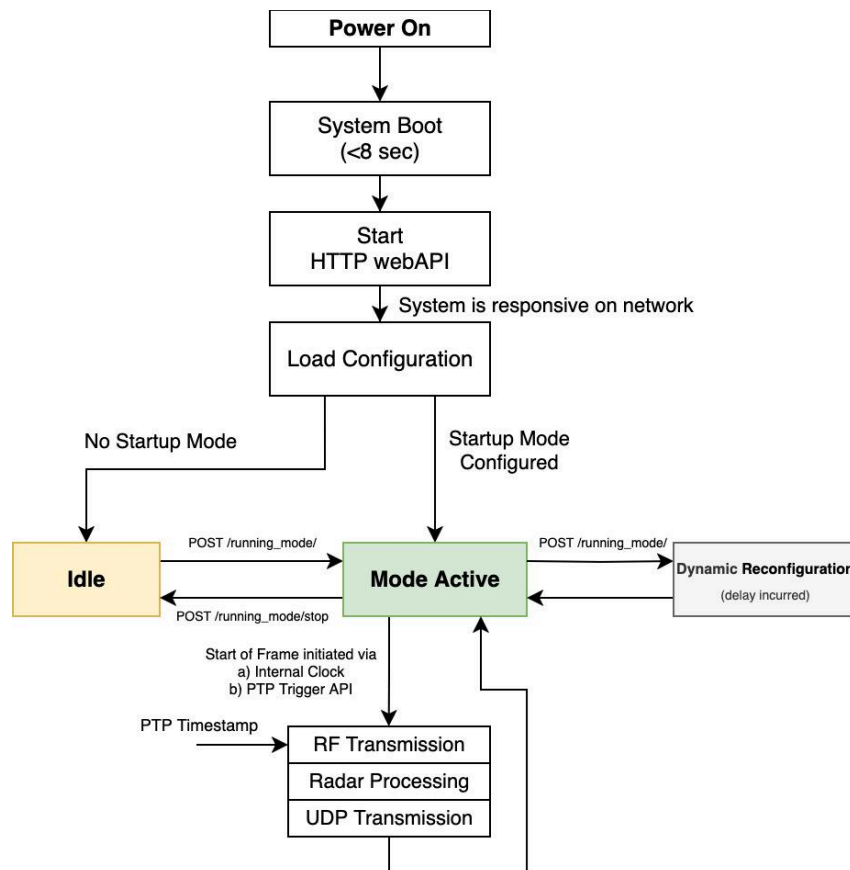


Figure 17. Radar State Machine

After applying 12V power, the radar takes approximately 8 seconds to boot. During this time the radar will not be reachable on the network. After boot is complete, and the T1 ethernet link comes up, the radar will be discoverable by ping and by Avahi mDNS auto-discovery. The radar's HTTP webAPI and configuration webpage will also become available.

By default, if no startup mode is set, the radar will enter idle mode. If a startup mode is set, then the radar will automatically begin framing according to the saved settings. Data will be sent to the UDP destination IP and port as saved in its configuration.

At any time, the radar can be started, stopped, or the mode can be changed via the HTTP webAPI. Changing modes while the radar is running will result in a delay while radar internal settings are reconfigured.

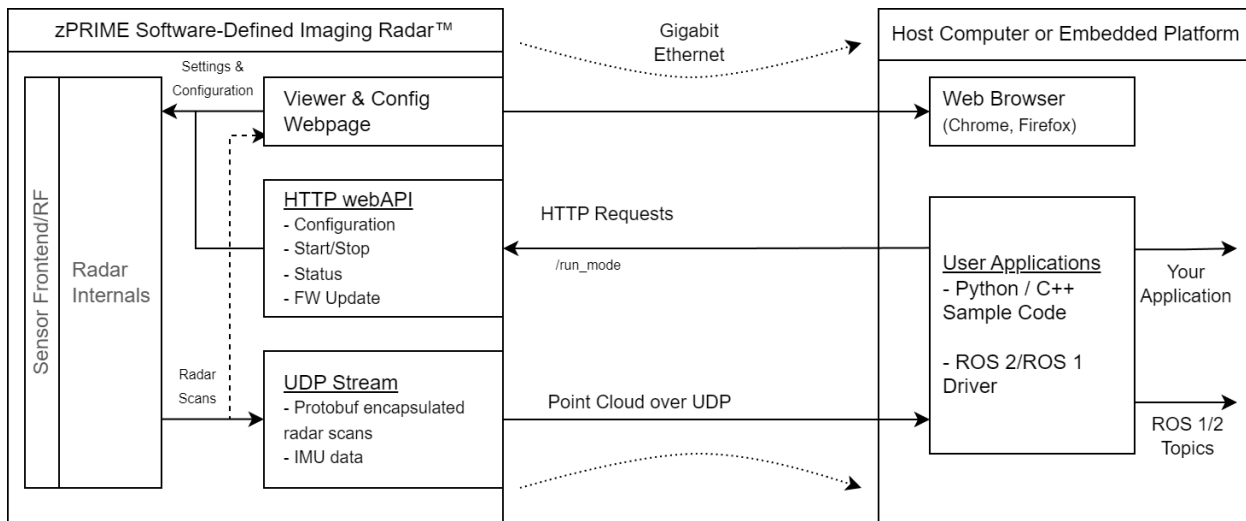


Figure 18. Software Integration Concept

Control of radar operation including starting and stopping transmission, selecting the operational mode, updating firmware, and changing basic settings such as sensor IP address can be achieved in two ways: via the configuration webpage or via the HTTP webAPI.

The configuration webpage provides an easy way to get started with the sensor. The HTTP webAPI allows users to write software to control the radar for production and real-world deployments.

Radar data outputs are provided via UDP stream. After a frame is complete, the radar scan data (point cloud, odometry, plus optional clusters, tracks, and classification) is formatted and then packed into the Protobuf data format. This Protobuf packed data is then sent over the network via UDP to a configurable destination where the receiver will then re-assemble and unpack the Protobuf data to extract the radar scan.

Protobuf provides a convenient, standardized, and forwards/backwards-compatible method of transmitting data. It allows Zadar Labs to add new data outputs to zPRIME in future firmware upgrades without breaking compatibility with existing user deployments.

Examples to start/stop/configure the radar via HTTP webAPI and receive point cloud data via UDP are provided in Python and C++.

4.2 Network Topology

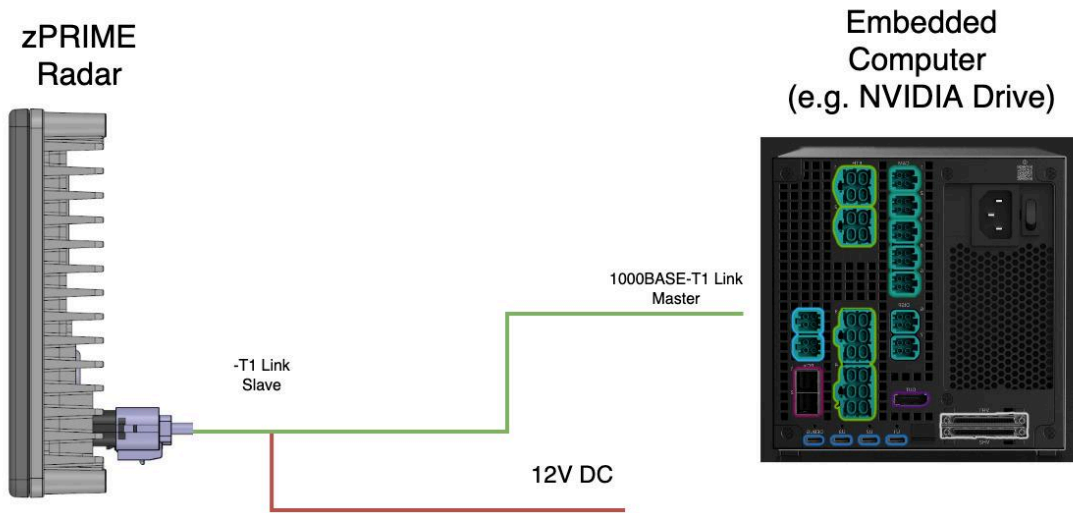


Figure 19. Direct connection of zPRIME to a 1000BASE-T1 host device

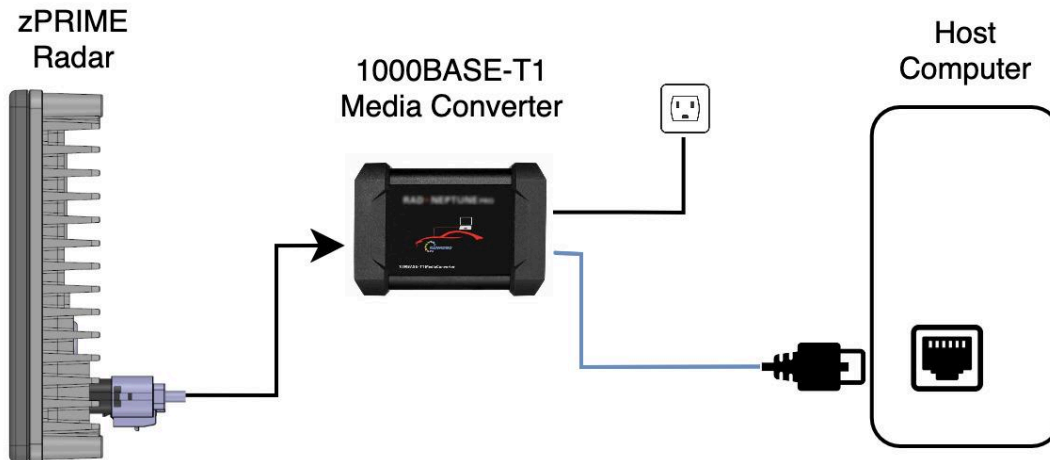


Figure 20. Connection of zPRIME to an RJ45 (1000BASE-T, traditional ethernet) host device

For the default network configuration, see section **3.2 Connection Guide**.

To connect to a radar, the host computer must be on the same subnet as the sensor. The host cannot have the same IP address as the sensor. One suggested configuration for host IP would be:

Suggested Computer Network Configuration

IPv4 Address	Subnet Mask	DHCP
192.168.0.20	255.255.255.0	Off / Static IP