Forward Collision Warning Radar System User Manual

Document Number: 000-101986

Revision History

Rev	Date	Author	Description
1	09/01/2023	Arthur L	Initial creation
2	9/14/2023	Arthur L	RF exposure distance updated to 20cm
3	9/18/2023	Arthur L	RF exposure distance updated to 20cm for French

1. Purpose and Product Usage

The Forward Collision Warning (FCW) system warns the rider against collisions that may occur due to being too close to a front vehicle. This is an information system to provide the rider additional data for making safer driving decisions. FCW is intended to :

- provide the rider with long range detection abilities
- detect vehicles to the front of the subject vehicle and warn the rider if reducing the speed is recommended.

 FCW is **not** meant to encourage aggressive driving and the absence of a warning **will not** guarantee that the rider can avoid any collision without any proper operation.

1.1 Vayyar VYYR7204 Radar Specifications

VYYR7204 integrates 48 ultra-wideband RF transceiver ports, synthesizers, ADC/DAC, and digital signal processing on a single Si device. This, combined with on-chip sequencer, DSP, large memories, ARM Cortex M33 Dual Core Lock-step, and flexible host interfaces, results in a highly programmable, low power, single chip solution for a variety of RF applications including RF sensing and tracking, MIMO radar, and RF imaging, planned to meet the requirements of the automotive and Robotics markets.

VYYR7204 has a LO generation units supporting 76-77GHz . LO cascading allows multi-chip configuration for even larger antenna arrays / port count allowing ultra-high-resolution applications.

Parameter	Value
Frequency Band	76-77 GHz
Bandwidth	80 MHz
No. Tx/Rx Antennas	22/23
Peak EIRP	30 dBmi
Single Tx Antenna Gain	9.5 dBi
Effective Antenna Gain	23 dBi (including MIMO)
AZ FoV - Applicative	± 12.5°
Tx Antenna Beamwidth	± 20° (3dB)

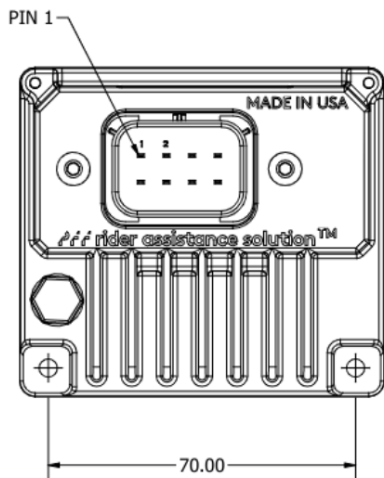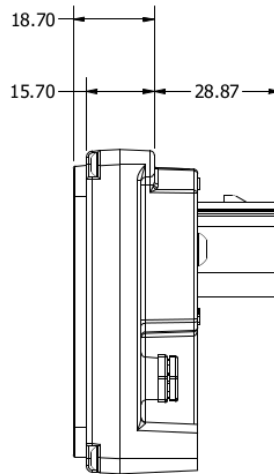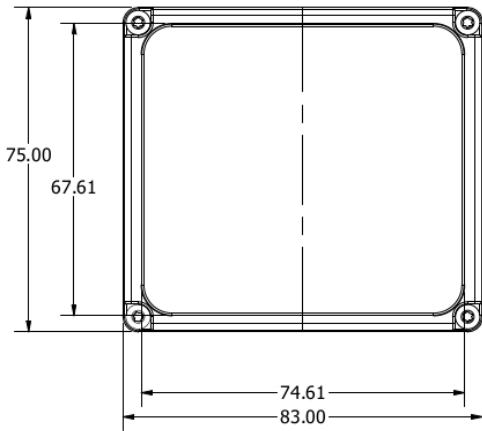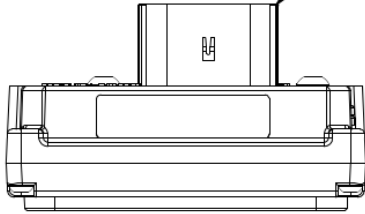| Parameter	Value
Maximum Range	80m (motorcycle). 120m (130 with good target Strength)
Minimum Range	1-2m
Field of Vue	Azimuth : ± 12.5 degrees Elevation : ± 5 degrees
Angular Resolution/Accuracy	Azimuth : ~= 1 degrees
Maximum Motorcycle Roll Angle	± 25 Degrees
Minimum/Maximum Relative Speed	15/125kph
Minimum/Maximum Self Speed	21/210kph
Output	CAN-Bus
Alert Time / Frame Rate	100ms / > 10fps
Minimum/Maximum Boot Time	0.5s / 2s
General	Power < 20W, VDC 13.5V (nominal) Self Diagnostics / UDS Programming
Board Dimensions	65*75mm
Reliability	-20/+65 degrees C, IP67

1.2 Environmental

- Operating Temperature: -20° C to 80° C
- Intrusion Protection: IP67 - Intended for Outdoor Use
- Approved for use in wet locations and exposure to direct weather conditions
- Humidity 20-95%rh
- Altitude up to 2750m
- Vibration: Piaggio Standard 4308, Class 2. 4 hours each on 3 axes (X, Y, Z) for A) Frequency from 10 to 60 Hz with constant shift of 1.5mm P-P, and B) Frequency from 60-200 Hz with acceleration of 10 g constant peak.

1.3 Mechanical Characteristics

- Size: 83.0mm wide x 87.1mm tall x 25.2mm deep (45.4mm including connector)
- Location: Fits under saddle at rear of vehicle in center
- Weight: 0.2 kg
- User clearance from radome front during normal operation: 20 cm

CONNECTOR: Molex 194280029
MATING CONNECTOR:
Molex 19418 Series
MATING CONNECTOR MUST BE
INSTALLED TO ACHIEVE
IP RATING

18.70

15.70

28.87

75.00

67.61

74.61

83.00

PIN 1

MADE IN USA

1   2

rider assistance solution™

70.00

1.4 Electrical Characteristics

This unit is intended for **OEM use** and is not intended for any aftermarket applications. This unit must be part of the original vehicle design and part of the original vehicle harness. This can not be wired into an existing harness.

When creating a harness design, the following considerations must be made:

● The CAN bus must have termination to a nominal 100-120 Ohms.
● Ignition must be a stable supply of power, as any drop below the minimum voltage will cause the module to restart or turn off.
● Do not connect Ignition directly to battery sources as the unit is not able to turn off or perform any low power states.
● Ignition signal is used for only turning the radar unit on/off. There is no current drawn from this signal. (Off state Q current <250 uA).
● This unit must be on a fused power source. Fuse size must be calculated with the other devices on the same protected line.
● Power Consumption: 20 watts .
● Power in per PG 7431 Ed. 7. Nominal 13.5 Vdc Operating range 8-16.5 Vdc

Pin Number	Type	Direction	Function	Spec
1	No Connect	-	-	-
2	Digital	Output	TBD (Open)	Active High
3	Digital	Output	Buzzer Driver	Active High
4	Supply	Input	Battery (+)	-
5	Enable	Input	Ignition (On/Off)	-
6	CAN*	Bidirectional	CAN-High	-
7	CAN*	Bidirectional	CAN-Low	-
8	Ground	Input	Ground	-

* CAN Signaling is Compliant with ISO 11898 1/2

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1.6 Manufacture Information

The units are assembled and tested in the United States by Piaggio Fast Forward. Contacting us can be done through the following:

info@piaggiofastforward.com

Piaggio Fast Forward | 52 Roland Street | Boston, MA 02129

1.7 EU Restrictions

This product has been so constructed that the product complies with the requirement of RED Article 10(2) as it can be operated in at least one Member State (Italy) as examined and the product is compliant with Article 10(10) as it has no restrictions on putting into service in all EU Member States.

1.8 Radar Safety

> **SAFETY WARNING:** *DO NOT OPEN OR ALTER the radar unit from original provide packaging*

For safety, this device requires that users have 20 cm distance from the radome front during normal operations. Do not install if dropped from a height above 1 meter or if there are signs of damage to the exterior.

The unit must be used in the intended manner outlined in Section 1 and in the environments that are outlined in this section. The user can not change, open or alter the device or its packaging to meet their product needs. This is a radar system that has been tested to operate safely in its current packaging without alterations of any kind. Any changes to the product package or operating range will deem the product to be unsafe for operation and not compliant with any of the safety standards outlined above.

2. Reference Standards

The FCW unit model F02129-FCW is compliant with the following standards. A Certificate of Conformity is located in Appendix A of this document.

Certification	Standards
	● See Section 2.1 for operation and compliance
RED testing and certifications for EU	● EN 62311:2008 ● EN 61010-1: 2010/A1:2019 ● ECE R10:2019 Addendum 9, Revision 6 ● EN 301 489-1 V2.2.3 ● EN 301 489-51 V2.1.1
	PFF procurement has certified that the following product is RoHS and REACH compliant
	This device conforms with the relevant Union harmonization legislation

PFF ensures that radio equipment is constructed so that it can be operated in Italy without infringing applicable requirements on the use of radio spectrum.

2.1 FCC/ISEL Declaration

2.1.1 Information for the user for operation and compliance with Chapter 15 of the FCC Rules and ISEL

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.

The user is not authorized to make any modifications to the equipment. Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

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 of the following measures:

Increase the separation between the equipment and receiver.

In addition, this equipment contains a radar sensing unit which conforms to the requirements of Part 95, Subpart M of the FCC rules. The user is permitted to operate this unit without an individual license subject to the terms of Part 15 listed above.

2.1.2 Information for the user for operation and compliance with Chapter 15 of the FCC Rules and ISEL CAN ICES-3 (B)/NMB-3(B)

This device contains license-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's license-exempt RSS(s). Operation is subject to the following two conditions:

This device may not cause interference;

This device must accept any interference, including interference that may cause undesired operation of the device.

When standing still you should maintain a distance of at least 20 cm from the front of the radome to comply with RF exposure limits.

Cet appareil contient un ou des émetteurs/récepteurs exempts de licence conformes aux RSS exempts de licence d'Innovation, Sciences et Développement économique Canada. Le fonctionnement est soumis aux deux conditions suivantes :

Cet appareil ne doit pas provoquer d'interférences ;

Cet appareil doit accepter toutes les interférences, y compris les interférences susceptibles de provoquer un fonctionnement indésirable de l'appareil.

Lorsque vous êtes immobile, vous devez maintenir une distance d'au moins 20 cm par rapport à l'avant du radôme pour respecter les limites d'exposition aux RF.

3. Operation Specification

3.1 Digital Signal Processing (DSP)

The DSP consists of the doppler radar and the mathematical manipulation of an information signal. Every (65-100ms), the velocity of the bike and the roll angle are received from ego and used in the subsequent radar return processing. Every target has a unique target ID that is used to track unique target tracks. When a target associated with a particular ID is no longer detected, the target ID is recycled. Every (65-100ms), a list of targets, be they persistent or new, is sent to the ARM core for processing.

3.2 Operational Logic
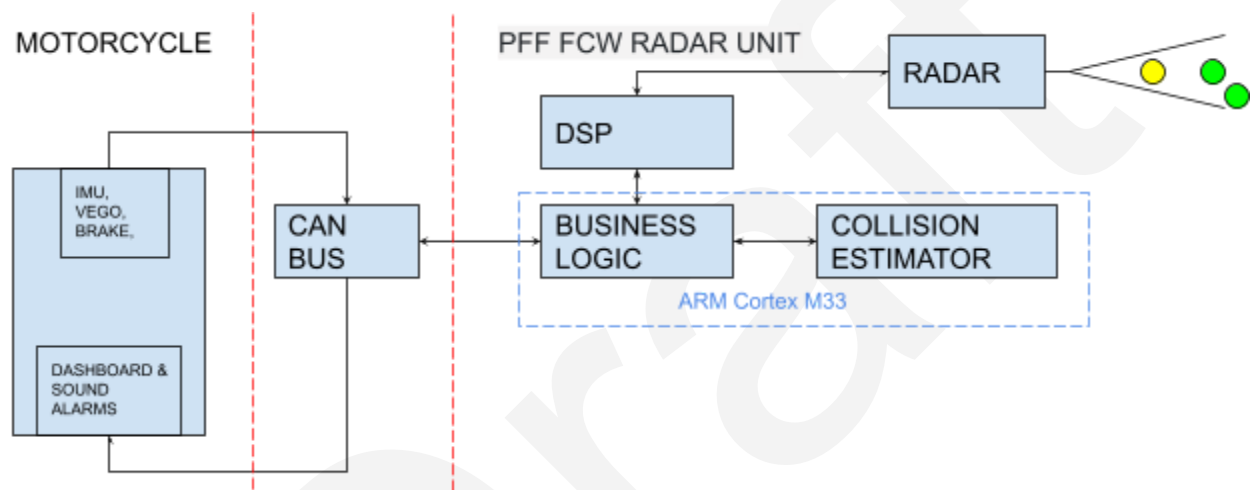
The FCW requires the ego to provide some basic information for the business logic to operate via the CAN bus:
- IMU Information (Roll Angle, Yaw and Yaw Rate)
- Current Velocity
- Brake Information

The DSP processes the radar signal and generates centroid based targets in a ± 12.5 degrees cone . The DSP generates the following:
- Target id
- Which targets are static
- The velocity vector (+/-) from the radar
- List of valid targets (x, y, z, vx, vy.) to the business logic.

The Collision Estimator integrates all the information over time (Target List, ego characteristics such as IMU, current speed) and applies processing in accordance with ISO 15623:2013. If the Collision Estimator identifies a valid threat (following too close for the vehicle speed, or approaching another vehicle too fast that will lead to a collision), it will inform the Business Logic of the specific threat, and in turn, the Business Logic will inform the ego of that threat

The position coordinates are given in Cartesian coordinates, x, y, z with the location of 0, 0, 0 located at the radar mount point. The velocity is differential to the mounted radar unit, where objects moving toward the radar unit will have a negative velocity, objects moving away from the radar unit will have a positive velocity and objects that are at a fixed point relative to the radar will have an approximately zero velocity.
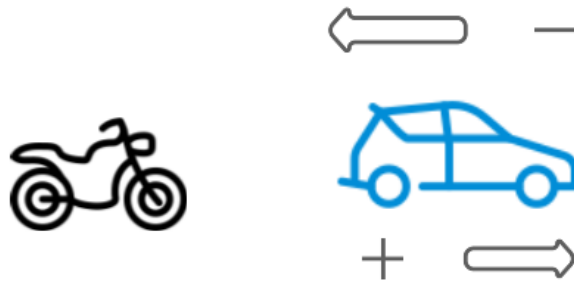
3.3 User FCW Warning Levels

Through the ego dashboard (or other UI), the vendor can create a screen/button that could provide a message to the FCW unit to:

● Disable operation
● Change warning types

The rider of the ego can decide to disable or change the type of warning based on their desired experience. This is a persistent setting for the duration of the ride. This setting is restored to factory default every key off/on. By default from the factory, the units are configured for FCW enabled with warning to dash and buzzer.

3.4 Auto-Alignment during operation

The FCW performs alignment checks during normal use. Initial operation requires that a factory alignment is performed during assembly or an ego repair if the radar is replaced. The alignment check can correct for up to 3° of movement from initial calibration. Larger deviations will require a factory calibration.

The alignment check will automatically run during a normal operation. It looks for static targets during the ride when the ego is traveling straight and no lean (0°±2°) is detected. Calculations are run comparing the over time and trip to measure a shift due to small changes since original installation. This adjustment is saved into memory and used the next key on to correct the coordinates of the targets received by the DSP.
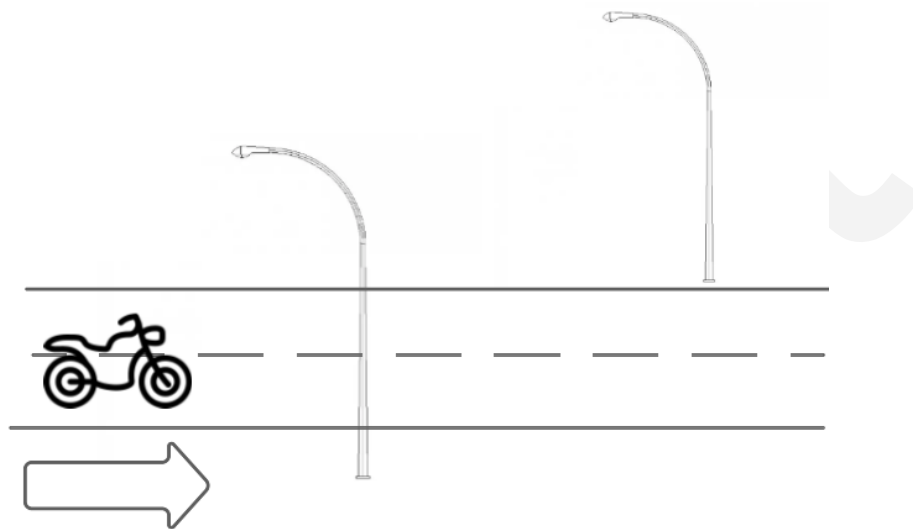
3.5 Output Drivers - (Audio Buzzer)

The Output drivers are a high side driver (ITS42k5D-LD-F). The business logic uses Pin 3 to drive an active Buzzer (**not a PWM**)
- Output Current Capability: up to 250mA per channel
- Nominal Voltage Range: 12 Vdc
- Operating Range 8-16 Vdc

3.6 DSP/Radar Characterization

The FCW tracks objects using a doppler shift and provides a three dimensional coordinate of the object being tracked. This is a long range radar operating as follows:

Frequency Range: 76.45 – 76.95 GHz
Peak EIRP 30dBmi
Frequency Bandwith: ~80mHz
Max Supported Range: 140m
Single Tx Antenna Gain: 9.5dBi
Effective Tx gain (22 antennas operating simultaneously): 23dBi
Max Velocity Range: -210km/hr to 100km/hr
Frame Duration: 67msec
Transmission Duration per Frame (CPI): 8msec

4. Factory Calibration

Once the unit is installed on the EGO, a calibration must be performed to ensure alignment for proper operation. Due to the large distance the radar is able to monitor, small differences due to part tolerances, installation tolerance and fork alignment can translate to large deltas in the target's true trajectory.

The vehicle manufacturer must create the proper setup and perform the operations to calibrate the unit to the installation on the ego.

5. Product Marking

The top side of every FCW radar unit is marked with important identifiers that will be used to track the product. Below is a detailed description of the information that is recorded in the product label.

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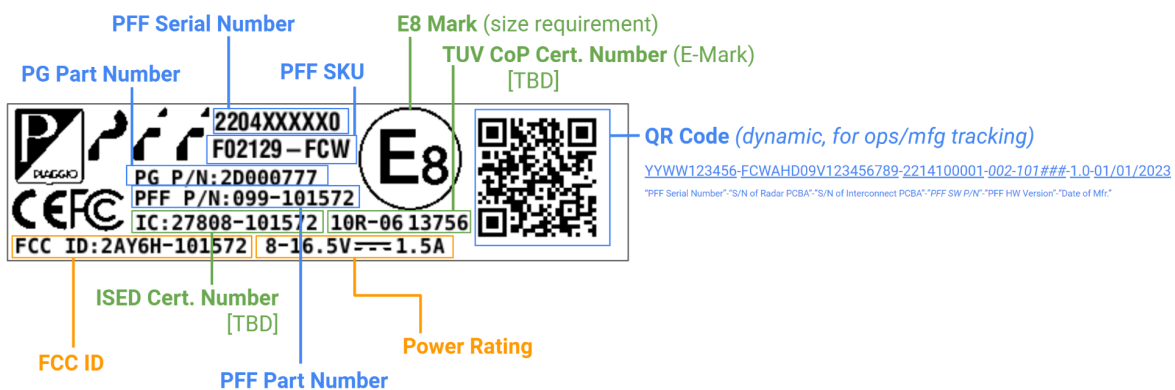
Appendix A - Declaration of Conformity

Hereby, Piaggio Fast Forward declares that this F02129-FCW is in compliance with the essential requirements and other relevant provisions of Directive 2014/53/EU.

(Attach when complete)