

TEF810X

76 GHz to 81 GHz car RADAR transceiver

Rev. 1.0 — 10 May 2019

Product short data sheet
COMPANY PUBLIC

1 General description

The TEF810X Car RADAR transceiver is a single-chip automotive FMCW RADAR transceiver for short-, medium- and long-range RADAR applications, covering the full car RADAR frequency band from 76 GHz to 81 GHz.

The packaged IC offers a low-cost fully integrated solution for all critical mm-wave functions, in combination with ADCs at each receiver path. The mm-wave front end part consists of a waveform generator offering flexible chirp control, three transmit chains featuring binary phase control and output level stabilization, and four receive chains with high input compression and low noise figure.

Each receive chain contains high-pass filters for suppression of strong low frequency signals, as well as low-pass filter functionality for suppression of signals in the ADC aliasing band. Each receive chain includes a 12-bit SAR ADC sampling at an effective rate of 40 MS/s (M samples per second). The ADC is followed by a programmable decimation filter with decimation factors of 1, 2, 4, 8 and 16.

The digitized signals from the four receiver chains are serialized. There are two digital output variants available:

- TEF8101 output is through four high-speed LVDS data lines, plus a bit and frame clock signals for data synchronization
- TEF8102 includes a CSI-2-DPHY interface with four data lanes and a clock lane

The chip uses a full-duplex SPI interface with 40 Mbps maximal transfer rate for bi-directional exchange of control and monitoring data between the RADAR IC and a host microcontroller.

The TEF810X contains a functional safety monitoring circuit, keeping track of key operational parameters such as chip temperature, status of RF connections to the PCB board, locking status of the PLLs during a frequency chirp, etc. The monitoring circuitry transfers some of the monitoring functions normally performed by the microcontroller into the TEF810X, creating a virtual *layered functional safety* concept, with the TEF810X functional monitoring circuitry as the inner layer.

The RADAR transceiver is packaged in a 7.5 mm x 7.5 mm eWLB package. The package has a 15 x 15 sized Ball Grid Array (BGA) with 0.5 mm pitch for easy interfacing to a wide range of antenna board technologies.



2 Features and benefits

- Single-chip fully integrated automotive FMCW RADAR transceiver with digital output
- Developed in accordance to ISO26262 SEooC methodology. Supporting ASIL-B applications
- Car RADAR frequency band from 76 GHz to 81 GHz, addressing short-, medium- and long-range RADAR applications for the global automotive market
- The mm-wave front end part consists of a waveform generator offering flexible chirp control with a chirp bandwidth up to 2 GHz, three transmit chains featuring binary phase control and output level stabilization, and four receive chains with high input compression point and low noise figure
- The timing engine supports different MIMO RADAR operation modes by simple programming of digital registers controlling timing parameters and front end configuration on a chirp-to-chirp basis
- The phase of the TX signals can be controlled on a chirp-to-chirp basis by the timing engine, or by digital I/O signals directly connected to the binary phase shifters of different TX sections
- Each receive chain contains programmable high-pass filters for suppression of strong low frequency signals, as well as low-pass filter functionality for suppression of signals in the ADC aliasing band.
- Each receive chain includes a 12-bit SAR ADC sampling at an effective rate of 40 MS/s. The ADC is followed by a programmable decimation filter with decimation factors of 1, 2, 4, 8 and 16
- TEF8101: data output on four high-speed LVDS lines, in two modes: raw ADC serial data streaming, or packetized format with added CRC information
- TEF8102: four data lanes and a clock lane. Lane speed configurable from 120 Mbps to 480 Mbps, as a function of the decimation factor
- The chip uses a full-duplex SPI interface with 40 Mbps maximal transfer rate for bi-directional exchange of control and monitoring data between the RADAR IC and a host microcontroller
- The TEF810X contains a functional safety monitoring circuit, keeping track of key operational parameters such as chip temperature, status of RF connections to the PCB board, locking status of the PLLs during a frequency chirp, etc.
- The functional monitoring circuitry transfers some of the monitoring functions normally performed by the microcontroller into the TEF810X, creating a virtual “layered functional safety” concept, with the TEF810X functional monitoring circuitry as the inner layer
- Total average power dissipation at typical conditions under 1.2 W (2TX at 50 % duty cycle) and peak dissipation under 2.5 W
- Operating junction temperature from -40 °C up to 135 °C
- Closed-loop, linear frequency chirp generator with < 0.2 % typical chirp nonlinearity
- Three chirp modes with Low Phase Noise:

| | Chirp BW (MHz/μs) | Slope (MHz/μs) | Phase noise (dBc/Hz @ 1 MHz) |
|-----|----------------------|----------------|---|
| MRR | 0.5 | 15 | < -90 (typical, in 76 GHz to 77 GHz band) |
| SRR | 1.0 | 30 | < -88 (typical, in 76 GHz to 81 GHz band) |
| USR | 2.0 | 60 | < -86 (typical, in 77 GHz to 81 GHz band) |

- 2 GHz chirp deviation for high-resolution distance detection in USR mode. Higher phase noise level allowed (-86 dBc/Hz @ 1 MHz), with respect to nominal 1 GHz deviation mode
- Excellent phase stability for high angular resolution
- Transmit power of typical 12 dBm at antenna reference plane
- Typical receiver noise figure less than 12 dB at antenna reference plane
- Operation from a 40 MHz crystal oscillator
- Provides the 40 MHz clock signal to a microcontroller
- Power consumption < 50 mW in standby mode. In this condition the crystal oscillator is operative as well as the master 3.3 V LDOs
- GPIO 3.3 V digital interface signals for compatibility with a wide range of MCUs
- The core circuitry operates on 1.8 V and 1.1 V supply voltages. To simplify the application and decrease overall system BOM, the TEF810X offers two LDO circuits to generate the 1.8 V and 1.1 V operational voltages from a typical 2.3 V to 3.3 V supply available on the customer PCB. The internal band gap and voltage comparators drive external transistors, to decrease on-chip power dissipation and overall chip-area
- The RADAR transceiver is packaged in a 7.5 mm x 7.5 mm eWLB package. The package has a 15 x 15 sized Ball Grid Array (BGA) with 0.5 mm pitch. Package $R_{th \text{ Junction-footprint}} \sim 18$ K/W
- ESD immunity at 2000 V Human Body Model (HBM), 300 V Charged Device Model (CDM), 750 V CDM for corner balls

3 Applications

Front-side of car

- Autonomous Emergency Braking (AEB)
- Adaptive Cruise Control (ACC)
- Narrow path assist
- Lateral collision avoidance
- Side pre-crash
- Traffic jam assist

Rear-Side of car:

- Lane Change Assist (LCA)
- Blind Spot Detection (BSD)
- Rear Cross Traffic Alert (RCTA)
- Rear pre-crash
- Parking Assist (PA)

4 Ordering information

Table 1. Ordering information

| Type number | Package | | |
|-------------|----------|--|-----------|
| | Name | Description | Version |
| TEF8101 | WFBGA155 | plastic very-very-thin profile fine-pitch ball grid array package; 155 balls | SOT1456-1 |
| TEF8102 | | | |

5 TEF810X block diagram

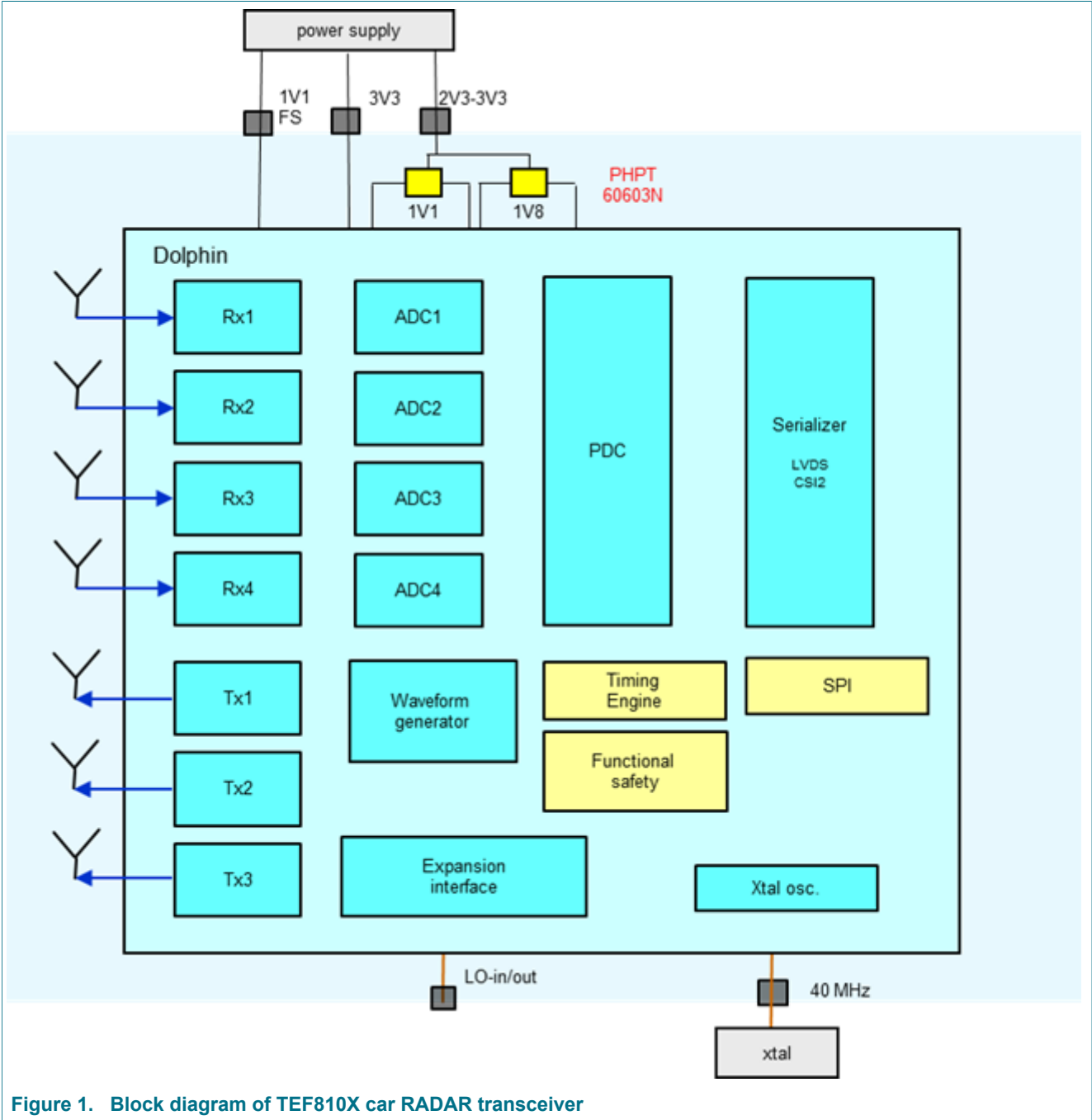


Figure 1. Block diagram of TEF810X car RADAR transceiver

6 Limiting values

Table 2. Limiting values

In accordance with limiting maximum rating system (IEC 60134).

| Supplies | Conditions | Min | Max | Unit |
|----------------------|--|------|------|------|
| 3.3 V supply voltage | | -0.5 | 3.96 | V |
| 1.8 V supply voltage | | -0.5 | 2.16 | V |
| 1.1 V supply voltage | | -0.5 | 1.54 | V |
| ESD | | | | |
| V _{ESD} | Human body model ^[1] | 2000 | - | V |
| | Charge device model (CDM) ^[2] | | | |
| | corner pins | 750 | - | V |
| | all other pins | 300 | - | V |

[1] Class 2 according to AEC-Q100-002 Rev – E.

[2] Class C3 according to AEC-Q100-011 Rev – C.

7 Characteristics

7.1 Global characteristics

Table 3. Global characteristics

| Description | Condition | Min | Typ | Max | Unit |
|----------------------------------|---|------|-----|-----|------|
| Operational frequency range | | 76 | - | 81 | GHz |
| Operational junction temperature | | - 40 | - | 135 | °C |
| Power dissipation | Strongly dependent on use-case. Stated value for 2 TX at 50 % duty cycle. | - | 1.2 | - | W |

7.2 Supply specifications

Table 4. Supply specifications

| Description | Condition | Min | Typ | Max | Unit |
|----------------------------|--|-------|------|-------|------|
| 1.1 V supply voltage range | ±5 % tolerance, spec compliance and reliability limits | 1.045 | 1.13 | 1.155 | V |
| 1.1 V supply voltage range | -5 % / +10 % tolerance, spec compliance limits | 1.045 | 1.13 | 1.21 | V |
| 1.8 V supply voltage range | ±5 % tolerance, spec compliance and reliability limits | 1.71 | 1.85 | 1.89 | V |
| 1.8 V supply voltage range | -5 % / +10 % tolerance, spec compliance limits | 1.71 | 1.85 | 1.98 | V |
| 3.3 V supply voltage | ±10 % tolerance | 2.97 | 3.3 | 3.63 | V |

7.3 TX Characteristics

Table 5. TX characteristics

| Description | Condition | Min | Typ | Max | Unit |
|---------------------------------|-----------|-----|-----|-----|------|
| Output power (76 GHz to 78 GHz) | | - | 12 | - | dBm |
| Output power (78 GHz to 81 GHz) | | - | 11 | - | dBm |

7.4 RX Characteristics

Table 6. RX characteristics

| Description | Condition | Min | Typ | Max | Unit |
|--------------------------|-----------|-----|-----|-----|------|
| RX NF (76 GHz to 77 GHz) | | - | 12 | - | dB |
| RX NF (77 GHz to 81 GHz) | | - | 13 | - | dB |
| ADC resolution | | - | 12 | - | bit |
| ADC clock | | - | 40 | - | MHz |

7.5 Chirp generator characteristics

Table 7. Chip generator characteristics

| Description | Condition | Min | Typ | Max | Unit |
|---------------------------------------|-----------------------|-----|-----|------|------------------|
| Chirp bandwidth | 76 GHz to 81 GHz band | 0 | | 2000 | MHz |
| Phase noise 0.5 GHz chirp (mode 1) | 76 GHz to 77 GHz band | | -90 | | dBc/Hz @1 MHz |
| Phase noise 1 GHz chirp (mode 2) | 76 GHz to 81 GHz band | | -88 | | dBc/Hz @1 MHz |
| Phase noise 2 GHz chirp (mode 3) | 77 GHz to 81 GHz band | | -86 | | dBc/Hz @1 MHz |

8 Application information

Figure 2 shows the overall configuration of a RADAR sensor based on a single TEF810X device. The main functional blocks are the TEF810X, an MCU, a power supply network and a CAN, FlexRay or Ethernet interface.

The interface from the TEF810X to the MCU consists purely of digital signals, with the digitized and serialized received signals being transferred by LVDS or CSI-2 lines (RADAR data line), in combination with general-purpose I/O (GPIO) lines operating at nominal logical levels of 3.3 V, for timing signaling, SPI programming, and functional monitoring interface.

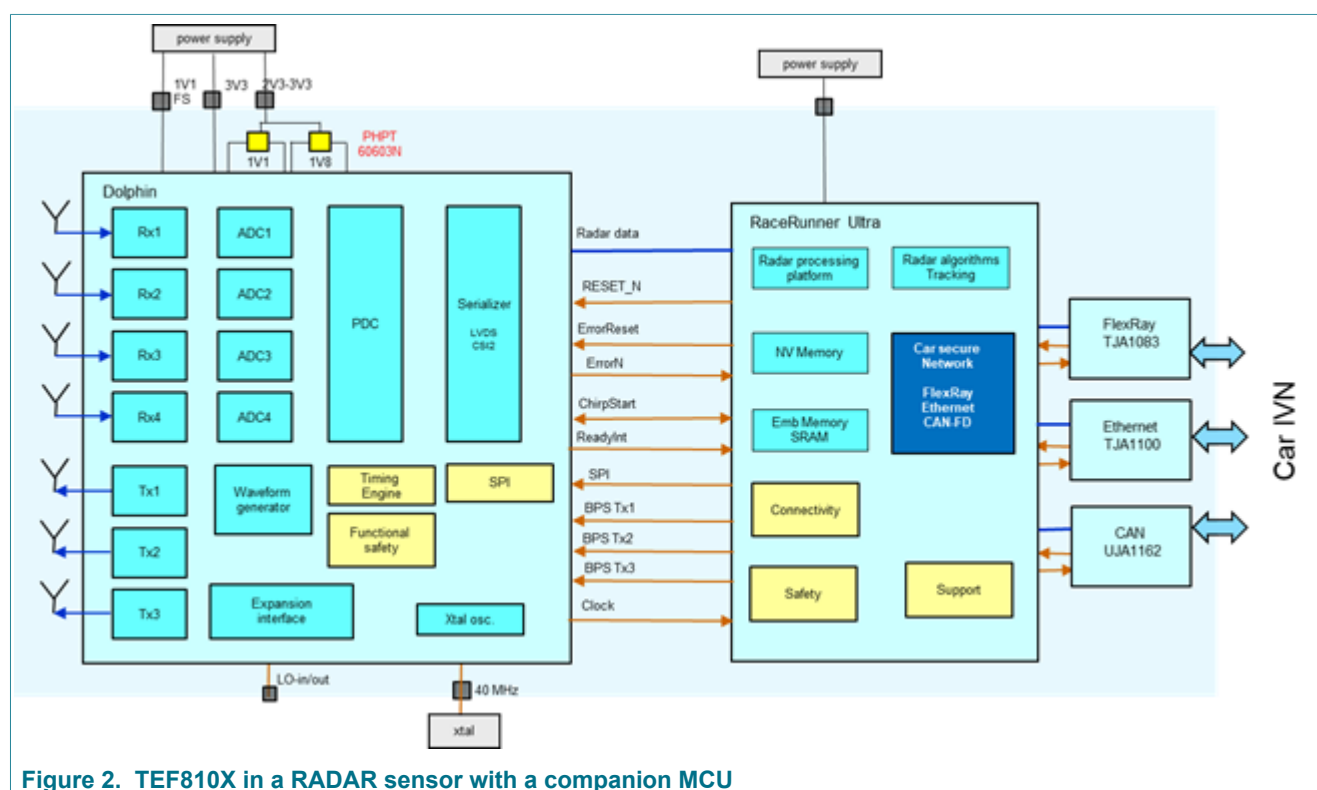


Figure 2. TEF810X in a RADAR sensor with a companion MCU

9 Package information

9.1 General

The TEF810X is packaged on a 7.5 mm x 7.5 mm eWLB package, with a pinning pitch of 500 µm.

9.2 Package Dimensions

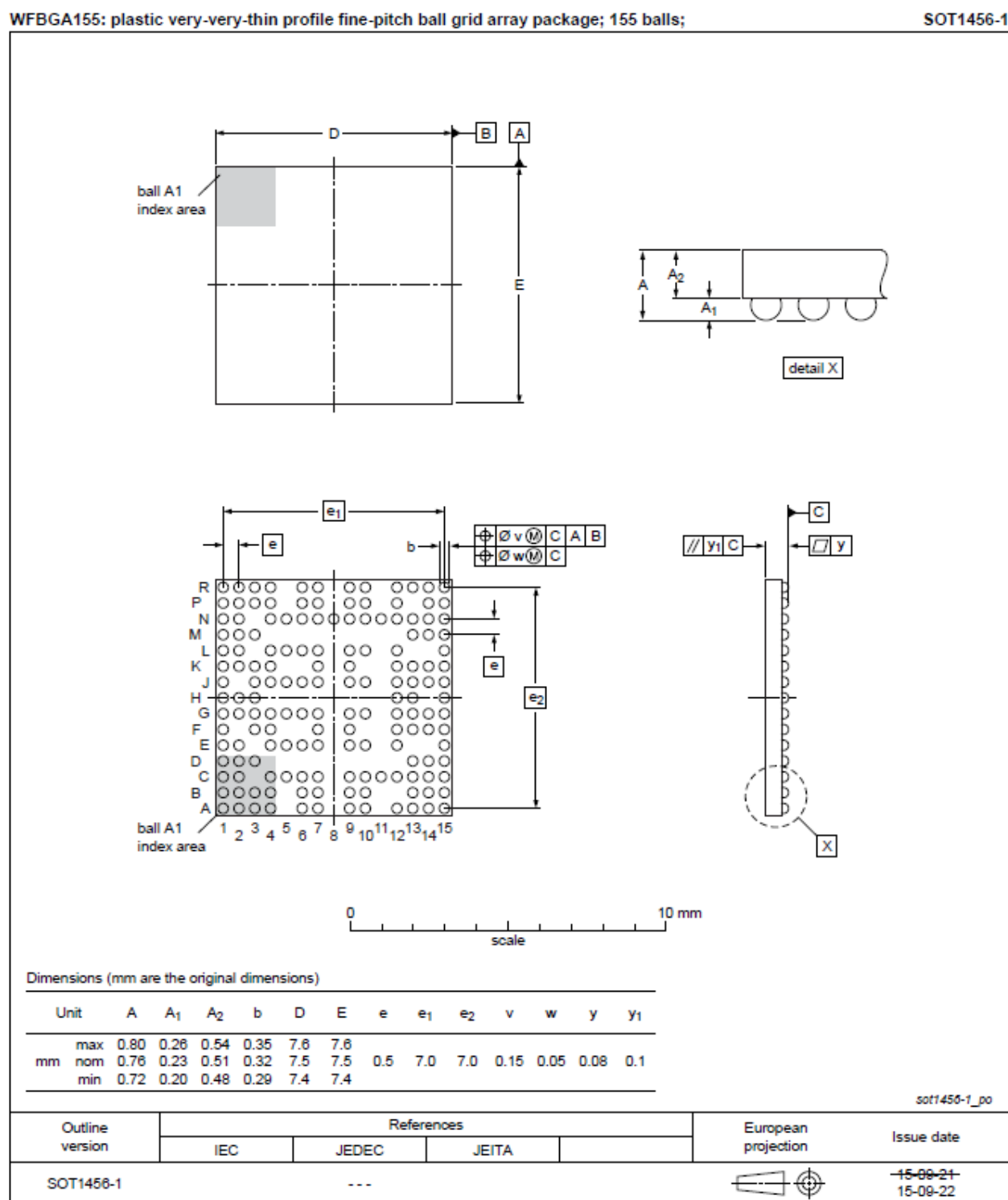


Figure 3. TEF810X package dimensions

10 Revision history

Table 8. Revision history

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|---------------|--------------|--------------------------|---------------|------------|
| TEF810X v.1.0 | 20190510 | Product short data sheet | - | - |

11 Legal information

11.1 Data sheet status

| Document status ^{[1][2]} | Product status ^[3] | Definition |
|-----------------------------------|-------------------------------|---|
| Objective [short] data sheet | Development | This document contains data from the objective specification for product development. |
| Preliminary [short] data sheet | Qualification | This document contains data from the preliminary specification. |
| Product [short] data sheet | Production | This document contains the product specification. |

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL <http://www.nxp.com>.

11.2 Definitions

Draft — The document is a draft version only. The content is still under internal review and subject to formal approval, which may result in modifications or additions. NXP Semiconductors does not give any representations or warranties as to the accuracy or completeness of information included herein and shall have no liability for the consequences of use of such information.

Short data sheet — A short data sheet is an extract from a full data sheet with the same product type number(s) and title. A short data sheet is intended for quick reference only and should not be relied upon to contain detailed and full information. For detailed and full information see the relevant full data sheet, which is available on request via the local NXP Semiconductors sales office. In case of any inconsistency or conflict with the short data sheet, the full data sheet shall prevail.

Product specification — The information and data provided in a Product data sheet shall define the specification of the product as agreed between NXP Semiconductors and its customer, unless NXP Semiconductors and customer have explicitly agreed otherwise in writing. In no event however, shall an agreement be valid in which the NXP Semiconductors product is deemed to offer functions and qualities beyond those described in the Product data sheet.

11.3 Disclaimers

Limited warranty and liability — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. NXP Semiconductors takes no responsibility for the content in this document if provided by an information source outside of NXP Semiconductors. In no event shall NXP Semiconductors be liable for any indirect, incidental, punitive, special or consequential damages (including - without limitation - lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory. Notwithstanding any damages that customer might incur for any reason whatsoever, NXP Semiconductors' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Terms and conditions of commercial sale of NXP Semiconductors.

Right to make changes — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without

notice. This document supersedes and replaces all information supplied prior to the publication hereof.

Suitability for use — NXP Semiconductors products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an NXP Semiconductors product can reasonably be expected to result in personal injury, death or severe property or environmental damage. NXP Semiconductors and its suppliers accept no liability for inclusion and/or use of NXP Semiconductors products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

Applications — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification. Customers are responsible for the design and operation of their applications and products using NXP Semiconductors products, and NXP Semiconductors accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NXP Semiconductors product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products. NXP Semiconductors does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using NXP Semiconductors products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). NXP does not accept any liability in this respect.

Limiting values — Stress above one or more limiting values (as defined in the Absolute Maximum Ratings System of IEC 60134) will cause permanent damage to the device. Limiting values are stress ratings only and (proper) operation of the device at these or any other conditions above those given in the Recommended operating conditions section (if present) or the Characteristics sections of this document is not warranted. Constant or repeated exposure to limiting values will permanently and irreversibly affect the quality and reliability of the device.

Terms and conditions of commercial sale — NXP Semiconductors products are sold subject to the general terms and conditions of commercial sale, as published at <http://www.nxp.com/profile/terms>, unless otherwise agreed in a valid written individual agreement. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. NXP Semiconductors hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of NXP Semiconductors products by customer.

No offer to sell or license — Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights.

Export control — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities.

Translations — A non-English (translated) version of a document is for reference only. The English version shall prevail in case of any discrepancy between the translated and English versions.

11.4 Trademarks

Notice: All referenced brands, product names, service names and trademarks are the property of their respective owners.

Tables

| | | | | | |
|---------|------------------------------|---|---------|--------------------------------------|---|
| Tab. 1. | Ordering information | 3 | Tab. 5. | TX characteristics | 6 |
| Tab. 2. | Limiting values | 5 | Tab. 6. | RX characteristics | 6 |
| Tab. 3. | Global characteristics | 5 | Tab. 7. | Chip generator characteristics | 6 |
| Tab. 4. | Supply specifications | 5 | Tab. 8. | Revision history | 9 |

Figures

| | | | | | |
|---------|--|---|---------|--|---|
| Fig. 1. | Block diagram of TEF810X car RADAR transceiver | 4 | Fig. 2. | TEF810X in a RADAR sensor with a companion MCU | 7 |
| | | | Fig. 3. | TEF810X package dimensions | 8 |

Contents

| | | |
|-----------|---------------------------------------|-----------|
| 1 | General description | 1 |
| 2 | Features and benefits | 2 |
| 3 | Applications | 3 |
| 4 | Ordering information | 3 |
| 5 | TEF810X block diagram | 4 |
| 6 | Limiting values | 5 |
| 7 | Characteristics | 5 |
| 7.1 | Global characteristics | 5 |
| 7.2 | Supply specifications | 5 |
| 7.3 | TX Characteristics | 6 |
| 7.4 | RX Characteristics | 6 |
| 7.5 | Chirp generator characteristics | 6 |
| 8 | Application information | 7 |
| 9 | Package information | 7 |
| 9.1 | General | 7 |
| 9.2 | Package Dimensions | 8 |
| 10 | Revision history | 9 |
| 11 | Legal information | 10 |

Please be aware that important notices concerning this document and the product(s) described herein, have been included in section 'Legal information'.

© NXP B.V. 2019.

All rights reserved.

For more information, please visit: <http://www.nxp.com>

For sales office addresses, please send an email to: salesaddresses@nxp.com

Date of release: 10 May 2019
Document identifier: TEF810X

Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[NXP:](#)

[TEF8105EN/N1Y](#) [TEF8106EN/N1Y](#) [TEF8107EN/N1Y](#) [TEF8104EN/N1Y](#) [TEF8102EN/N1Y](#) [TEF8101EN/N1E](#)
[TEF8101EN/N1Y](#) [TEF8102EN/N1E](#) [TEF8103EN/N1Y](#)