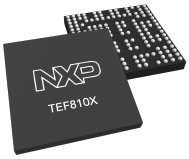


TEF810X

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 ^{o}C up to 135 ^{o}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 $Rth_{Junction\text{-}footprint}$ ~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

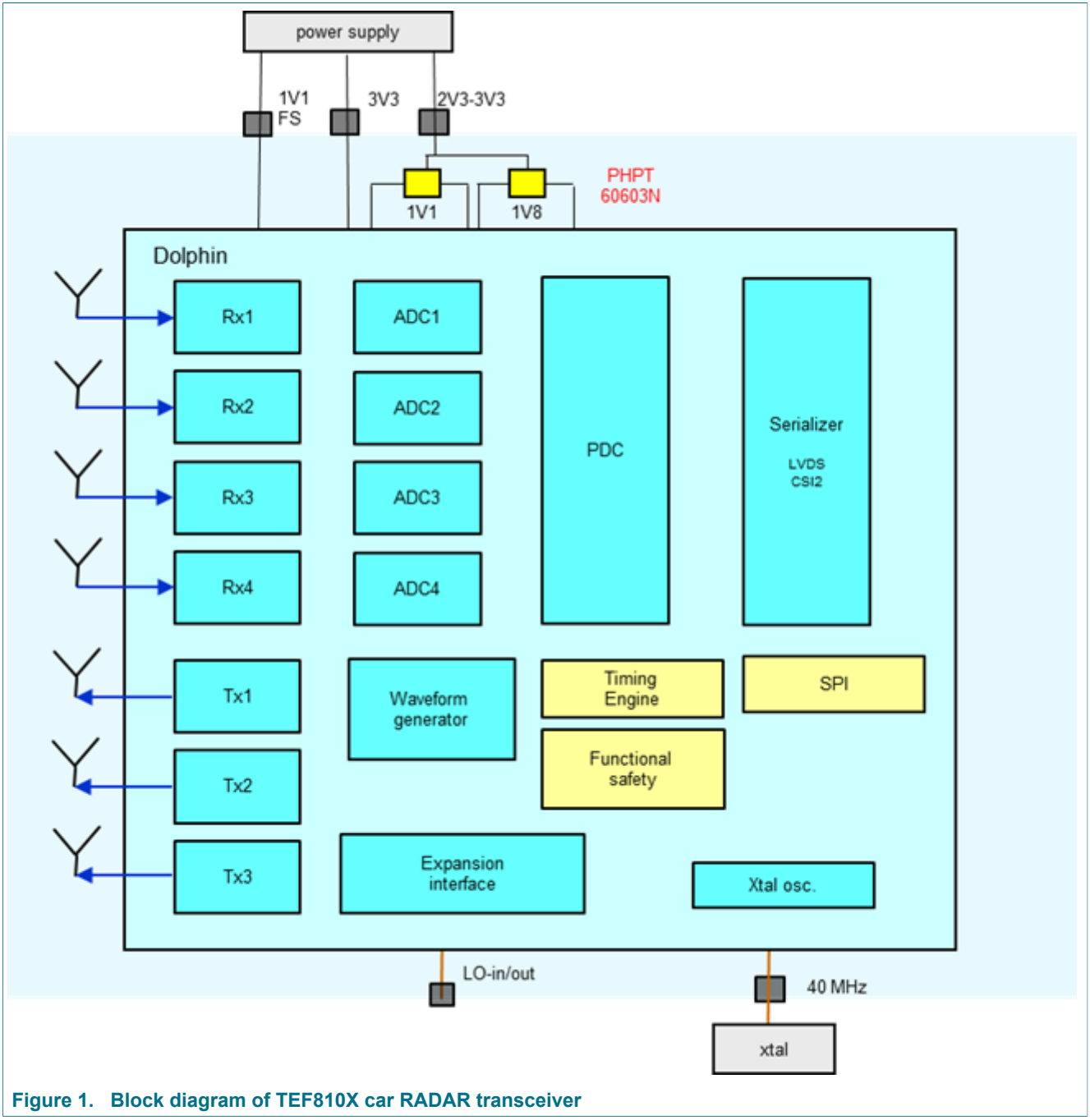


Figure 1. Block diagram of TEF810X car RADAR transceiver

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.

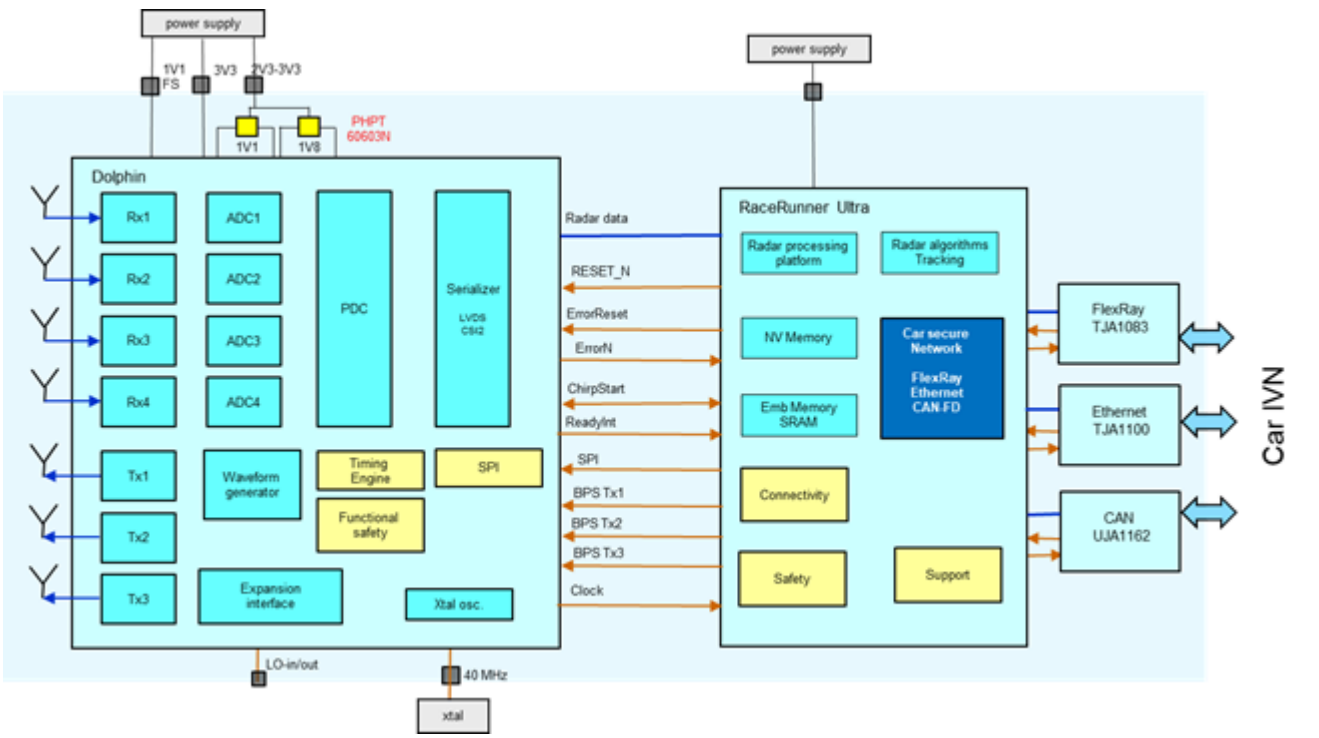


Figure 2. TEF810X in a RADAR sensor with a companion MCU

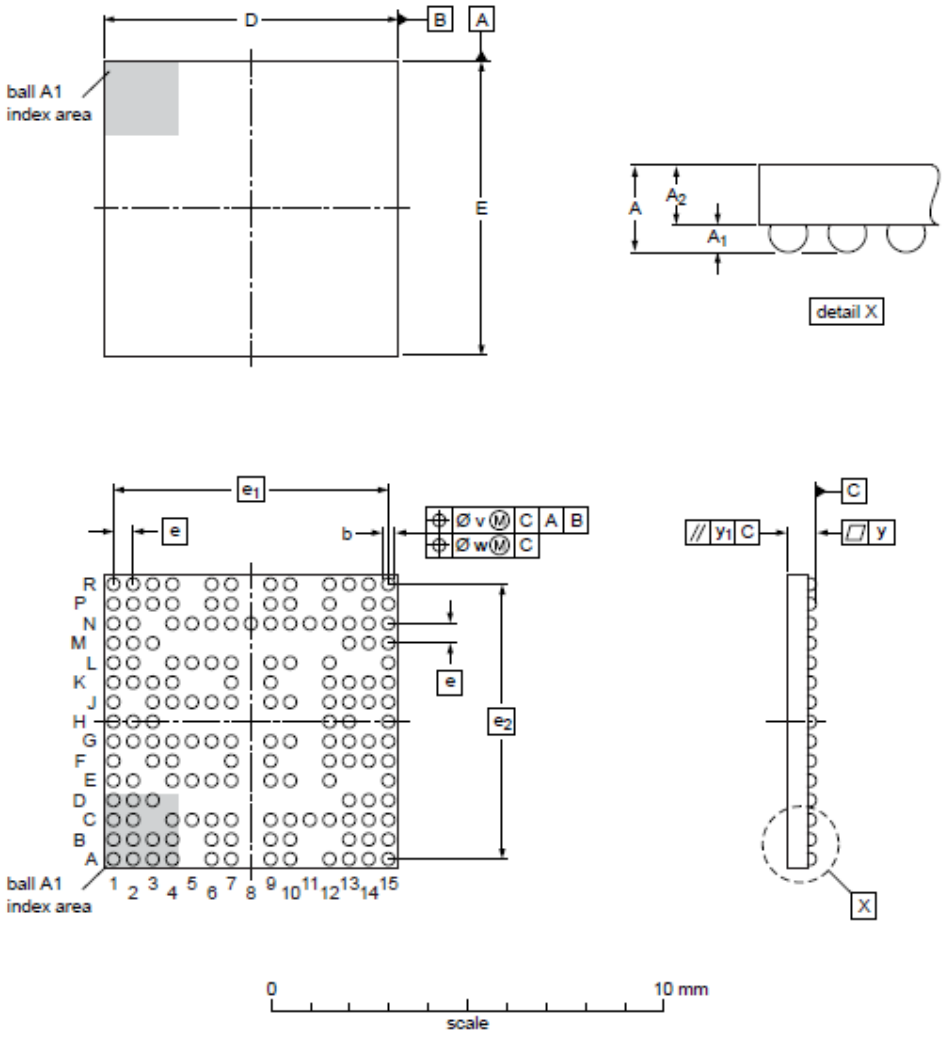
9 Package information

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

WFBGA155: plastic very-very-thin profile fine-pitch ball grid array package; 155 balls; SOT1456-1



Dimensions (mm are the original dimensions)

Unit		A	A_1	A_2	b	D	E	e	e_1	e_2	v	w	y	y_1
mm	max	0.80	0.26	0.54	0.35	7.6	7.6							
	nom	0.76	0.23	0.51	0.32	7.5	7.5	0.5	7.0	7.0	0.15	0.05	0.08	0.1
	min	0.72	0.20	0.48	0.29	7.4	7.4							

sot1456-1_po

Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
SOT1456-1		---				~~15-09-21~~ 15-09-22

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".
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