Technical documentation

Frequently asked questions for 24GHz industrial radar

What is radar?

Radar is an object-detection system that uses radio waves to determine the range, angle, or velocity of objects. A radar system consists of a transmitter producing electromagnetic waves in the radio or microwaves domain, an emitting antenna, a receiving antenna (separate or the same as the previous one) to capture any returns from objects in the path of the emitted signal, a receiver and processor to determine properties of the object(s).

What product family is available?

The BGT24M/L family is the largest and highest integrated 24GHz ISM band radar transceiver family currently in the market. It saves ~30 percent board space compared to discrete line ups. Infineon offers 4 different components, the BGT24MTR11 which combines one transmit and one receive channel, the BGT24MTR12 which comprises one transmit and two receive channels, and the BGT24MR2, a chip with 2 receive channels, combinable with both chipsets. Infineon recently released a new lower power, smaller form factor radar transceiver called BGT24LTR11 which comprises of one transmit and one receive channel.

What applications can radar be used in?

- Drones-soft landing and collision avoidance
- Street lighting projects
- Intelligent door openers
- Home automation
- Speed meters
- Robotics
- Internet of things

What are the radar processing technologies?

Technique	Complexity	Movement	Speed	Distance of moving objects	Distance of static objects	Angle of moving objects
Doppler	Low	✓	✓			
FSK	Medium	✓	✓	✓		
FMCW	High	✓	✓	✓	✓	
Monopulse	Medium					✓

Monopulse is an additional option for all the above operating modes

www.infineon.com/24GHz

Version 1, December 2016

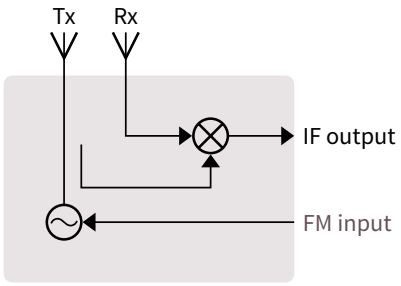
What are some of the main features of the products available?

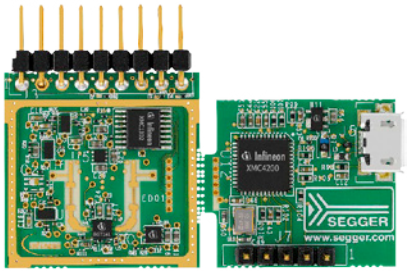
› Highest integration currently in the market
› Multiple combination Tx/Rx configurations available
› Fully packaged solution
› Low cost TSNP-16-9 package
› Distance detection up to 100 m
› Smallest packaged radar chip on the market

What is radar transceiver?

Radar transceiver (**trans**mitter re**ceiver**)

› Transmits low energy radio frequency signal over Tx antenna (24 GHz, max. 100 mW)
› Receives reflected signal over Rx antenna
› Moving target generates low frequency Doppler output signal (so called IF)

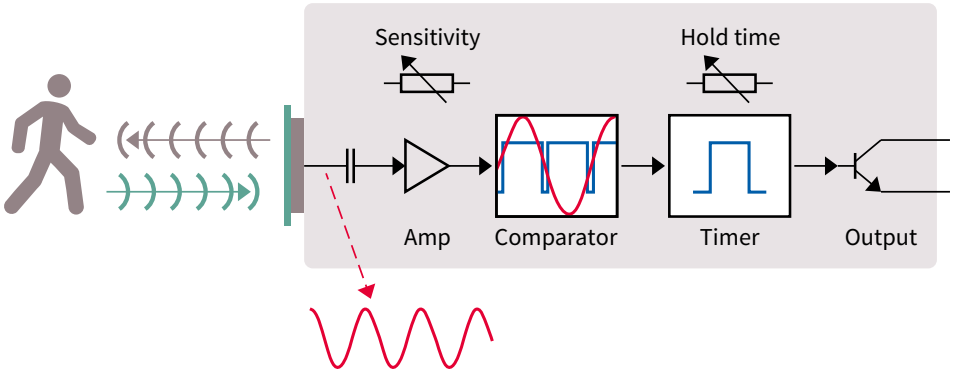




How does radar detect movement?

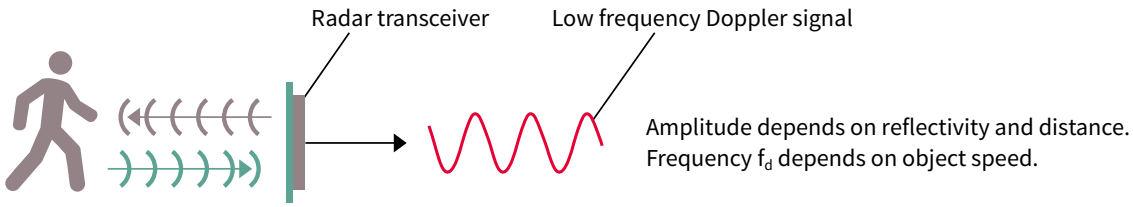
Basic movement detector

› Output becomes active as soon as Doppler signals are present
› Implemented with discrete components or simple microcontroller



What is the Doppler effect?

Doppler effect



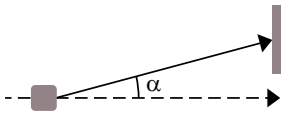
Calculating the Doppler frequency

$$f_d = \frac{2 \cdot f_{Tx} \cdot v}{c_0} \cdot \cos \alpha \quad (1)$$

or

$$v = \frac{c_0 \cdot f_d}{2 \cdot f_{Tx} \cdot \cos \alpha} \quad (2)$$

f_d	Doppler frequency
f_{Tx}	Transmit frequency (24 GHz)
c_0	Speed of light ($3 \cdot 10^8$ m/s)
v	Object speed in m/s
α	Angle between beam and object moving direction



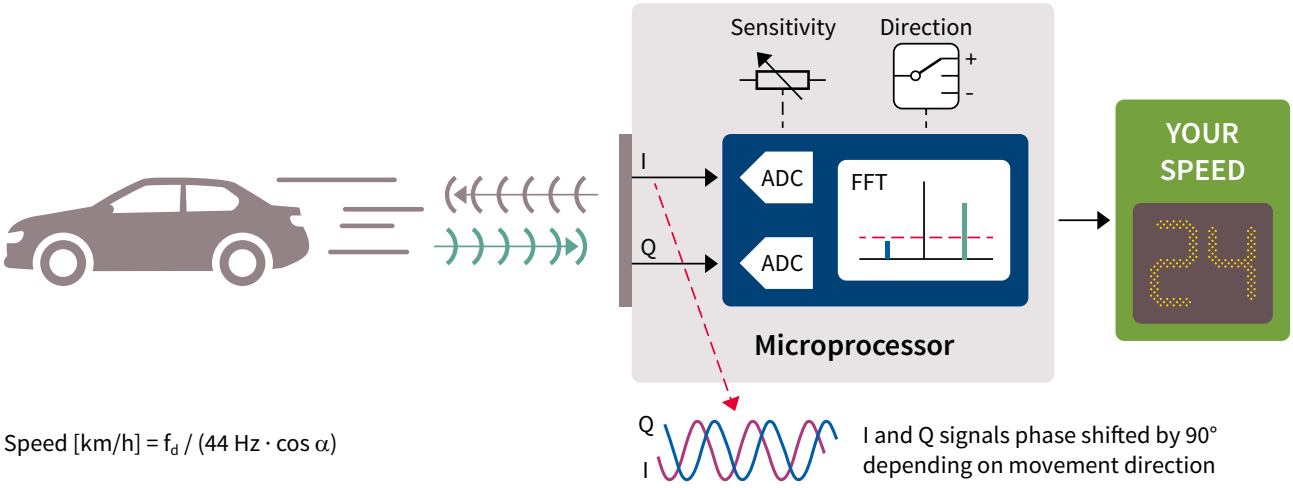
At a transmit frequency of f_{Tx} = 24.125 GHz we get a Doppler frequency for a moving object at the IF output of

$f_d = v\,[km/h] \cdot 44\ Hz \cdot \cos \alpha$ or $f_d = v\,[m/s] \cdot 161\ Hz \cdot \cos \alpha$ (4)

How does Doppler processing calculate speed?

Speed display

- Frequency (= speed) and direction are detected by complex FFT
- Implemented with FFT (Fast Fourier Transform)



Speed [km/h] = f_d / (44 Hz · cos α)

I and Q signals phase shifted by 90° depending on movement direction

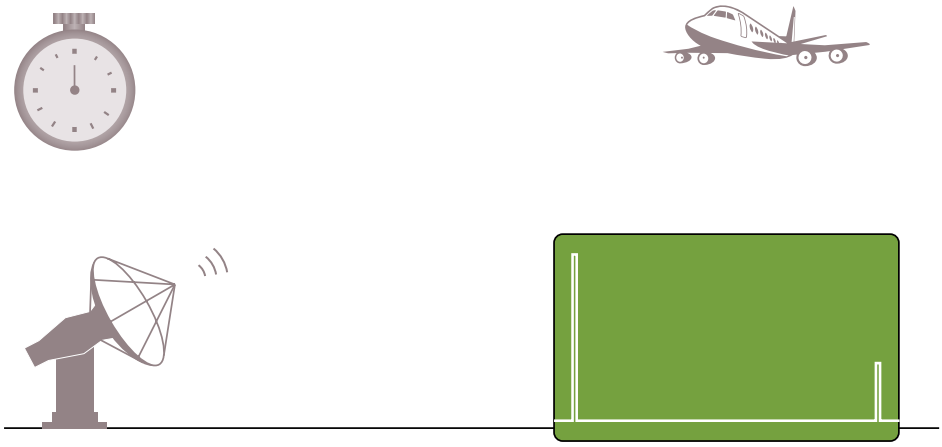
How does radar measure distances?

Typical measurement methods

Distance measurement always needs bandwidth / modulated carrier

Pulse radar

› Sends out a very short, powerful pulse
› Measures time of flight of reflected pulse
› Needs high bandwidth → not usable in K-band



Continuous wave methods

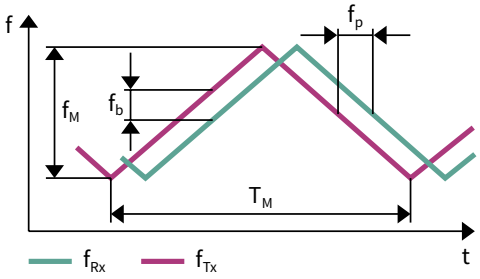
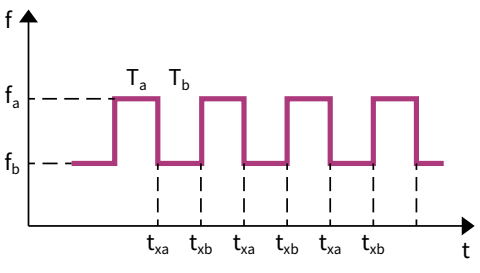
No pulse, but a continuous, frequency modulated carrier is sent

› **FMCW:** used to detect stationary and moving objects.
A so called chirp is sent and mixed with the received signal. Low frequency output represents distance.
› **FSK:** used to get distances of moving objects.
2 frequencies are sequentially sent. 2 phase shifted Doppler signals represent distance.

What is the difference between FMCW and FSK?

FMCW and FSK

Measuring distances need modulation of carrier → bandwidth

	FMCW (Frequency Modulation Continuous Wave)	FSK (Frequency Shift Keying)
Use	For stationary and moving objects	For moving objects only
Modulation		
Formula	$R = \frac{c_0}{2} \cdot \frac{f_b}{f_M} \cdot \frac{T_M}{2}$	$R = \frac{c_0 \cdot \Delta\phi}{4\pi \cdot (f_a - f_b)}$
Resolution	1 m, limited by K-band bandwidth 250 MHz	1–100 cm, depending on signal processing

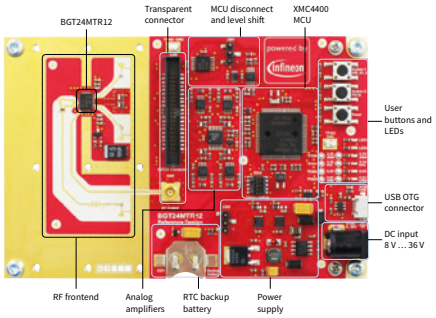
What is current system availability?

There are 3 demo boards available now. Please see below description and images.

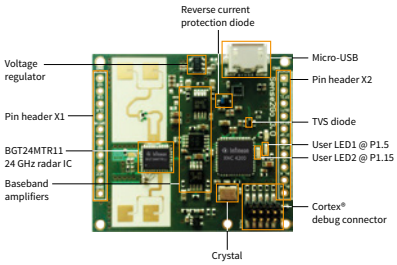
2014	2015	2016
RFB2412 (BGT24TR12 + XMC4400)	Sense2Go2 (BGT24MTR11 + XMC4200)	Sense2GoL (BGT24LTR11 + XMC1300) [1]
› 1 transmitter + 2 receivers › Motion detection › Doppler radar for speed monitoring › Software based FMCW for distance measurement of stationary objects - NEW › Angle of arrival estimation - NEW	› Starter kit for radar and microcontroller development › 1 transmitter and 1 receiver › Motion detection and Doppler radar for speed › Low power mode for enhanced battery life › Industrial standard interfaces via CAN and IOLINK › Range to 15 m	› Starter kit for radar as well as IFX microcontrollers › Low end solution + development kit › 1 transmittet and 1 receiver › Motion detection and Doppler radar for speed › Low power mode for enhanced battery life › Ultra small form factor

1) Now available

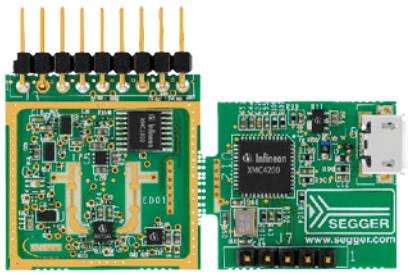
RFB2412



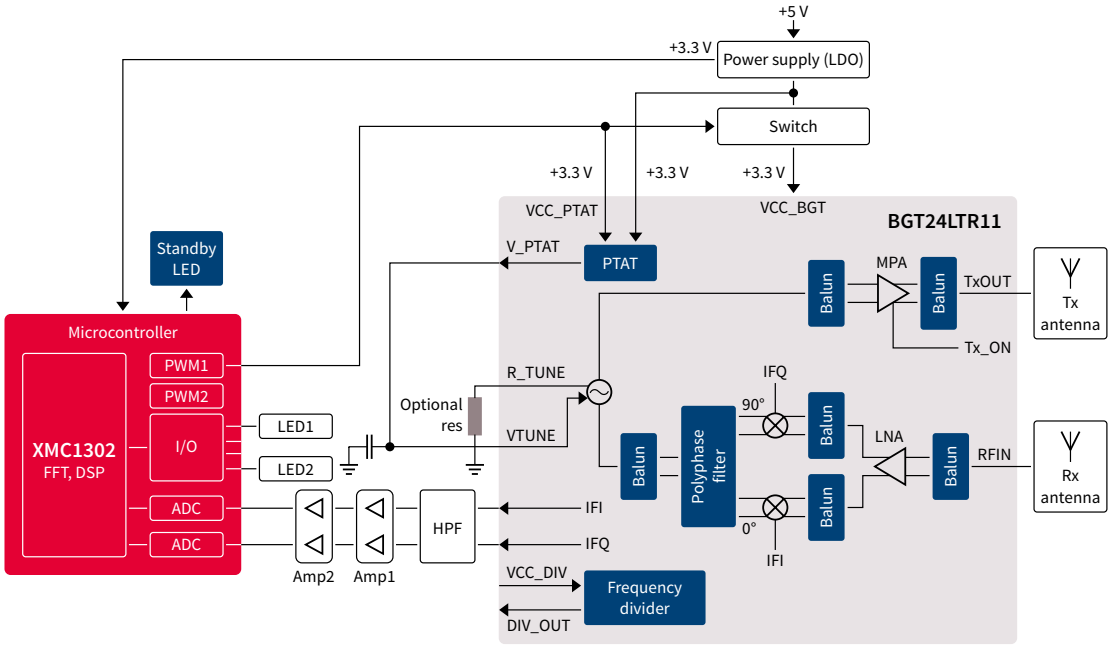
Sense2Go2



Sense2GoL with break away debugger



Is there a block diagram available for the Sense2GoL?



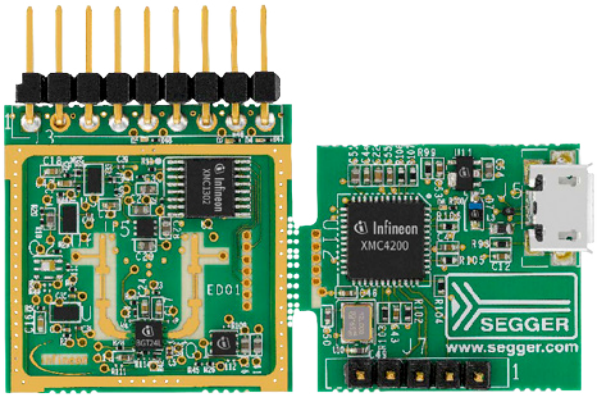
What are the key features of the Sense2GoL demo board?

Features

- Capability to detect motion, speed and direction of movement (approaching or retreating)
- BGT24LTR11 – 24 GHz highly integrated low power RF MMIC
- XMC1302 ARM® Cortex®-M0 – 32-bit industrial microcontroller
- Integrated patch antennas
- Segger debugger break off board for reprogramming

Kit contains

- User manual
- SW GUI to operate kit
- Precompiled C libraries provided
- PCB schematic and Gerber files



Is this available as an MMIC or complete module?

Infineon smart sensing solutions

MMIC	Module suppliers using Infineon chip	
Features	Technical benefits	Customer benefits
› Radar-based motion detector operating in the 24 GHz ISM-band › Long range distance detection of moving objects up to 30 m › Wide range speed detection up to more than ±100 km/h	› Large coverage areas such as warehouses, parking lots, ect. › Robust against harsh conditions (rain, dust and temperature) › Precise presence detection › Fast measurement updates	› Excellent movement detection › Fewer false alarms › Energy savings › Concealable › Customized solution › Off the shelf module from market partners

Where do I go for additional information?

www.infineon.com/24GHz

Notes

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