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Doppler module KMY 24:
Radar sensor detects motion and direction

Eligibility for worldwide approval, detection of direction as well as motion, compact dimensions and an operating range of up to eight meters are the outstanding features of the low-cost KMY 24 microwave sensor, which opens up markets previously reserved for infrared systems.

Fig. 1 The radar sensor – shown here as a laboratory sample with a footprint of 38 x 28 mm – can be used virtually anywhere thanks to its low insertion height of only 12 mm

Doppler modules are radar sensors which operate in continuous wave (CW) mode. Their principal function is to detect movements within their sensitivity range without measuring the absolute distance to the object.

Poised for worldwide approval

Under current telecommunications regulations, only motion sensors operating in the 2.45 and 24.125 GHz frequency bands can be marketed worldwide. Although 24.125 GHz systems offer distinct technical benefits, they are difficult to implement at present with surface mount devices (SMDs), so their development will depend on future advances in the state of the art. For this reason, Siemens has designed its KMY 24 Doppler module, which already has German BZT approval G127520H and is available in sample quantities, to operate in the 2.45 GHz band.

Triplate filters minimize harmonic radiation

The core of the sensor is a four-layer epoxy multilayer board with SMDs mounted on one side. The board has four layers because triplate filter structures are provided for all DC terminals (V+, DS1, and DS2) and the RF output in order to minimize radiation of harmonics. A patent is pending for this circuit design. In addition, a new type of patch antenna with minimized dimensions permits maximum gain at the operating frequency of 2.45 GHz (**Fig. 2**).

The oscillator generating the RF radiation (**Fig. 3**) consists of a standard BFR 92P transistor with a transition frequency of 5 GHz, a ceramic coaxial resonator, several resis-tors and capacitors of the 0805 series, and various microstrip conductors. An oscillator output power of about 10 dBm can thus be generated. An adjusting screw as used in the KMY 10 (formerly the SMX-1) 9.35 GHz sensor [1] is not required here. The phase noise of the oscillator is reduced by using a transistor with a minimal transition frequency f_T. The following equation represents the basic rule for oscillator design:

$$f_T = 2 \times f_0$$

Detecting direction with two mixer diodes

The KMY 24 Doppler module detects not only the presence of an object, but also the direction in which it moves. This supplementary information is obtained

Table 1 Key technical data of the KMY 24 motion sensor

	Symbol	Measured value min.	typ.	max.	Unit
Operating frequency	f_0	2.4	2.45	2.4835	GHz
Equivalent isotropic radiated power at f_0	$EIRP_1$		8	10	dBm
Range	r		5	8	m
Operating voltage	V_0	10.8	12	15.6	V
Operating current	I_0		22		mA
Radiated harmonic power 1st/2nd/3rd harmonics	$EIRP_n$		–45	–36	dBm
Time between turn-on and first detection	t_p		3		ms

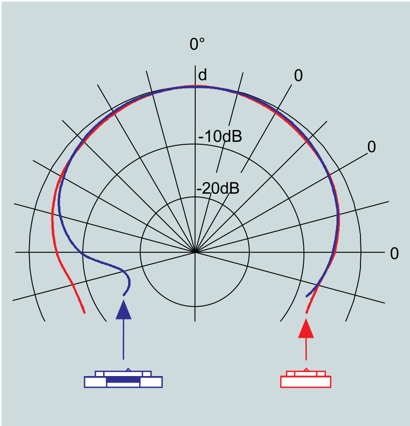


Fig. 2 Vertical/horizontal diagram of the patch antenna at 2.45 GHz

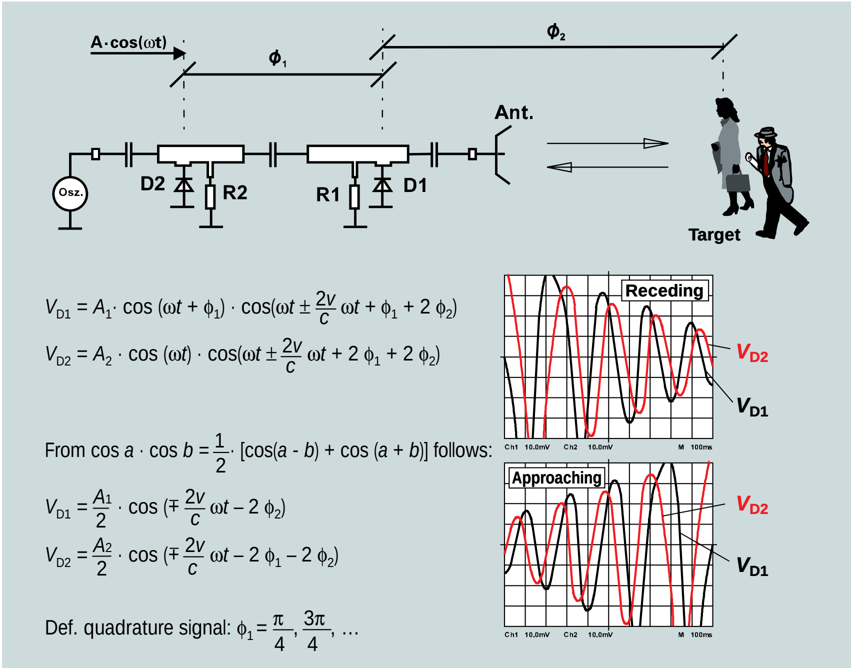
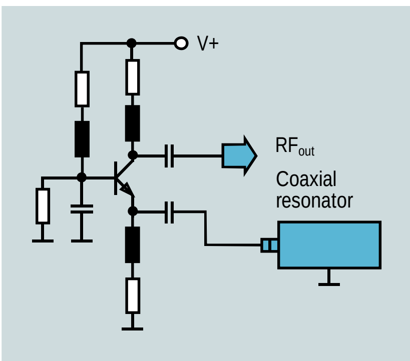


Fig. 4 Two diodes are arranged with an offset equal to a defined phase difference to determine whether an object is approaching or receding from the sensor

using two mixer diodes, driven by the RF oscillator, which have a defined phase difference. If the reflected signal is also included, the phase angle between the diodes D1 and D2 must be an odd multiple of $\pi/4$ to obtain a Doppler signal with an ideal phase offset of 90°. If this condition is satisfied, V_{D2} will lead with respect to V_{D1} when an object approaches the module, while it will lag when the object moves away (**Fig. 4**). The amplitude of the Doppler signal V_{D1} is always greater than V_{D2}, since the reflected RF signal is weakened by the diode D1. If detection of direction is not required in a particular application, the Doppler signal of diode D1 is used.

If both signals are evaluated, the direction of the moving object can be unambiguously inferred. This is done with the aid of a flipflop and a monoflop after suitable preamplification and filtering (gain V_0 of 1000, cutoff frequency f_g of 30 Hz). On the other hand, these two signals can be used to suppress any disturbing effects because they do not have any phase shift.

Fig. 3 The GHz oscillator used in the KMY 24 Doppler module comprises a BFR 92P transistor, ceramic coaxial resonator, resistors, capacitors and microstrip conductors



No problems with power hum

The advantages of the new motion sensor are its suitability for worldwide approval, its low insertion height, and its ability to detect direction. Another advantage becomes apparent when, for example, the Doppler signal of a pedestrian moving at 5 km per hour is observed: in this case, the Doppler frequency of the KMY 24 is 22.7 Hz compared with 86.6 Hz for the KMY 10. So if the KMY 24 is used solely to detect motion, 50 Hz interference (from power lines, fluorescent tubes, etc.) can be easily suppressed without filters. The KMY 10 with its higher resolution is preferable only for speed measurements.

When an application circuit is designed, it must be remembered that the modules will also emit RF radiation at the back if no protective shielding is provided. The ratio of front-to-back radiation is about 3:1 for the KMY 24. The reason for this is the relatively low gain of the transmit/receive antenna. It may be utilized to operate automatic light switches in building management systems, for example. This application will be described in a future article. Further applications are currently being examined in automotive engineering.
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studied telecommunications at Vienna University of Technology and joined the Semiconductor Group of Siemens AG in 1987, where he worked on a phased array project in the X band. He was later responsible for various discrete GaAs semiconductors and Doppler radar modules. Since 1993, Mr. Lohninger (34) has been project manager for silicon MMICs and responsible for products based on fourth-generation bipolar transistors.