FM Narrowband Transmitters & Receivers

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In this article, the characteristics of FM narrowband transmitters and receivers will be explained, in comparison with wideband radio.

The technical and regulatory parameters for Short Range Devices are defined in CEPT/ERC RECOMMENDATION 70-03 and the test specifications are contained in EN300 220-1. These regulations summarize the requirements for the bandwidth and modulation method. They are two important specifications that must be carefully considered when designing radios. The requirements of these regulations can be summarized in the following two sentences;

- Basically, a transmitter can operate in any bandwidth within the specified frequency band.
- All types of modulation can be used.

Short range devices in Europe are widely used in the 433.050 MHz-434.790 MHz ISM band. The radio parts used in the most popular short range devices in Europe, such as wireless alarm and keyless entry, are designed to meet those requirements described above. The majority of RF designs for these devices use OOK-AM modulation with SAW oscillator or direct FM modulation for the transmitter. For the receiver, wideband OOK-AM demodulation that covers the large frequency drift of SAW oscillators, or direct FM demodulation is utilized.

This RF design technique enables lower cost, miniaturization and low power consumption, allowing many RF products to be marketed for various applications. On the other hand, most of these devices are designed for wideband, which can cause a severe interference problem in the 434 MHz band.

Under such circumstances, the device that can resolve the interference problem is the narrowband device. It ensures reliability of communication and uses the limited RF spectrum most effectively.

It is often suggested moving into the 868MHz band to escape from interference in the 434MHz band, however there is a possibility of causing the same problem in the future, as long as the wideband method is used.

With regard to the general characteristics of radio waves, the 434MHz band (or 868MHz band) has good diffraction characteristics and line-of-sight 1 Km operating range is possible with a properly designed 10mW narrowband device. The 434MHz band (868MHz band) is much easier to handle than a higher frequency such as 2.4GHz.

The essential part of FM transmitter & receiver design in this easy-to-handle 434MHz (868MHz) band is outlined below, focusing on two important parameters: receiver sensitivity and selectivity.

Receiver sensitivity

The sensitivity of a receiver is generally defined by the signal level required to gain the given signal-to-noise (S/N) ratio. This means sensitivity is increased when there is less noise.

The following formula shows the factors used to define receiver sensitivity.

S(dBm) = -174+NF+10logB+10log(S/N)

S (dBm)	Receiver sensitivity
-174 (dBm)	K x T x B = 1.38E-23 (J/K) x 290(K) x 1(Hz)
NF	Noise figure
B	Receiver bandwidth (IF filter, base band filter band)

If communication is established by FSK with 12dB of S/N ratio equivalent to BER 1E-4 and 3dB of total circuit NF (deterioration of NF is compensated with high frequency amplifier gain), receiver sensitivity with a wideband receiver will become –100dBm, and receiver sensitivity with a narrowband receiver will become –117dBm. This was calculated using the following formula and assumption of bandwidth.

	Sensitivity	Formula	Receiver bandwidth
Wideband receiver	-100dBm	-174+3+59+12= -100dBm	800k
Narrowband receiver	-117dBm	-174+3+42+12= -117dBm	16k
Difference in sensitivity	17dB		

A sensitivity difference of 17dB between a narrowband and wideband receiver is equivalent to approximately 50-fold in transmission power. The communication range of a 10mW transmitter with a receiver that has –117dBm sensitivity is equivalent to the range of a 500mW transmitter with a –100dBm sensitivity receiver. This shows that the use of narrow and radio contributes to energy saving and effective use of spectrum.

Selectivity

When receiving certain signals, as the signals have their own occupied bandwidth, the receiver needs to receive

the specified bandwidth only. It is important to eliminate the band out of the specified bandwidth as an unnecessary frequency component, to increase performance against interference.

The receiving bandwidth depends on the transmitter configuration. If the transmitter uses a SAW oscillator that has inaccurate frequency stability, at least 800k of receiver bandwidth is required. It does not give good receiver performance against interference.

Combination of various filters (RF filter: SAW, IF filter: crystal or ceramic filter) used in narrowband receivers enables more than 50dB of selectivity at +/-25k of receiving frequency. Also to have RX frequency +/-6kHz received signal pass bandwidth , the temperature characteristics of transmitter frequency stability have to be less than +/-4 ppm (-10 C to +55C).

If the required data rate of the system is lower than 9.6 kbps, it is recommended that a high-selectivity radio is used, even though the cost is higher.

(CIRCUIT DESIGN, Inc. is a manufacturer of low power radio products in Japan. This article is based on the experience of the narrowband technique and design concept complying with Japanese radio law.)

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