Radiometrix

Hartcran House, 231 Kenton Lane, Harrow, HA3 8RP, England

Tel: +44 (0) 20 8909 9595, Fax: +44 (0) 20 8909 2233

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Application note 019

Narrowband ?

By Myk Dormer - Senior RF design engineer, Radiometrix

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Any user with reasonable familiarity with the low power radio marketplace, or with the dominant specifications that regulate it, will be aware that radio modules seem to fall into one of two definite “camps”.

On one hand there are low cost, short ranged modules with very high data rates. These have been in the spotlight recently as the suppliers and promoters of the various defined-network architechtures (Zigbee, Bluetooth) buy increasing amounts of advertising column space. With the advent of these architechtures, the associated radio modules are also providing much more sophisticated, software-heavy interfaces

On the others side, there is a class of apparently more “old fashioned” narrowband radios. While these units claim longer operating range, they also have lower data rates (usually less than 10kbit/ sec, occasionally only an audio baseband connection) and higher comparative cost.

Before we follow the advertising hype, and assume that higher data rate is always better, we should examine what the actual difference between a “narrowband” and a “wideband” radio is.

The definition is (unusually for an industry buzzword) based in basic communication theory:

The modulation index of an FM carrier b = Dw/wm (Dw = max deviation)
(wm = max mod freq)

Narrowband FM is defined as the condition where b is small enough to make all the terms (sidebands) after the first two in the series expansion of the FM equation negligible.

Narrowband Approximation: b = Dw/wm < 0.2 (but can be as high as 0.5, though)

So the occupied bandwidth BW is approximately 2wm

Wideband FM is defined as when a significant number of sidebands have significant amplitudes. (occurring when b >1). In this case the occupied bandwidth BW approximates to 2Dw

To relate this to practical telemetry data radio practice, we see narrowband radios with channel spacings of 25KHz or less, and maximum data rates around 10kbit/sec (b ~ 0.5). Wideband radios typically operate with channel spacings of over 200KHz, and data rates exceeding 64kbit/sec (b > 5, although most higher frequency 2.4GHz band units have proportionately wider channels (several MHz occupied bandwidth) with corresponding megabit-per-second data rates).

The less obvious trade-off here is in sensitivity (and hence range for a given transmitter power) as each doubling of signal bandwidth degrades S/N by 3dB.

Thus, while a narrowband 25KHz unit will show a typical sensitivity of -118dBm at 2.5Kbit/sec, a comparable wideband unit will achieve only -107dBm at 40kbit/sec and will require a 300KHz wide channel. For the same transmitter power, this will result in about half the range compared to the 25KHz radio.

In terms of actual circuit design, the choice of wide or narrow channel has some important implications. (Unfortunately, some of these are also issues that drive narrowband radio prices up)

1. Required frequency accuracy is proportional to the width of the occupied channel:
A 25KHz channel needs a centre frequency accuracy of around 1.5-2KHz. In the 433MHz UHF band this corresponds to approximately 3ppm reference stability.

A wideband radio in the same band with 300KHz channel width can tolerate over 50ppm of drift before the wanted carrier is outside the receive filter's optimum passband.

So the wideband unit can use an inexpensive crystal, or even a good SAW resonator, while the narrowband unit needs a TCXO, or hard-to-source high stability crystal.

2. Receive filters require narrower bandwidth and far better shape factors:
The narrowband radio requires crystal and/or high performance ceramic filters. The wideband receiver can use low cost "broadcast" 10.7MHz elements, or can even use low or zero IF techniques and integrate the receive filters onto a chip

(There have been attempts to combine narrowband operation with on-chip filtering in some recent products, but the actual RF performance is so far woefully inadequate compared with "traditional" crystal filters, resulting in adjacent channel rejection figures below 30dB, where 60-70dB are needed)

3. Local oscillator noise (purity) is far more critical in the narrowband design:
simply because the adjacent channel is closer to the wanted frequency, so low noise oscillator design techniques are required. The resulting circuitry is more complex, requires more careful screening, and uses more costly, large, high-Q parts.

4. Transmitter circuitry is more complicated:
Transmitter switching is slower (10-50mS typically) and transmitter circuitry is more complicated in narrowband radios compared to wideband, since the acceptable frequency abberation (or 'pull' when turning on or off) is also proportional to channel width, and phase stability (recirculation) is more critical with the lower modulation index.

On the other hand, some factors decidedly favour the narrowband module:

5. Regulatory authorities often permit higher transmit power on narrowband only:
Frequency allocations (in the UK for instance, 10mW is the maximum power in the 'all modes' 433MHz band, but 500mW is allowed on the 458MHz narrowband only allocation)

6.More Channels per allocated MHz:
Obviously, the smaller channel widths allow more channels per allocated MHz, permitting practical use to be made of very simple frequency division multiple access band plans, and making it easier to avoid fixed interferers (by changing channel)

7. Most, if not all, VHF allocations are narrowband only:
Including most of the new 169MHz band, and all of the older UK allocation at 173MHz

The upshot of this comparison is clear:

If data rate and cost are crucial, and multiple users are accommodated by limited duty cycle or time division duplexing, then choose a wideband module

But if range, resistance to interferers, better power efficiency, or multiple channel operation are required, then a narrowband radio module is still the best choice.

Radiometrix Ltd

Hartcran House
231 Kenton Lane
Harrow,
Middlesex
HA3 8RP
ENGLAND
Tel: +44 (0) 20 8909 9595
Fax: +44 (0) 20 8909 2233
sales@radiometrix.com
www.radiometrix.com

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