Frequency Block Diagram
(Taken from data sheet for nRF2401)

BLOCK DIAGRAM

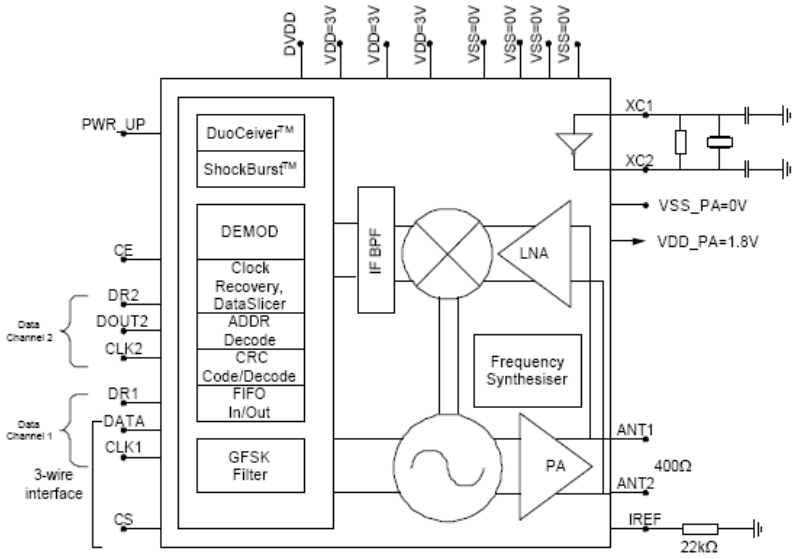

Figure 1 nRF2401 with external components.

Your ref.: Our ref.: 1159710/BEF Date: 2006-09-20

nRF2401/nRF2402/nRF24E1/nRF24E2, additional information to TELEC

nRF2401/nRF24E1 in Receive Mode

The nRF2401/nRF24E1 receiver uses a dual-conversion super-heterodyne topology with on-chip mirror cancellation with a high first intermediate frequency (IF1) and a low second intermediate frequency (IF2) as shown in Figure 1.

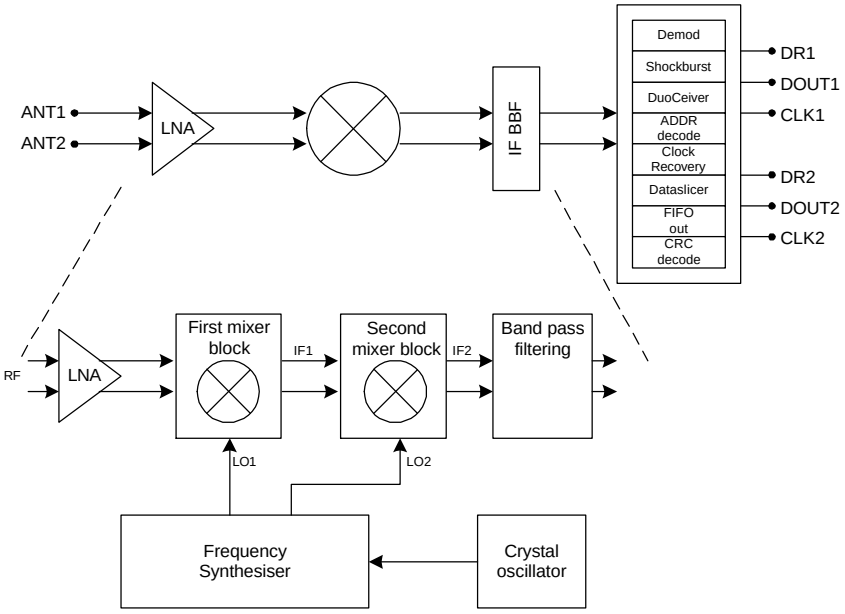

Figure 1: Block diagram receiver in nRF2401/nRF24E1.

In contrast to a homodyne receiver, the LO frequency in this topology is not equal to the frequency of the receiving signal. That is, the first LO signal is located outside the receiving frequency band, and it may be seen on a spectrum analyzer if the noise floor is set low enough.

f_{LO1} and f_{LO2} is given by:

$$f_{LO1} = \frac{8}{7}\left(f_{TX\_ch1} + 3MHz\right) \qquad f_{LO2} = \frac{1}{7}\left(f_{TX\_ch1} + 3MHz\right)$$

nRF2401/nRF24E1 has on-chip suppression of all mirroring frequencies generated in the mixing processes. Figure 2 and Table 1 shows the location of the first LO and the mirror frequencies in the case when nRF2401/nRF24E1 is receiving on channel 45 (2445 MHz).

Signal	Receiving signal	First Local Oscillator	Mirror 1	Mirror 2a	Mirror 2b
Frequency	2445.0	2797.7	2451.0	3144.4	3150.4

Table 1: Frequency location in the nRF2401/nRF24E1 receiver when programmed to channel 45 (all numbers in MHz).

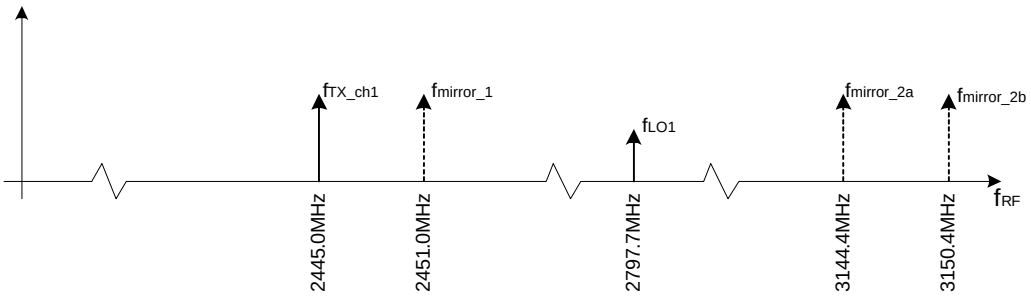

Figure 2: Frequency location in the nRF2401/nRF24E1 receiver when programmed to channel 45.

nRF2401/nRF24E1 Receiver Bandwidth

The band-pass filter (IF2, 3 MHz fixed) serves as channel-selection filter and noise bandwidth limitation. The bandwidth of the filter is as small as possible but still wide enough to not degrade the signal spectrum. An optimal filter bandwidth could be found regarding noise bandwidth and signal energy degradation. The filter bandwidth has to be selected to cover frequency offset and drift in the system.

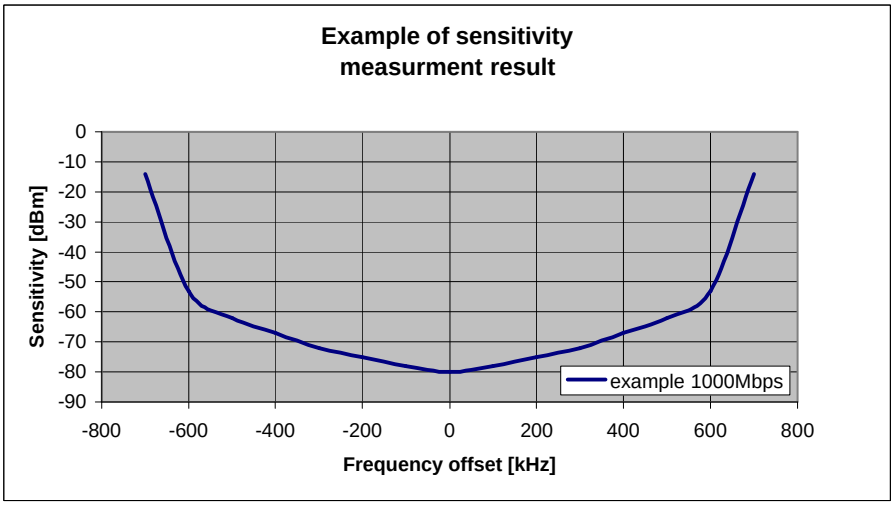

Figure 3: Example of sensitivity measurement result versus frequency offset

Figure 3 shows an example of a sensitivity measurement on a nRF2401/nRF24E1 chip with a 1Mbps incoming signal. Such a test gives a good view of the overall receiver bandwidth. The bandwidth and center-frequency of such a plot may differ slightly from chip to chip due to process variation. However, the filter and the radio system are designed to cover both frequency offset and process variations. So small changes in filter characteristic should be of no concern when using the chip.

IF1 is not filtered.

$$f_{IF1} = \frac{1}{7}\left(f_{TX\_ch1} + 8 \cdot 3MHz\right)$$

nRF2401/nRF2402/nRF24E1/nRF24E2 PLL

The PLL in nRF2401/nRF2402/nRF24E1/nRF24E2 is built as a M/N PLL.
For a 16 MHz crystal frequency, M and N have the following values:

Transmitt mode, TX: (nRF2401/nRF2402/nRF24E1/nRF24E2)

M=32 for all channels (Comparator freq = 0.5 MHz)

N=4800 for f=2400 MHz
N=4804 for f=2402 MHz
N=4880 for f=2440 MHz
N=4960 for f=2480 MHz
N=4966 for f=2483 MHz

Receive mode, RX: (nRF2401/nRF24E1)

M=28 for all channels (Comparator freq = 8/7 * 0.5 MHz)

N:
N=4806 for f=2400 MHz
N=4810 for f=2402 MHz
N=4886 for f=2440 MHz
N=4966 for f=2480 MHz
N=2483 for f=4972 MHz

nRF2401/nRF2402/nRF24E1/nRF24E2 in Transmitt mode.

nRF2401/nRF2402/nRF24E1/nRF24E2 transmitt data at 1 Mbit/s or 250 kbit/s. The modulation is GFSK, deviation +/- 156 kHz, modulation bandwidth is less than 1 MHz (20 dB bandwidth). nRF2401/nRF2402/nRF24E1/nRF24E2 uses open-loop modulation. This means that there will not be PLL spurious in the transmitted spectrum.

Frequency stability given by crystal, specified to be less than +/- 30 ppm by Nordic Semiconductor.

For more information, please refer to nRF2401/nRF2402/nRF24E1/nRF24E2 Datasheet at http://www.nordicsemi.no

Best regards,
Nordic Semicondutor ASA

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