Discretely designed radio modules versus RFIC systems

During the last ten years, we have observed a steady trend in chip manufacturing towards one-chip transmitters/receivers and transceiver solutions in the LPD sector. In the meantime there are so many products on the market that only a few experts have an overview and know all the available products. For a design engineer, these RFIC solutions (Radio Frequency Integrated Circuit) are very attractive, because depending on the chip, only a few external components are required. This reduces the time to market.

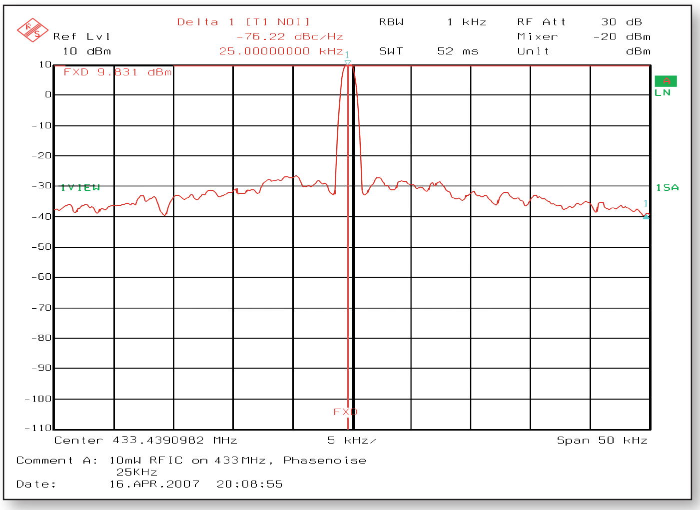

Fig. 1: 10 mW RFIC transmission spectrum at 433.4 MHz with a 50 kHz spacing

The chip industry has recognized the considerable market potential of these one-chip solutions. In the automotive sector, for example, one-chip solutions are indispensable due to their minimal space requirements for integration in car keys, and especially due to a drop in chip prices forced by immense competition for RFIC manufacturers. Depending on the quantity, properties and complexity of the RFIC components, prices range from € 0.50 up to approximately € 6.00. Apart from numerous wideband concepts which use cost-efficient crystals for frequency stabilisation, some manufacturers also offer narrowband systems with high receiver sensitivity.

As a manufacturer and distributor of radio systems we are often asked by our customers about the differences between our discretely designed products and RFIC solutions. Frequently, our customers notice the price difference between the discretely designed modules and RFIC modules. In this comparison, discrete narrowband solutions, due to their multitude of components used, do less well than RFIC solutions. In the practice, both versions are justifiable, depending on the potential application.

We analysed the characteristics of our discretely structured modules in laboratory tests and compared them to conventional RFIC solutions. Many RFIC transmitters show a typical transmission spectrum, demonstrated in Figures 1 and 3. Transmitter noise is -79 dBc/Hz with a 25 kHz spacing from the carrier. Here, the possible limitations of the application become evident, e.g. if a receiver is in the vicinity of such a transmitter, this device will “flood” it with noise. In the practical situation, this results in a marked reduction of the RFIC system range. For comparison, Figure 2 shows the transmission spectrum of a discretely designed CDP-TX-02E-R transmitter manufactured by Circuit Design. Many RFICs feature an integrated VCO without external frequency-determining components. In this case, the design engineer has more or less no freedom in influencing the phase noise of his synthesizer.

If we consider Figure 3, it becomes clear that, with a 250 kHz spacing, the RFIC transmitter measured, just about reaches the phase noise level of CDP-TX-02E-R when the frequencies are spaced 25 kHz (-108 dbc/Hz) apart. Especially in narrow band receivers, the phase noise of the mixing oscillator acts very nega-

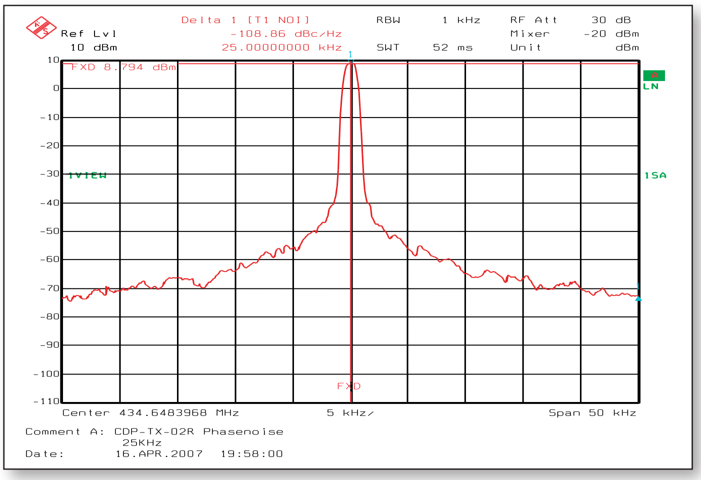

Fig. 2: Transmission spectrum/phase noise of a CDP-TX-02E-R transmitter in a discrete design at 433.65 MHz with a 50 kHz spacing

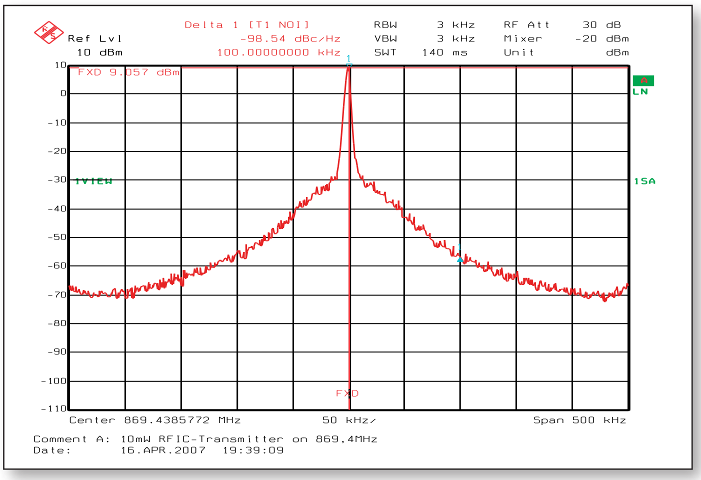

Figure 3: Phase noise of a RFIC transmitter with 10 mW at 433.4 MHz with a 500 kHz spacing

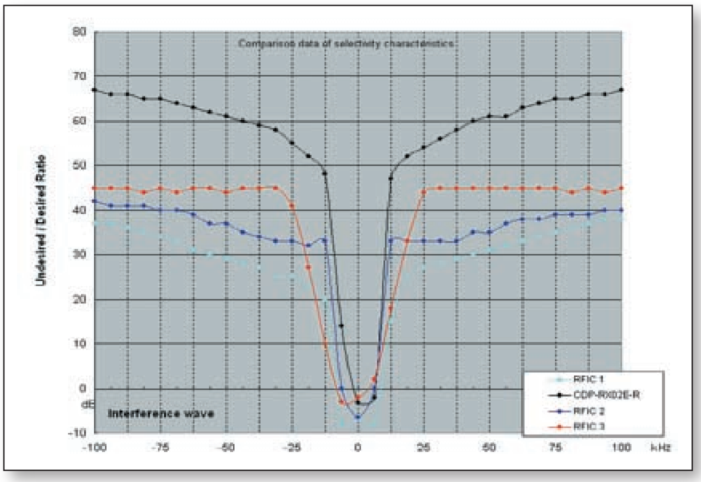

Fig. 4: Selectivity curves in comparison. All receivers were set to a bandwidth of 16 kHz.

tively on receiver selectivity due to reciprocal mixing. Figure 4 shows the difference between Ciruit Design's CDP-RX-02E-R and three different RFIC solutions. The superhet concept of CDP-RX-02R with filter phase at 21.7 MHz and 450 kHz contributes to the good receiver selectivity. Here it can be seen that as soon as several transmitters and receivers are working in a confined space, the application of RFIC systems becomes problematic. The range of such a transmission system, which might possibly reach up to one kilometre with a good RFIC, is drastically reduced to a few metres when another transmitter is activated close to the receiver. Within the ISM bands, it is to be expected that transmitters with a considerably higher transmission power are operated by other users at adjacent frequencies.

Cost-efficient RFIC systems can be utilised under the following conditions:

- low-level frequency band use in rural environments
- low requirements on availability
- relatively short distances
- larger spatial separation between transmitter and receiver
- application of intelligent radio protocols

Here, we only take the narrowband systems of the two groups into account. Cheaper broadband systems (in most cases equipped with super-regenerative receivers), frequently available in DIY superstores, yield even considerably worse results regarding receiver selectivity than cheaper RFIC solutions and should be used only if there is an adequate fall-back solution at hand (e.g. in the case of a controlled garden pump which can also be activated/deactivated manually). Otherwise it may happen that the equipment is no longer controllable because another radio application is suddenly using the same frequency. In the following list we summarise the essential advantages and disadvantages of discretely designed narrowband solutions:

Advantages:

- reduced transmitter noise
- higher receiver selectivity
- better blocking behaviour
- better intermodulation characteristics
- higher receiver sensitivity, higher range (several km using a transmission power level of 10 mW)
- frequently lower power consumption over the same range
- high transmission systemavailability

Disadvantages:

- higher costs
- sometimes larger dimensions

▶ *Circuit Design, www.circuitdesign.de*