White Paper

Benefits of DigitalTune™ Architecture

By Julian Hayes, VP of Marketing at Elonics Ltd

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Benefits of DigitalTune™ Architecture

Introduction to DigitalTune™

Mobile digital consumer devices from mobile phones to portable media players increasingly have to accommodate multiple radio frequency (RF) transceivers. For example, a state-of-the-art mobile phone might have as many as four or five radios, and even portable media players are beginning to contain multiple RF connection methods. Operators and broadcasters are exploring new ways to deliver content using a number of different video and radio broadcast standards and manufacturers are coming up with new ways to use existing services, for example using GPS co-ordinate data to provide location information alongside digital pictures.

With the number of radio standards seemingly increasing exponentially combined with the demand for portable devices to support more and more services, the problem is not going away. Semiconductor companies such as Elonics must mitigate the increases in cost, power consumption and PCB board area that arise from these pressures. Manufacturers are looking for them to come with innovative solutions to the problems that arise from these trends.

A single RF tuner that is capable of receiving signals ranging from low MHz to GHz clearly represents a move to solving some of the problems that must be tackled to achieve a commercially viable solution. Elonics DigitalTune™ is a patent pending radio frequency architecture that does exactly that; it enables designers to create a multi-band RF front end using a single monolithic CMOS IC.

Elonics DigitalTune™ digitally programmable multi-band architecture is used in the new E4000 tuner family to cover the complete spectrum from VHF to L Band (76MHz to 1.70GHz) for mobile broadcast applications. However, DigitalTune™ is a universal architecture and is capable of supporting other RF applications where re-configuration is highly desirable.

Traditional Radio Frequency Architectures

Each broadcast standard has traditionally been served by separate radio receivers comprising an RF tuner and a digital demodulator, see Figure 1. However as a result, multi-application devices require multiple receiver solutions, which would be acceptable if the consumer did not care about cost, size and power consumption. But they do, and as a consequence solutions need to be found that solve these issues.

Conventional tuners are inflexible. Designers have grown up building solutions that have been crafted and honed for the principle task of meeting the requirements of one specific standard. As a result, radio architectures have gone down an evolutionary path that makes them intrinsically inflexible and unable to meet the new challenges of today's multi-tasking and multi-standard consumer products.

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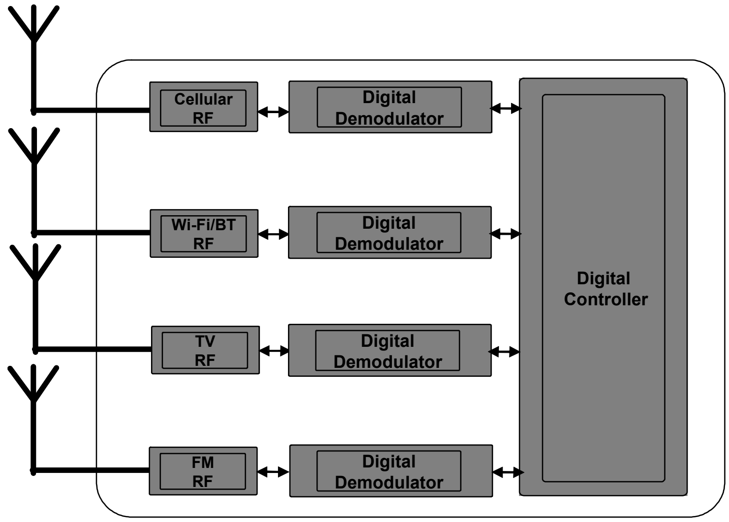

Figure 1: Traditional Radio Frequency Architecture

Elonics, without this historical baggage has had the opportunity to take a completely fresh look at architecting an RF tuner that is not only able to meet this challenge head on, but to do so without compromising the requirements of the consumer market; low cost, low power and small footprint.

Elonics New Radio Frequency Architecture

Portable devices that must support multiple RF standards are becoming increasingly common. Whilst the mobile phone is at the forefront of this trend, it is by no means the only product that must support a variety of RF standards. For example, portable media players that are capable of receiving broadcast TV are becoming commonplace.

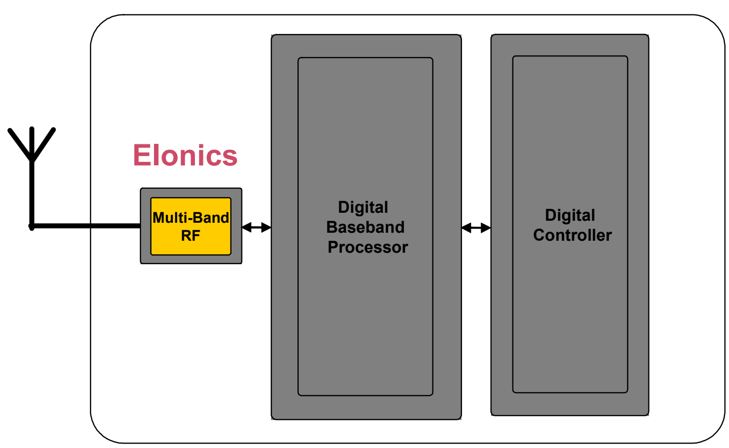

Figure 2: Elonics New Flexible Radio Frequency Architecture

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Given that it is now possible to use flexible digital baseband processors to digitally demodulate multiple different broadcast RF standards, the ideal companion is a single flexible RF tuner capable of supporting those same standards, as shown in Figure 2. The development of Elonics new flexible RF tuner is driven by the desire to create a solution that provides a number of key benefits for designers of consumer electronics.

The benefits of the Elonics solution are immediately apparent to anyone who is interested in implementing single function or multi-function RF tuner solutions. Whilst the CMOS implementation makes the Elonics E4000 very competitive when compared to conventional tuners, its true value is clearly highlighted in Figure 3 when more than one broadcast standard needs to be supported.

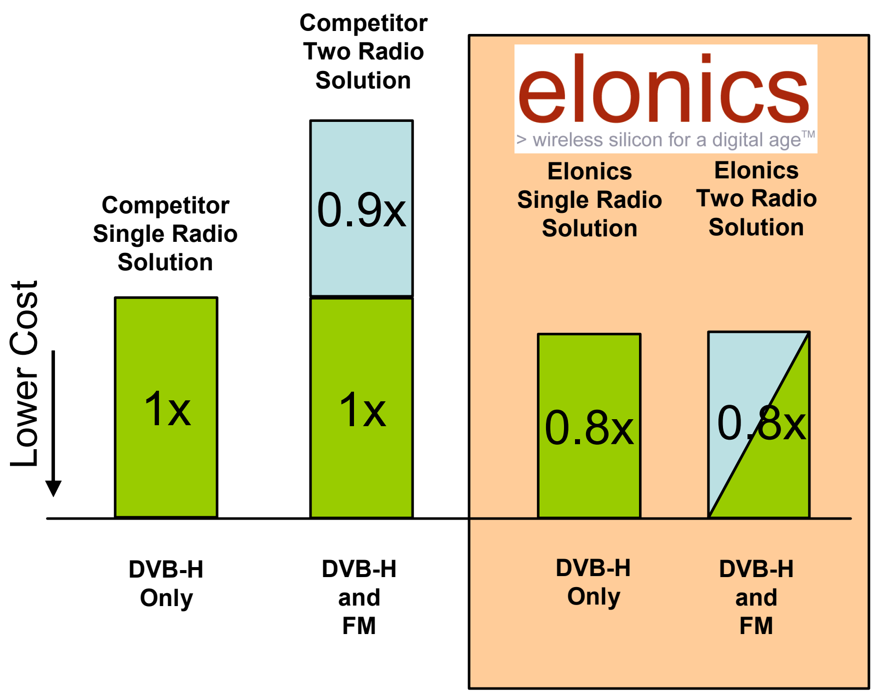

Figure 3: Benefits of Elonics New Flexible Radio Frequency Architecture

Summary of Benefits

- A single re-configurable RF tuner front end that covers the complete spectrum of broadcast frequencies
- Parametric performance comparable to single function tuners
- Low system power
- Small PCB footprint
- Few external components
- Low system cost

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The Elonics DigitalTune™ architecture revolves around the ability to optimize each part of the tuner signal chain from input to output. The value proposition is simple in concept. The tuner must be able to cover the complete frequency spectrum required by the product, and output the desired channel of interest all under control of the system controller. However, behind this apparently simple concept lies a hugely complex and challenging design problem. In order to provide such a solution, each stage in the RF tuner signal chain must be capable of being modified to optimize the signal path characteristics for downstream processing, dependent on the broadcast standard and the desired signal characteristics chosen by the system designer.

Figure 4 shows the internal block diagram of the E4000 multi-standard RF tuner. Although the signal path looks conventional, the E4000 using the DigitalTune™ architecture provides unique flexibility at each stage in the process from input to output.

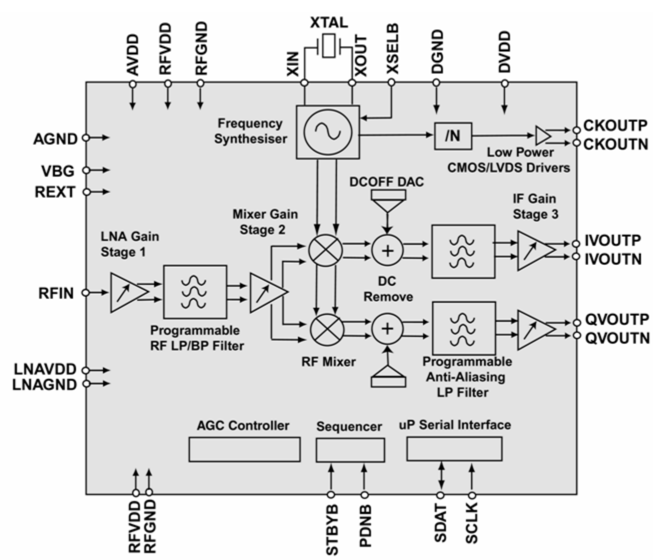

Figure 4: E4000 RF Tuner Block Diagram

The E4000 is a multi-band CMOS RF tuner packaged in a 32-lead QFN. Designed in CMOS, it is designed for the new generation of TV and radio services being beamed to portable digital consumer electronics.

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The Low Noise Amplifier (LNA)

A single input wideband low noise amplifier (LNA), which is able to receive signals over a very wide frequency range as shown in Figure 5 is the first part of the design.

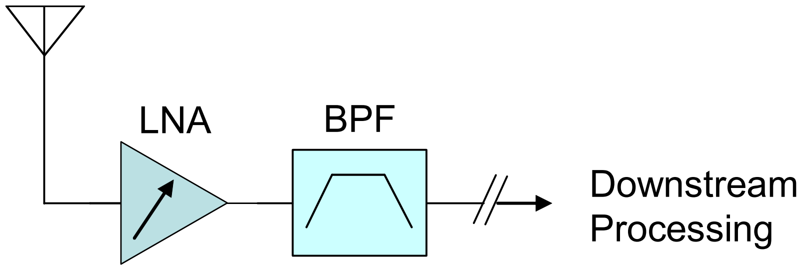

Figure 5: RF LNA and Filter

Conventional tuners as used to receive FM or DVB-H broadcasts typically have an LNA filter that is optimised for a specific frequency range. Whilst this approach is adequate for some applications, the user has little control over the signal path and the conventional architecture is clearly inadequate for multi-band tuner applications.

There are a number of approaches to solving these problems. The principle method is to implement multiple LNAs and RF filters specifically for each band of interest. Whilst solving part of the problem, there are a number of disadvantages for the designer of portable digital consumer electronics equipment. It consumes more power, increases the number of pins on the device and incurs a significant cost penalty.

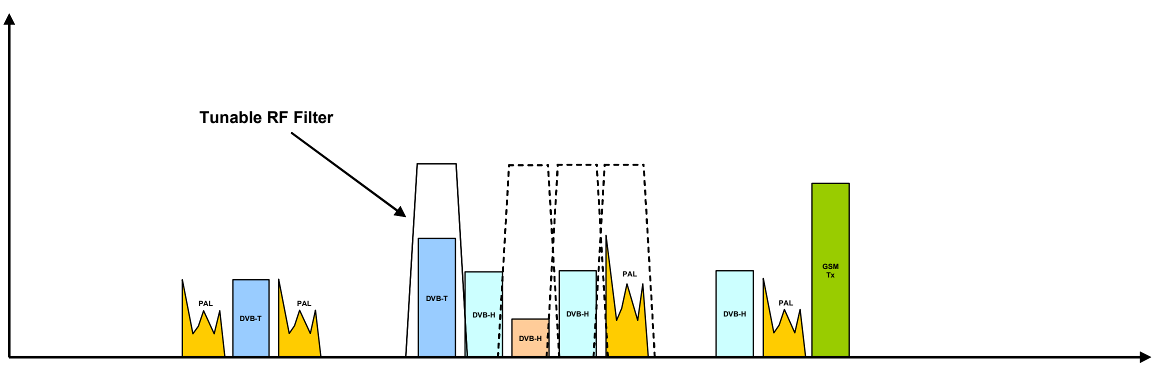

Figure 6: DigitalTune™ Tunable RF Filter

The Elonics DigitalTune™ architecture takes another approach. Firstly, there is a single patented LNA capable of accommodating multiple frequency bands. Secondly, there is a programmable RF bandpass filter as shown in Figure 6, which is capable of spanning the same frequency bands. Irrespective of the additional features of the Elonics LNA, this strategy saves device pins, reduces system power consumption and dramatically reduces silicon area. The tunable frequency response is particularly important in a wide band radio receiver as it allows significant attenuation of unwanted interferers before they enter the mixer.

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The LNA offers adjustable input impedance, programmable linearity and gain. Due to the wide signal power range, the input stage of the RF tuner must be able to have low noise performance when input signals are very low and yet maintain a high degree of linearity when the input signals are large. In the case when large input signals are present it is often desirable to increase power consumption or sacrifice noise performance for increased linearity. This programmable method of improving the LNA allows the designer to make the optimum trade-off between power consumption, the noise figure and linearity depending on the input signal characteristics.

The RF filter provides a tunable frequency response allowing the user to choose the type of filter (bandpass or lowpass), the filter bandwidth and the centre frequency under microprocessor control. This unprecedented level of flexibility makes it very easy for the receiver designer to optimise the parametric performance of their system whilst at the same time saving power, cost and PCB real estate.

Zero IF Architecture

A zero IF architecture is part of the DigitalTune™ concept. A homodyne or zero IF architecture as shown in Figure 7 employs a single stage to down convert the RF signal using a single sideband mixer to a baseband signal centred at DC. A subsequent low pass filter removes the higher frequency mixing products and attenuates unwanted out of band signals.

This filtered signal can then be digitised directly by a fast sampling ADC that has enough dynamic range to absorb both the wanted and unwanted signals. Final fine tune filtering can then be performed digitally.

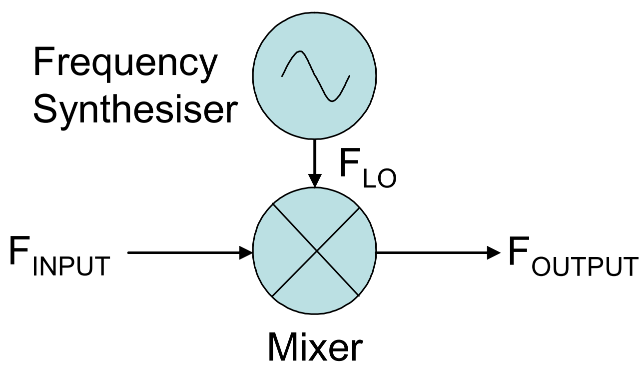

Figure 7: Zero IF Mixer Architecture

The mixer output contains the sum and difference of the input signal frequencies to the mixer.

$$F_{OUTPUT} = mF_{INPUT} \pm nF_{VCO}$$

The advantages of a zero IF architecture are numerous if the intrinsic problems can be overcome. There is no image because the signal is mixed to baseband, and therefore no image filter is needed. Because there is no intermediate IF stage, there is also no requirement for a bandpass IF filter. Finally power consumption is reduced, not only due to the simplification of the signal chain but also because the signal amplification is done at lower frequencies.

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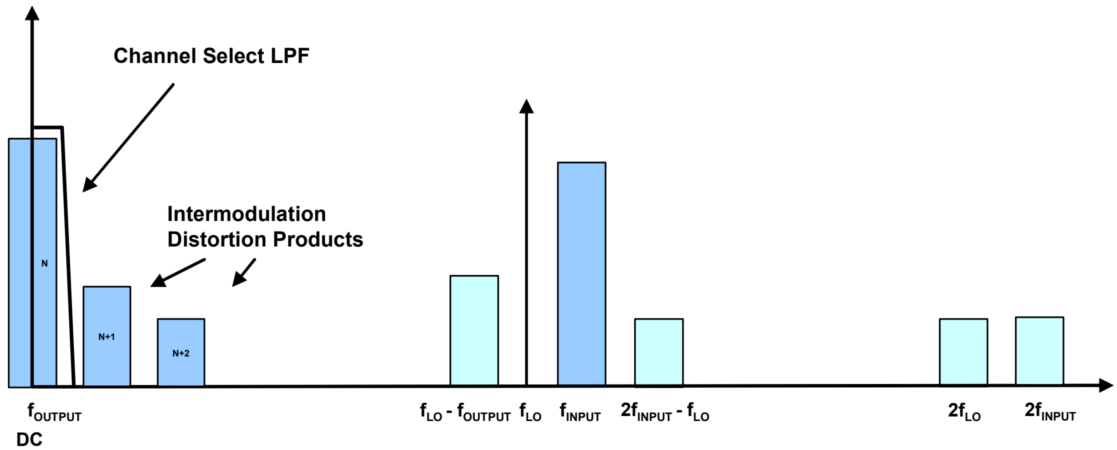

Figure 8: Mixer Output Spectrum

In practice as shown in Figure 8, there are also distortion products in the output spectrum due to LNA imperfections (for example intermodulation distortion, leakage across the mixer from the RF input to the output, leakage to the antenna that gets reflected back into the input and other self mixing effects. Good design and layout practice, circuit isolation and circuit implementation all combine to control these generic issues.

The zero IF architecture is deceptively simple. However, there are a number of issues that must be overcome, solutions for which are encompassed in the DigitalTune™ architecture. When the signal is mixed-down to baseband (DC), errors incurred in this process due to circuit component mismatches, amplifier non-linearities and other imperfections generate their own DC components.

DC output errors are a particular problem in zero IF systems, especially due to the very wide gain range over which the LNA must operate. It therefore becomes impossible to distinguish between these errors and the signal of interest. DigitalTune™ incorporates a number of DC correction schemes to minimise this problem. It allows the user to dynamically monitor the DC error and make corrections using the DC offset removal DAC. This process is undertaken independently of the gain setting, constantly tracking the DC error over the full range of signal values. DigitalTune™ also allows the user to override this autonomous operation and implement other DC offset control algorithms if needed.

The final stage of the DigitalTune™ architecture is automatic gain control (AGC). Prior to digitisation by the ADC, the signal needs to be adjusted to match the full scale input range of the ADC. This is required to maximise the dynamic range of the signal at the ADC input and reduce the burden on the digital demodulator.

The output AGC has a number of modes that provide the user with the maximum degree of flexibility. The AGC can be run fully autonomously, with the user selecting from a number of pre-programmed options. Alternatively, the AGC can be integrated into a baseband processor control loop.

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Summary of DigitalTune™ Benefits

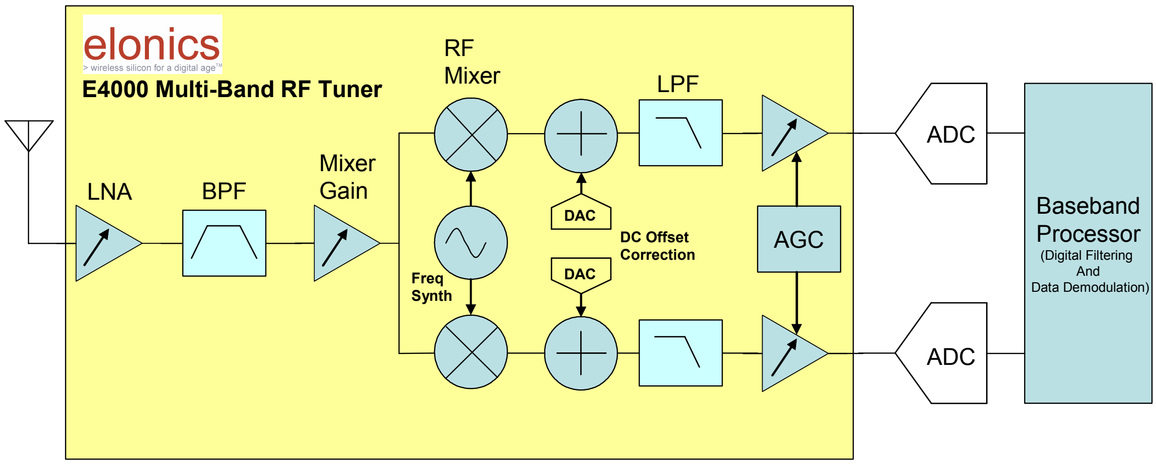

Figure 9: Multi-Band Radio Receiver Solution

The Fundamental Tenets of the DigitalTune™ Architecture

- ***Flexible Re-Configuration***
- ***Intelligent Parametric Control of all Signal Processing Blocks***
- ***Autonomous System Operation***

The DigitalTune™ concept shown in Figure 9 is an integral part of the evolution in radio receiver design. As discussed previously, radio receivers were traditionally designed to accommodate one particular broadcast standard. The demand for smaller, lighter, cheaper and lower power consumer electronics has spurred on the development of new architectures that meet the challenge face on. Data demodulation is increasingly being undertaken inside ever more powerful baseband processors in the digital domain, and this trend has been supported by the creation of architectures like Elonics DigitalTune™ that provide equal flexibility in the analogue domain; providing better performance, lower power, smaller size and lower cost.

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Figures

Author Biography

Julian Hayes is vice president of marketing at Elonics. He joined Elonics following a nine year period at Wolfson Semiconductor where he held the position of vice-president of marketing, heading up the company's global marketing team. In this role he was responsible for the development of the company's strategy for the audio industry. Prior to joining Wolfson, he worked at Analog Devices in a number of sales and marketing positions.

About Elonics - "Wireless Silicon for a Digital Age"

Elonics Ltd. is a fabless mixed-signal semiconductor company specialising in the design and development of multi-band radio frequency (RF) IC products. Founded in 2003 and based in Livingston, United Kingdom, Elonics has developed an innovative radio frequency architecture called DigitalTune™ that is the foundation for a family of re-configurable CMOS RF front end products.

Elonics innovative technology allows manufacturers to design high performance multi-band radio transceivers with unrivalled power consumption and low system cost. Elonics products are targeted at high volume portable consumer electronics applications that require wireless multi-media connectivity where size, performance, price and power consumption are paramount.

Elonics' first product family is the E4000 series of silicon tuner solutions targeted at the reception of multi-standard digital TV and radio including DVB-T, ISDB-T, T-DMB, DVB-H, ISDB-H, DMB-T, DAB and FM radio. Elonics secured £2M ($4M) Series A funding in February 2008. Key investors include Braveheart Investment Group, Scottish Venture Fund and a number of private investors including Brian Souter and Sir Tom Farmer.

About DigitalTune™

Elonics DigitalTune™ is a patent pending radio frequency architecture that enables the design of multi-band RF front ends using a single monolithic CMOS IC. The digitally programmable multi-band architecture is used in the E4000 tuner family to cover the complete spectrum from VHF 2 to L Band (76MHz to 1.70GHz) for mobile broadcast applications. DigitalTune™ is a universal architecture, and is capable of supporting other RF applications where re-configuration is highly desirable.

The direct conversion zero IF architecture is designed to save power and lower system cost. It eliminates the requirement for expensive and bulky external components such as SAW filters and RF baluns, yet offers extremely high performance. Elonics innovative DigitalTune™ architecture enables manufacturers to significantly improve upon today's solutions offering support for multiple standards with a common re-configurable RF front end.

Website: www.elonics.com

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