DESIGN SOLUTIONS

AUTOMOTIVE

Choose a Flexible and Scalable Front-End Tuner for Your Software Defined Radio

Introduction

Traditional radio receivers integrate a front-end tuner with a baseband processor, hardwired to one specific radio standard. This means that there are as many radio receiver chips as there are standards. In contrast, Software Defined Radio (SDR) architectures perform the baseband processing using software, enabling reception of a wide range of radio standards with a single radio platform, as required in the smart multimedia system of Figure 1.

This article discusses different ways to handle the SDR baseband processing and proposes a cost effective, flexible, and scalable implementation that best actualizes the potential of SDR.

Figure 1. Smart Multimedia Touchscreen System for Automobile

The Radio Receiver

Figure 2 illustrates the block diagram of a typical radio receiver. The front-end section amplifies (via the LNA) and downconverts (with the mixer) the signal from the antenna. The signal is filtered and then digitized, after which it is digitally processed for optimal signal quality and demodulator efficiency. The conditioned signal is then demodulated, and the demodulator's audio output is routed to the audio output of the radio.

Software Defined Radio (SDR)

As shown in Figure 2, all post ADC signal processing may be implemented via an SDR approach. For optimal efficiency and simplified design, some of the functions may be implemented in hardware in the front-end. This is especially true of wide bandwidth signal processing that may be easier to realize in hardware. In addition, decimation, which reduces the bandwidth of the interface between the front-end device and the SDR processor, can be implemented in the front-end to simplify the interface. In this case, any signal processing realized in the front-end must be sufficiently adaptable to avoid compromising the flexibility of the SDR backend.

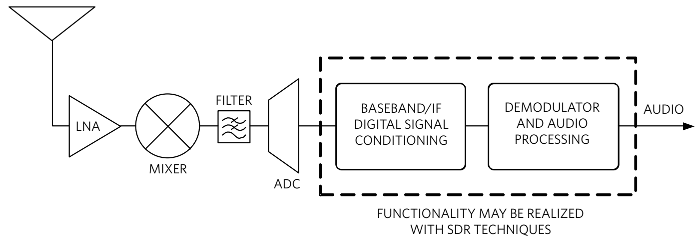

Figure 2. Typical Radio Receiver

In an ideal SDR implementation, any signal processing uniquely related to a particular standard should be implemented using SDR techniques. This enables a single radio front-end to be used with numerous broadcast standards through the SDR software.

Heavy Integration Approach to SDR

Although the baseband processing may be implemented in software with SDR, the software still needs to run on some hardware platform. One implementation, outlined in Figure 3, places two baseband signal processing cores on the same chip, each with its own front-end, to handle AM and FM. This architecture does not fully lend itself to the SDR strategy, since more standards exist. The demodulation algorithm is also hardwired inside the baseband signal processing section, hence there is no possibility for adapting to a variety of techniques and evolving standards as desired for an ideal SDR.

World Band Radio

In order to fully achieve the flexibility envisioned by SDR, a more flexible architecture is needed. A stand-alone front-end tuner

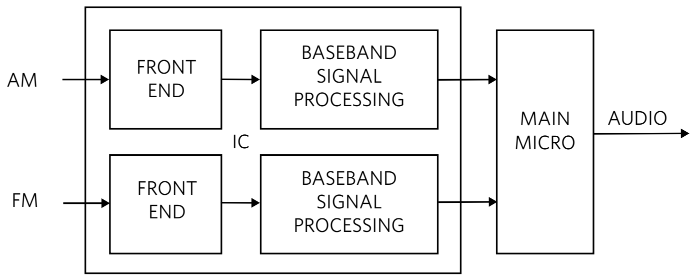

Figure 3. Highly Integrated Approach to SDR

capable of implementing all primary analog and digital radio standards (Table 1), dubbed World Band Radio (WBR), has been proposed by Maxim Integrated. This flexible tuner, paired with an SDR backend, enables a single radio platform to receive all global radio standards.

ANALOG	AM
	FM
DIGITAL	DAB (EU)
	DRM (INDIA)
	HD (US)
	DMB

Table 1. Radio Standards

The advent of powerful multicore processors has enabled this approach to SDR. With a multicore processor, the software flexibility required by SDR can be pushed inside the main application processor, where one core can be dedicated to each standard. This simplifies the radio design and reduces cost by more efficiently utilizing the multicore application processor already present in the system.

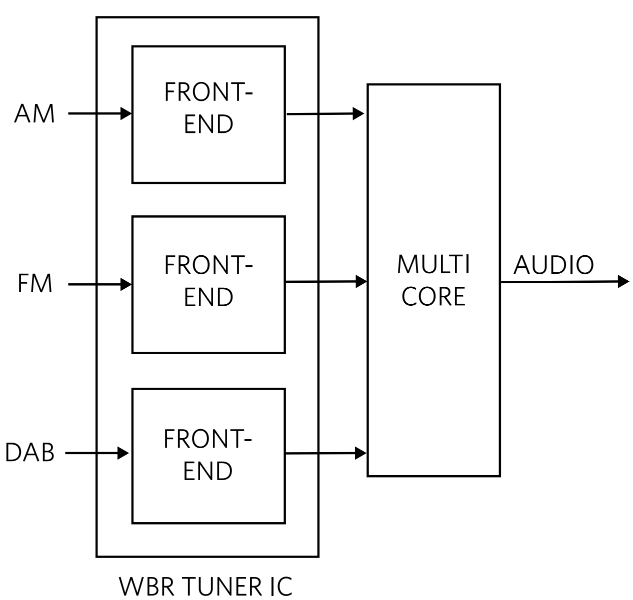

Figure 4. World Band Radio IC

Flexibility and Scalability

The proposed WBR architecture makes a true SDR possible and is highly flexible and scalable. In the example below (Figure 5) a typical car radio employs three WBR tuner integrated circuits (ICs): one for the main station, one for background scan (searching for alternate frequencies), and one for phase diversity.

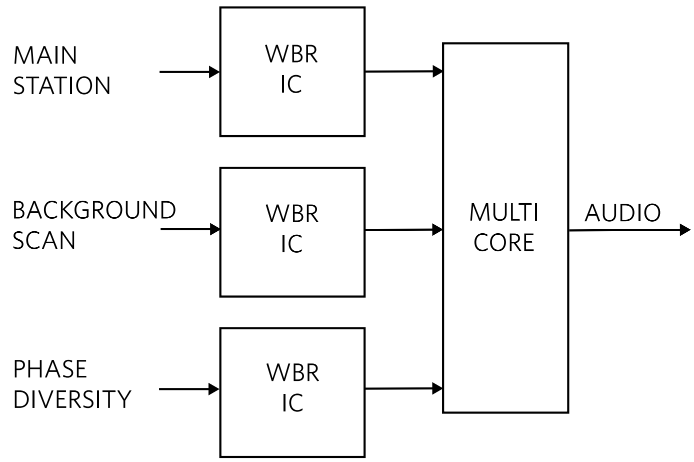

Figure 5. WBR Scalable Architecture

MAX2175 World Band Radio Receiver

The MAX2175 IC is an advanced RF to Bits® automotive radio tuner. This highly integrated tuner uses direct conversion for digital audio broadcast (DAB) and digital multimedia broadcast (DMB) applications, covering VHF Band-III and L-Band. Reception of FM, DRM+, FM-HD, and Weather-Band is supported using a Low-IF and digital conversion to baseband. AM (LW, MW, and SW) and DRM reception is supported using direct sampling and digital conversion to baseband (Figure 6).

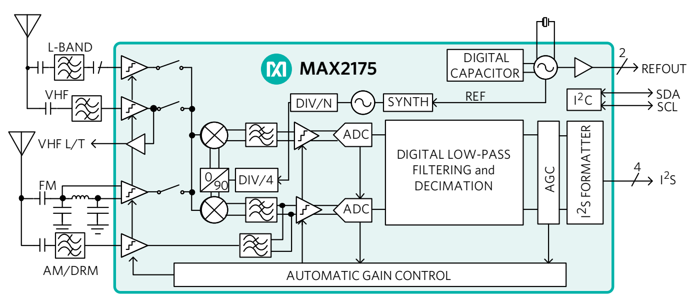

Figure 6. MAX2175 World Band Radio Receiver

The MAX2175 provides a buffered differential output of the reference frequency to support multi-tuner systems. The design integrates all key blocks, enabling low-power, tuner-on-board designs with advanced baseband solutions. The tuner includes digital filtering to minimize the MIPS required in the baseband processor to demodulate the desired channel. The resulting I-channel and Q-channel data words are transferred to the baseband via an industry standard I²S digital interface. The MAX2175 IC is available in a 48-pin TQFN package (7mm × 7mm) with an exposed pad. Electrical performance is guaranteed over the extended -40°C to +85°C temperature range.

Conclusion

We have reviewed, at a high level the ideal software defined radio architecture. We discussed the system partitioning steps necessary to enable software control of the baseband signal processing, such that a wide range of radio standards can be received by a single radio platform.

We looked at a highly integrated solution which handles two standards, each with its own baseband processor and front-end. We found that this solution lacks the flexibility needed to fully implement SDR. The MAX2175, Maxim Integrated's World Band Radio receiver, was presented as a superior alternative. This advanced RF to Bits® automotive radio tuner enables the most flexible and scalable SDR implementation and reduces cost, by more efficiently utilizing the multicore application processor.

Learn more:

MAX2175 RF to Bits® Automotive Radio Tuner

AM: Amplitude Modulation

Band-III: VHF Frequency Band Typically used for DAB Broadcast

BASEBAND: Frequency Domain of signals after downconversion in tuner. SDR signal processing is primarily realized in the baseband domain.

DAB: Digital Audio Broadcast. A digital radio technology for broadcasting radio stations, used in several countries across Europe and Asia Pacific.

DAB+: An upgraded version of DAB.

DECIMATION: Reduction of a signal sampling rate by filtering to mitigate aliasing distortion due to simple down-sampling of a signal. Complementary to interpolation, which increases sampling rate.

DMB: Digital Multimedia Broadcast

DRM: Digital Radio Mondiale (India)

DRM+: DRM standard when used in the VHF frequencies.

FM: Frequency Modulation

HD: The US digital audio standard.

IF: Intermediate Frequency

L-Band: Higher frequency DAB broadcast band.

LNA: Low-Noise Amplifier

LW: Long Wave

MIPS: Million Instructions per Second

MW: Medium Wave

PHASE DIVERSITY: Robust reception implemented with multiple antennas receiving the same signal.

SDR: Software Defined Radio

SW: Short Wave

TUNER: A device that receives radio frequency (RF) transmissions and downconverts them into an intermediate frequency (IF) ready for demodulation.

VHF: Very High Frequency

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