Miniaturized Receiver Modules for Wireless Communications

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WIRELESS TRENDS & RECEIVER DESIGN

Change drives wireless growth, bringing new challenges to receiver designers:

- **Standards.** The goal of "communications anywhere, anytime" is driving multi-lband multi-mode phone development, adding new complexity to receiver design. Different standards require separate IF filters bandwidths (30kHz for TDMA, 200kHz for GSM and 1.25MHz for CDMA) and dynamic range tradeoffs.

- **Time-to-Market.** Competition and technology are interdependent factors contributing heavily to the growth of mobile telephony. Phone models often run for only 15 to 18 months, being replaced with upgraded designs. Changing requirements demand short product development cycles.

- **Features.** Value-added services such as messaging (voice mail, fax, e-mail), paging, security, and Web browsing are blurring the line between mobile phones and wireless modem-equipped products like notebooks, Personal Digital Assistants, and handheld PC's. Typically implemented in the digital baseband section of the radio, these features compete with the RF section for precious board space.

- **Physical Size.** The 700 gram/40 minute talk-time handsets of the mid-80's have been replaced by models that are one quarter the size, 30% lighter, and have double the talk-time. Even after human physiology becomes the limiting factor in phone size, features and new applications will always place pressure on board real estate.

- **Cost.** Mobile phone prices continue to fall ~15% per year so a 1998 handset sells for 40% of what it did in 1993.

INTEGRATION OF FUNCTIONS

Integration of functions continues to be the best path for dealing with these challenges. One approach has been to work from the baseband portion of the receiver and try to integrate toward the front-end functions, trying to replace components with DSP. Simultaneously meeting dynamic range and selectivity performance presently limits the effectiveness of this approach.

The alternative is to integrate from the front-end towards the baseband function, providing receiver modules that combine the best performing consumer electronics front-end technologies (GaAs receiver IC's and SAW filters) and optimize the overall performance.

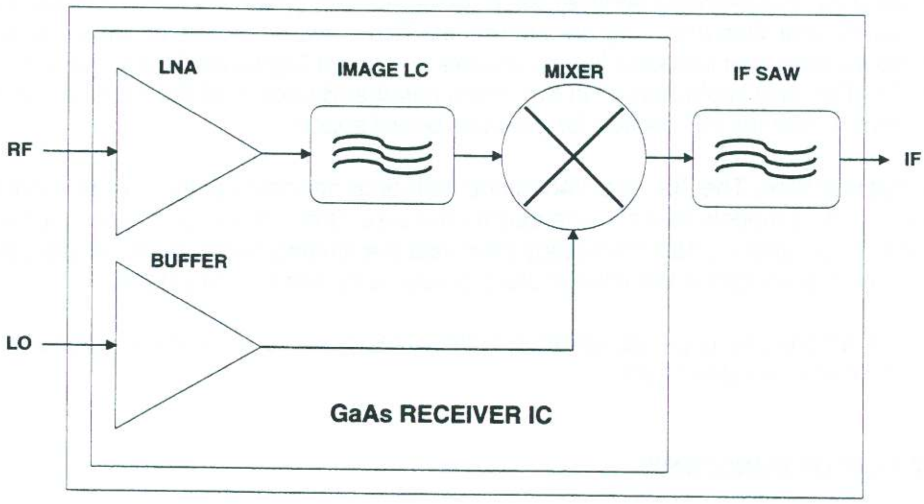
RECEIVER MODULES

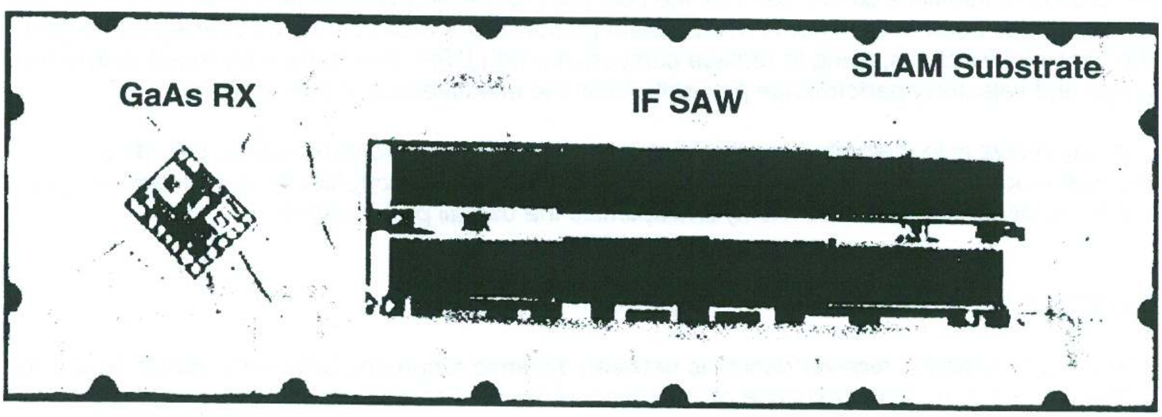
The critical tradeoff in receiver design is between dynamic range and selectivity. Better selectivity in filters is achieved at the expense of insertion loss and in-band phase performance. Higher insertion loss requires more gain to maintain noise performance, which raises the input intercept requirements for the active circuits. The situation is made more difficult for PCS/DCS applications, where parasitic capacitance becomes the dominant loss mechanism.

GaAs receiver IC's provide low noise figure, high gain, and excellent input intermodulation distortion intercept points in all cellular bands. The semi-insulating substrate greatly reduces lossy parasitic capacitances. GaAs is well-suited for applications such as TDMA and CDMA systems where higher linearity is required due to system requirements imposing hardware tradeoffs. As metropolitan cellular system traffic increases, a higher importance must be placed on linearity to handle strong interferers.

SAW filters provide exceptional performance characteristics compared to LC and dielectric filters. Proximity resonator designs may have 0.05% fractional bandwidths with less than 100ppm center frequency drift over temperature, making them well-suited for TDMA applications. Transversal filter designs offer very good control of passband and group delay ripple over wider bandwidths, matching requirements of CMDA applications. IF processing may augment filter selectivity, but dynamic range issues prevent replacement of frontend filters.

An example of a receiver module is shown below. It consists of a singleband GaAs receiver die with an on-chip image filter and an IF SAW filter. The module is 5mm x 15mm x 2mm, only 30% longer than a conventional SAW filter package. Performance characteristics are given below.





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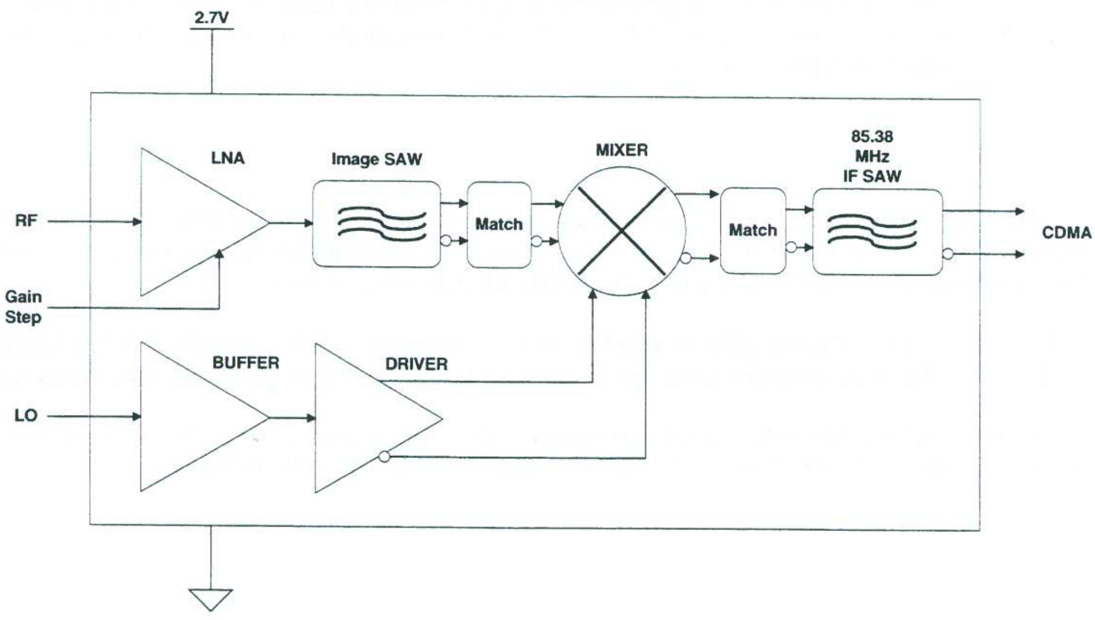
Parameter		Measured	Units
Frequency Range	RF	869.952	MHz
	LO	894.977	
	IF	83.160	
Conversion Gain		15 min	dB
Rejection	LO-IF	-40	dBc
	LO-RF	-20	
	RF-IF	-50	
	Image	-10	
IIP3		-10	dBm
Half IF IP		+10	dBm
IF Output			
	3dB Bandwidth	30 min	kHz
	Ripple	1.0 Max	dB
	Group del. Var	10 max	us
	30kHz reject	9 min	dBc
	60kHz reject	30 min	dBc
	120kHz reject	53 min	dBc
DC Current @ 5V		15 max	mA

An example of a CDMA module is shown below. This module incorporates both the image and IF filters along with a double balanced mixer architecture. This provides better common-mode rejection to other signals in the phone, as well as reducing LO leakages from the receiver.



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RECEIVER MODULE STRATEGIC ADVANTAGES

Application Specific Designs

Receiver modules are an enabling technology for new applications. Dualband architectures including LNA bypassing, IF switching, and filtering functions can be incorporated into a unique application-specific module design. Custom modules provide a significant barrier to "diffusion" of intellectual property.

Combining both active and passives in the same module allows the optimizations between performance characteristics such as gain, linearity, and filter insertion loss. A custom design also gives the radio designer more flexibility in the radio frequency plan since the center frequency of the IF filter (as well as it's characteristics) can be moved to non-standard IF frequencies.

Time to Market

Short design cycles are characteristic of a strong, emerging market. Receiver modules shrink the design cycle:

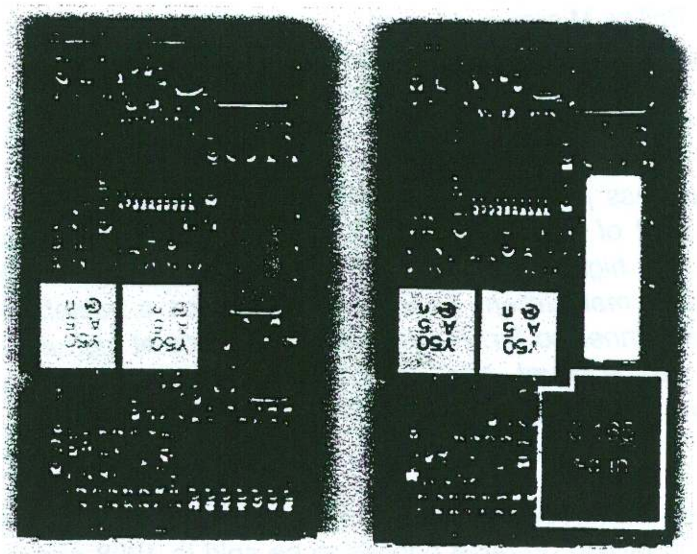
- RF receiver design expertise is embodied in a highly integrated module, shortening the learning curve for new phone designs as well as providing an opportunity for design re-use.
- Interfaces are removed from the board level, so less time is spent matching between components.
- Having fewer components reduces board layout issues such as parasitics and isolation. This greatly improves the probability of first pass success in the layout.
- With fewer layout issues, there is greater correspondence between prototype and radio board performance.

Cost

Receiver modules leverage on the higher package costs required for SAW filters by adding more functionality within the same size package. As a result, the module can be very competitive with other solutions, allowing the designer to meet difficult product cost targets.

Development costs are drastically reduced by ease of integration of the module with the rest of the radio. The reduced time-to-market translates to a substantial savings in lost opportunity costs.

Finally, the switching costs from another solution to the module are minimal. Receiver modules can be mounted from tape & reel with the same equipment used for SAW filters.



Board Space

The photo illustrates the space savings that can be achieved with a receiver module. The board section on the left is an AMPS receiver, utilizing a GaAs receiver IC, a SAW image filter, and a SAW IF filter for the front-end. The receiver module on the right integrates these front-end functions, freeing 0.165 square inches of board space for other use.

Manufacturability

Lowered component count improves the manufacturability of the radio from both a reliability and logistics standpoint. Incoming inspections are reduced as well as assembly issues.

GOALS

The goal for receiver modules is to provide:

- High-performance dualband front-ends
- Low cost
- No external components
- Simple interfacing (RF-in, IF-out, and power)