S+M Siemens Matsushita Components

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Cordless phones:

No strings attached with SAW filters

Manufacturers of cordless telephones supply both the mass market with economy versions and the professional sector with high-performance models. With a wide range of types in various packages for both RF and IF stages, Siemens Matsushita Components offers the right SAW filter for every cordless application.

Cordless telephones such as the Siemens Gigaset can be produced more economically thanks to SAW filters

Established analog cordless telephone systems transmit and receive at frequencies in the 900 MHz range (**Table 1**) using a bandwidth of 1 MHz (CT1) to 4 MHz (CT2). They currently account for the largest share of the market and are available in various quality and price classes. New, digital systems in the 1.9 GHz range require higher capacity and therefore operate with about 20 MHz of bandwidth. In digital systems, DECT (Digital European Cordless Telephone) and PHS (Personal Handyphone Service) are enjoying the highest growth rates. DECT is most popular in Europe, PHS in Japan. In the Asian countries, there is fierce competition between the two systems, and PHS is currently gaining an edge over DECT thanks to its greater versatility, e.g. in integrated Telepoint applications.

An interesting new development in the United States is the cordless ISM (Industrial Scientific Medical) standard. ISM permits free selection of receive and transmit frequencies as well as of digital or analog transmission mode within the 26 MHz of bandwidth available. In addition to the usual multiple access procedures TDMA (Time Division Multiple Access) and FDMA (Frequency Division Multiple Access), efforts are being made to exploit the benefits of CDMA (Code Division Multiple Access). In the latter, the bit sequence to be transmitted is multiplied by a code so that the transmit signal is spread across a bandwidth of 1.2 MHz. CMDA thus permits more efficient utilization of bandwidth, so that the number of users can ultimately be increased.

System architecture of the receiver

The RF stage of a tuner (**Fig. 1**) for cordless telephones consists of a receive and a transmit path following the antenna and duplexer. After passing through filter and amplifier stages, the signal received by the antenna is mixed down to the baseband for demodulation. A front-end filter suppresses the noise and all interference outside the receive band, including the strong transmit signal, to prevent overdriving the preamplifier (LNA). Interference, especially at the image frequency, is attenuated by an interstage filter. At the intermediate frequency, interference from adjacent channels caused by other users of the same communication

Table 1 Frequency ranges of cordless systems

Standard	Transmit band	Receive band	Bandwidth	Channel width	Mode
CT1	914 to 915 MHz	959 to 960 MHz	1 MHz	25 kHz	Analog
CT1+	885 to 887 MHz	930 to 932 MHz	2 MHz	25 kHz	Analog
CT2	864 to 868 MHz		4 MHz	100 kHz	Digital
CT ISM	902 to 928 MHz		26 MHz		Analog/digital
DECT	1880 to 1900 MHz		20 MHz	1.2 MHz	Digital
PHS	1895 to 1918 MHz		23 MHz	220 kHz	Digital

system must be removed from the signal. This is done by the IF filter, which must consequently have high adjacent channel selectivity at a low bandwidth as well as high linearity.

In the transmit path, the signal is mixed up, filtered and raised to the required output level by a power amplifier (PA). Cordless telephones operate with output powers in the region of 12 dBm for CT1 and CT1+, and up to 14 dBm for ISM systems. An output power of 14 dBm leads to a power tolerance of 17.5 dBm with an insertion loss of 3.5 dB in the RF filter. A high-power SAW filter has been developed for this application. It is designed for a power tolerance up to 20 dBm. The transmit front-end filter attenuates the noise and the strong nonlinearities in the receive band which occur in the power amplifier and mixer. The transmit interstage filter suppresses the noise before the signal reaches the power amplifier.

Cutting cordless costs with RF SAW filters

To ensure high transmission quality, the analog standards CT1 and CT1+ (**Fig. 2**) call for high adjacent channel suppression as well as image frequency selectivity of about 80 dB. As such high selectivity cannot be obtained with a single filter, two filters must be connected in series. In the past, microwave ceramic filters were used in the front end and interstage for this purpose. But their moderate adjacent channel selectivity requires a higher first IF of 50 MHz or higher. The quartz filters available for these frequencies are not only relatively expensive, but also require costly manual tuning when cascaded.

With a selectivity of 45 dB – both for attenuation of the local oscillator and selection of the image frequency – the SAW filter has a definite edge here (**Table 2**). Another decisive factor is the low insertion loss of typically 3.5 dB, which improves the signal-to-noise ratio. Thanks to its extremely steep edges, the filter attains the high adjacent channel selectivity required. This allows the first IF to be reduced to 21.4 MHz. For this range, low-cost quartz filters are available, which can also be used for channel selection.

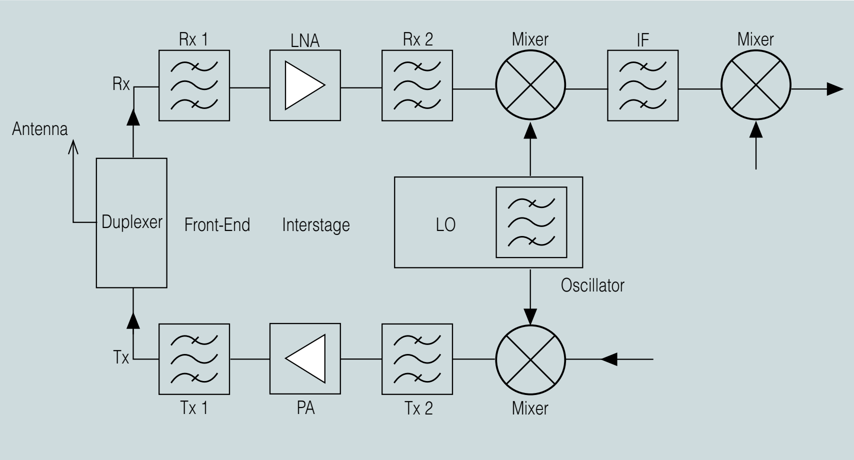


Fig. 1 RF stage of a tuner for cordless phones

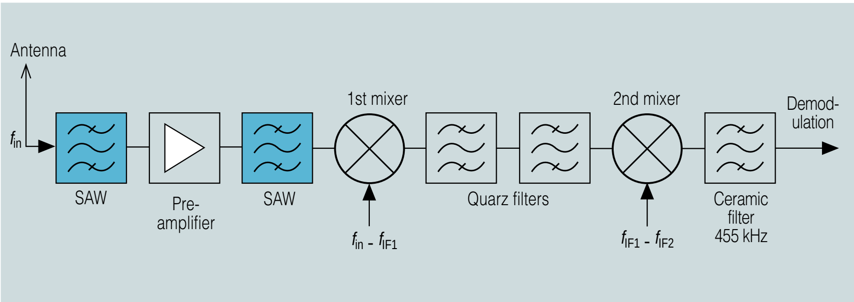
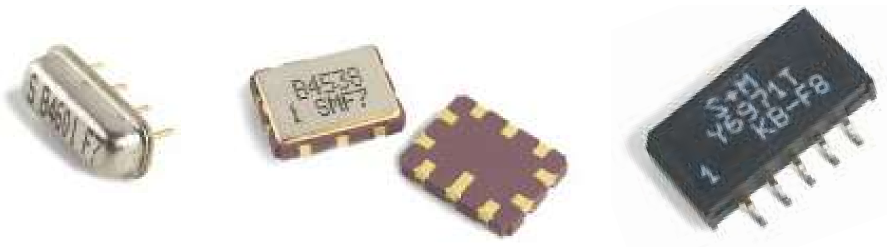


Fig. 2 CT1+ receiver (double superheterodyne)



Using SAW filters for the RF stage thus cuts costs for the overall receiver. What's more, SAW filters take up less space than microwave ceramic components.

To cover all requirements, SAW filter types are available for standard 150 Ω impedance matching as well as for self-matching to 50 Ω typical of CT1 and CT1+ systems.

Table 2 Comparison of SAW and microwave ceramic filters for RF stages

	SAW	Ceramic (2-pole)	Ceramic (3-pole)
Maximum insertion loss in passband	3.5 dB	3.0 dB	5.3 dB
Amplitude ripple	1.0 dB	0.5dB	0.5 dB
Selectivity at ± 21.4 MHz	45 dB	17 dB	31 dB
Selectivity at ± 42.8 MHz	45 dB	26 dB	45 dB
Dimensions in mm	10.9 × 4.4 × 3	10.2 × 8 × 3.75	12 × 15 × 4.5
Self-matching to 50 Ω	yes	yes	yes

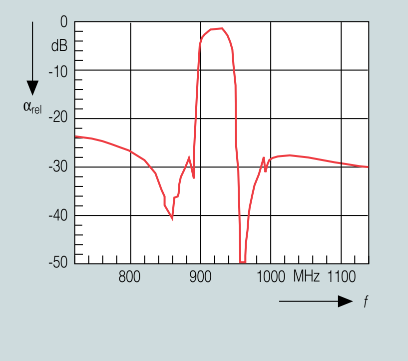


Fig. 3 Frequency characteristic of a SAW filter for the broadband digital cordless standard

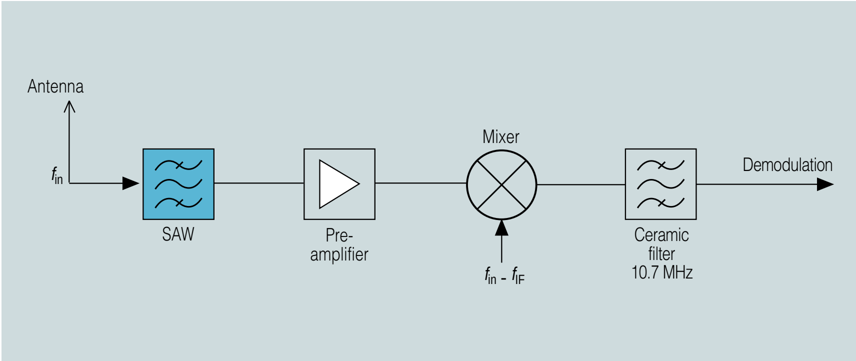


Fig. 4 Superheterodyne receiver for narrowband digital cordless phones

Special SAW filters for digital systems

Digital cordless systems operating in the 900 MHz can be divided into narrowband and broadband systems. In the ISM system with its bandwidth of 26 MHz, there is a narrowband CT system with an RF bandwidth of 2.7 MHz, which operates as a digital system based on TDMA. The duplex procedure used is FDD (Frequency Division Duplexing) with center frequencies of 926.5 and 914.5 MHz for the receive and transmit bands respectively. The broadband version with 26 MHz of RF bandwidth operates with the CDMA multiple-access procedure and is part of the spread spectrum concept.

The receive paths of analog and digital cordless systems are designed differently because of their different requirements in terms of selectivity and adjacent channel suppression. This can be illustrated by the frequency characteristic of a SAW filter for the ISM broadband digital cordless standard (**Fig. 3**). This filter is designed for a center frequency of 915 MHz and bandwidth of 25 MHz. Minimum insertion loss and ripple in the passband each have a typical value of 1.0 dB. If a steep-edged SAW filter is used in the broadband ISM system, the pager band from 929 to 931 MHz immediately above the ISM band can be adequately suppressed.

Used in digital narrowband systems, SAW filters help to simplify receiver design drastically. This trend is also supported by developments in the semiconductor sector. Here low-cost demodulators with more than 10.7 MHz of bandwidth are now available. The high bandwidth of the demodulator and the high adjacent channel selectivity of the RF SAW filter support a receiver architecture with only one IF filter (**Fig. 4**). The input signal is initially filtered by the SAW filter with an image frequency suppression of 45 dB – which is quite adequate for this application – and is subsequently mixed down to 10.7 MHz. After channel filtering with a ceramic filter, the signal is demodulated. This receiver architecture reduces the component count and thus space requirements. It also slashes costs for the overall tuner.

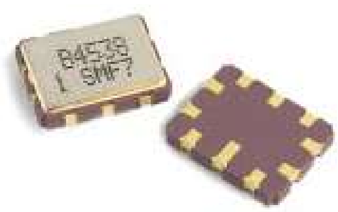


Table 3 Key data of SAW filters for DECT IF stages

Filter	Package	Center frequency	Insertion loss typical	Group delay	Remarks
B4535	DCC14	110.59 MHz	3.0 dB	500 ns	High-performance
B4536	DCC14	112.32 MHz	3.0 dB	500 ns	High-performance
B4538	QCC10	110.59 MHz	8.0 dB	200 ns	High-performance
Y6971T	SIP5K	110.59 MHz	11.3 dB	150 ns [1])	Economy
Y6972T	SIP5K	112.32 MHz	11.5 dB	150 ns [1])	Economy
Y6930T	SIP5K	110.59 MHz	11.4 dB	200 ns [1])	Temperature-stable
Y6932T	SIP5K	112.32 MHz	12.5 dB	120 ns [1])	Temperature-stable

[1]) Group delay at mismatch

Three-port duplexers save board space

Duplexers have different filter requirements, depending on whether TDD (Time Division Duplexing) or FDD (Frequency Division Duplexing) is used. The FDD system requires two front-end filters because it transmits and receives in different frequency bands. In this case, the duplexer consists of a passive matching network of λ4 microstrip lines or of discrete reactive components. In TDD, transmission and reception take place in different time slots, but the same frequency bands. The duplexer design usually comprises a simple pin diode for switching and a front-end filter.

Siemens Matsushita Components is currently developing a new concept: a three-port duplexer for CT1+ which combines the two front-end filters and the required matching circuit in a single component. This duplexer will be available in a hermetically sealed QCC8B ceramic package measuring 3.8 × 3.8 mm and offer an alternative to conventional designs. The experience gained with this duplexer for CT1+ will go into development of a three-port duplexer with FDD for ISM, where the 22.5 MHz duplex spacing calls for a transmit filter with steep edges (**Fig. 5**). The reduced component count also saves space and weight on the tuner board, thus cutting costs for the cordless phone as a whole.

SAW filters for 2 GHz in submicron technology

The DECT standard in the frequency band from 1880 to 1900 MHz describes ten frequency channels in the TDD-TDMA time multiplex procedure. Microwave ceramic filters meeting this standard are currently being used for the RF stage. Siemens Matsushita Components is also developing SAW filters for this frequency range which require finger widths of about 0.5 µm due to the high frequency. New machinery at Siemens Matsushita facilitates production of SAW filters in this submicron range. SAW filters are also being developed for the third generation of mobile phones, operating at frequencies above 2 GHz, and for W-LAN (Wireless Local Area Network) applications at 2.5 GHz.

The standard intermediate frequencies for DECT are 110.59 and 112.32 MHz. A wide range of channel filters is available for this spectrum (Table 3). Filters for professional applications are available in DCC14 or QCC10 hermetically sealed ceramic packages. They are distinguished by very low insertion loss, high temperature stability (thanks to LiTaO3 crystals) and good group delay ripple.

SAW filters in low-cost SIP5K plastic packages are now available for IF stages as a temperature-stable version based on lithium tantalite crystals. These products offer an outstanding price/performance ratio, which is essential today because many cordless manufacturers have targeted the mass market for economy phones as well as the high-performance segment.

Steep-edged SAW filters for channel selection are also available for the Japanese PHS system operating in the range from 1895 to 1918 MHz. These filters for an intermediate frequency of 248.45 or 243.95 MHz have an image frequency suppression of more than 60 dB and are housed in QCC10 ceramic packages measuring 9 x 7 mm. Thanks to

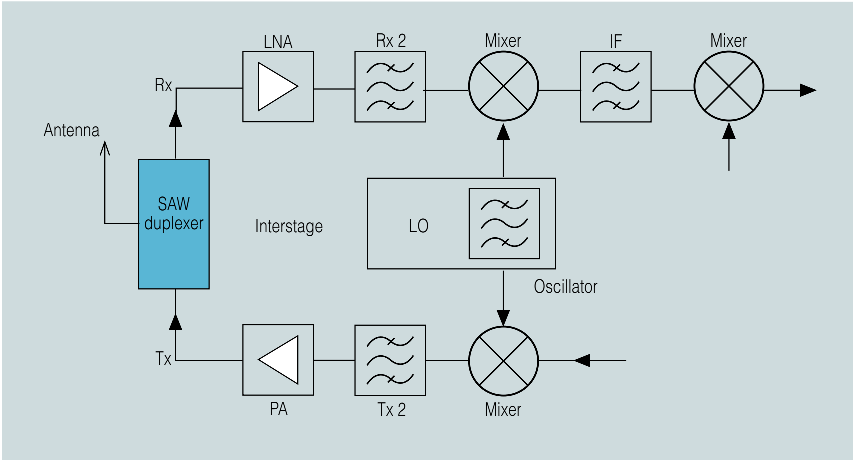
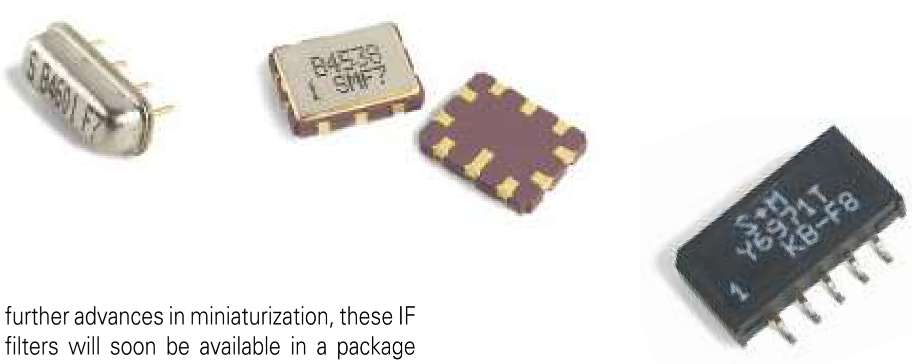


Fig. 5 RF stage of a tuner with integrated dupllexer



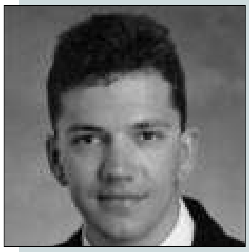
further advances in miniaturization, these IF filters will soon be available in a package almost 20% smaller.

Packages match performance

RF filters for CT1 and CT1+ are available in two package types: the low-cost SIP4M-(F11-) metal package, and a hermetically sealed DCC6 for SMDs. The ISM and CT2 RF filters come in the SIP4M package. In addition, the broadband RF filter for ISM is supplied in QCC8 and DCC6 ceramic packages.

IF filters for DECT are available both in low-cost SIP5K plastic packages and as high-performance components in DCC14 or QCC10 ceramic packages. The channel filters for PHS are housed in QCC10B ceramic packages. All SMD types are available taped and reeled, the SIP4M filters in sleeve magazines.

Siemens Matsushita expects to step up its production capacity for SMD ceramic filters to 55 million units this year, while output of plastic filters in SIP5K packages, which originate in TV technology, will top 100 million. A tenth of production is earmarked for mobile phone applications. For SAW filters in wired SIP4M (F11) packages, a production capacity of 10 million units will be available next year. ☐



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studied electrical engineering at Saarbrücken University, where he wrote a diploma thesis on a direct conversion receiver concept for GSM cellular radio. Since 1995, Mr. Ruffing has been involved in product marketing of SAW filters for mobile radio to customers in Asia and Europe at Siemens Matsushita Components.