FUTURE HIGH VOLUME APPLICATIONS OF SAW DEVICE
BUDÚCNOSŤ VYUŽITIA PAV SÚČIASTOK

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Summary This paper examines the prospects for continuing market growth during the next 15 years by surveying both RF communications technology for systems which use or will use SAW devices. It is predicted that the SAW wireless label will be the largest SAW application. Also, it is predicted that the majority of SAW devices will operate at UHF in contrast to current SAW devices which are primarily at VHF.

Abstrakt Budúcnosť aplikácií súčiastok s povrchovými akustickými vlnami. V príspevku sa skúma stály rast komunikačnej technológie, ktorá využíva alebo bude využívať povrchové akustické vlny (PAV). Je predpovedané, že bezdrôtový identifikačný systém s PAV bude najrozšírenejší PAV aplikáciou. Tiež je predpovedané, že väčšina zariadení s PAV bude pracovať na veľmi vysokej frekvencii (300 – 3000MHz) na rozdiel od bežných zariadení s PAV, ktoré pracujú najmä na frekvencii 30 – 300 MHz.

1. INTRODUCTION

This paper examines future high volume applications which may continue this growth trend. Section II of this paper describes communications technology trends which are projected to be important driving factors during the next 20 years. In section III, various product trends will be discussed in both commercial and consumer areas. The saw impact on each of these products will discussed. Section IV describes development challenges for SAW device technologists.

2. COMMUNICATIONS TECHNOLOGY TRENDS AND RF SYSTEMS ARCHITECTURE TRENDS

SAW devices have become widely accepted in RF systems and are now impacting the architecture of these systems. For example, many systems are now implemented with a "building block" approach using gain blocks, filtering blocks, demodulator blocks, etc. While this trend is partially the result of advances in semiconductor integrated circuit technology, SAW technology has been an important factor in this trend [1].

Another impact of SAW technology is that modern systems now require levels of performance for phase response, amplitude response, and/or impulse response characteristics which were unrealistic 5 to 10 years ago. This is evident in consumer products such as television, is commercial products such as digital communications equipment, and military products such as EK receivers. Systems designers now routinely specify phase and considered impossible in the past.

A third trend in RF systems architecture is that sophisticated signal processing functions is now being used routinely. This trend initially started in military equipment with such items as monopulse and doppler processing for radar. In commercial equipment, the adaptive equalizers which are routinely used in telecommunications modems and digital microwave radio equipment. Similar techniques are planned for consumer products such as (TV) and satellite receivers. In many cases, the SAW device only performs a part of the signal processing with the remainder being done using digital techniques. However, even in systems which rely on digital signal processing, SAW filters with highly reproducible amplitude and phase response are needed to ensure proper operation of the digital processor.

A fourth change in new systems architecture is the trend toward multi-channel systems. This is evident in consumer products such as television where the "parallel sound" systems are planned for improved sound fidelity. Examples in military hardware are mono-pulse radar, EW channelized receivers, and missile seekers. This trend is made possible by the low cost, small size, and highly reproducible performance which SAW devices provide. This is an area of flexibility which has not been fully exploited in both commercial and consumer products. Another impact of SAW technology is the move to high "intermediate frequency (IF)" receiver architectures. By using higher IF frequencies, one can substantially eliminate imagine response and other mixer spurious response problems which plague traditional IF frequency choices. By removing these spurious responses, one can either partially or totally eliminate varactor-tuned front end filters with their attendant alignment and frequency tracking problems. The result is better systems performance, improved reproducibility and cost reduction.

A sixth trend is significant growth in RF hybrid modules which constitute complete RF systems or subsystems. For example, complete receivers in hybrid circuit form have been rare because one could not implement a high performance receiver without the use of multiple coils which are too large for hybrid circuit use. Now however, most of these critical functions can be performed by SAW devices. Initial SAW-based RF hybrids are simple oscillators and transmitters which use the SAW device for frequency control.

A final important trend is the continuing shift toward increasing use of portable equipment. This is true of telephones, satellite receivers, military radar and many other items. The desire for portability has existed for a long time and now many complex RF systems are being implemented in portable form because of SAW technology. Many of these architecture trends are the result of advances in both SAW and semiconductor technology. Some SAW device technologists fear that semiconductors may ultimately replace SAW devices but this is generally an unfounded fear. The analogy filtering and frequency control functions of SAW technology are simply not available in semiconductor form. The two technologies are complementary and not competitive in most areas.

3. FUTURE TRENDS FOR SAW RELATED PRODUCTS OF BROADCAST AUDIO PRODUCTS

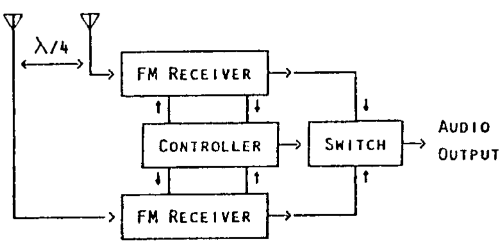

Fig. 1. Spatial diversity system for elimination of signal drop-out due to multi-path propagation

The consumer market with good growth potential is the area of broadcast. The current FM stereo broadcast systems suffer severe performance degradation in most metropolitan areas due to multipath interference. Multipath interference causes two different types of distortion. The most severe one is simple signal drop-out due to localized nulls caused by the multipath propagation. The second problem is one of amplitude and delay distortion across the received band. Adaptive equalizers can successfully attack amplitude and delay distortion, but signal drop--outs can only be solved by using a "spatial diversity" receiver system as illustrated in figure 1. In this system, two receiving antennas and two FM receivers are used. The antennas have a spatial separation of approximately quartet wavelength. For proper operation, the two receivers must be well matched in their characteristics [2].

In the simple implementation shown here, an audio switch is used to select the best performing receiver output.

More complex versions of this system would also use an adaptive equalizer for further audio improve- ment. Obviously, SAW's may also play a role in the adaptive equalizer function.

The other strong possibility for the next 10 years is the emergence of broadcast digital stereo. The multilevel waveforms provide the necessary spectrum efficiency to allow this development. As was discussed earlier, this system would require precision multi-channel IF filters and adaptive equalizers for implementation. This system is technically feasible and would probably find widespread consumer acceptance as is evidenced by the popularity of compact digital disc systems.

SAW Wireless Label System

The largest potential SAW application is for SAW wireless label system. This system is illustrated in figure 2 which shows a SAW label affixed to the side of a shipping carton. This label can be read from a remote location by using a pulsed transmitter which a short interrogation burst to the label. After a short time delay, the label emits a coded reply which is read using a time gated receiver and phase detection circuitry.

Figure 2 shows a simplified diagram of the coded SAW wireless label used in such a system. It consists of a SAW device in which the input and output transducers are connected to a single pair of bus bars. These bus bars are then connected to an antenna. A loop antenna is shown in this example.

The SAW device will use an operating frequency near 1000 MHz to allow a large number of information bits while retaining small chip size. One design criteria is that the free propagation distance must be greater than the code length so that the regeneration signal inside the coded section of the label is past before the desired output starts. The SAW label system has several important advantages when compared to other labelling techniques (either optical or using a semiconductor microchip). First, compared to optical systems, the SAW label is insensitive to label orientation. Also, a SAW label should not be visible and could in fact be packed inside the shipping box. While optical labelling systems have enjoyed good success in grocery stores, they have generally demonstrated poor performance in warehousing, shipping, material handling, and other commercial applications.

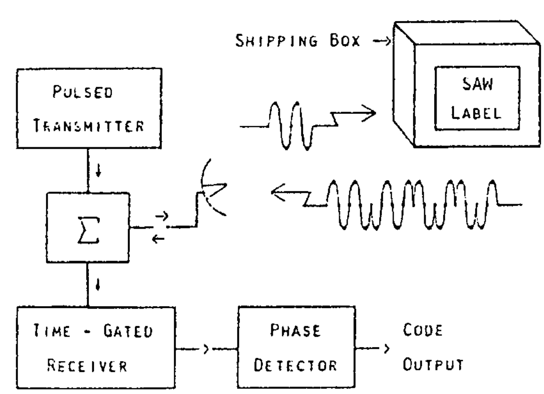

Fig. 2. SAW wireless label system

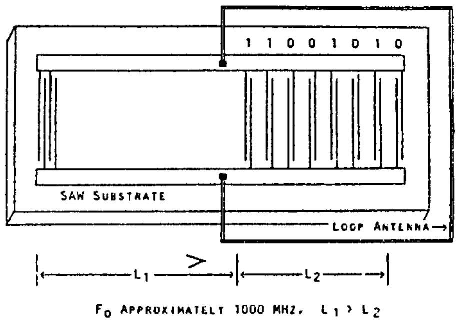

Fig. 3. Coded SAW wireless label

Other label systems are available which use semiconductor microchips but these systems are generally very expensive and also require that power be supplied to the label which greatly restricts potential uses.

A SAW label system can have many potential codes. Code lengths of 128 bits appear to be feasible for many low cost applications.

4. FUTURE CHALLENGES FOR SAW TECHNOLOGY

Table 1 gives a list of areas of desired technology improvement which would result in significantly expanded uses for SAW technology. While progress has been made in all the shown areas, major breakthroughs are desired. The first item, improved low-loss filters, is motivated by one of the oldest problems in the technology. While much progress has been made using three phase transducers and other techniques, further improvements are desired. Desired improvements include (a) very low loss (1 dB or less), (b) high power capability (1 to 10 watts), (c) elimination of 3 phases matching, and (d) achieving a tuneable filter. One promising technique for low loss filters is the single phase unidirectional transducer [3].

The second item, improved packaging, is important front several viewpoints. Achieving a lower cost package is important in consumer applications because packaging is the dominant cost in consumer SAW device. Also, there is a widespread desire to achieve a chip-mount package for compatibility with other components which are now available in this form for automated assembly. Third, many current packages degrade performance either due to parasitic capacitance and resistance or due to lack of hermiticity and degraded cleanliness. These problems will all become worse as the trend toward UHF and microwave SAW devices continues.

Tab. 1. SAW Technology Challenges

1. Improved Low-Loss Filters
2. Improved Packaging
3. Microwave Frequency Devices
4. Programmable Filters
5. More Accurate Filter Design Techniques
6. Improved Materials & Processing

The third item in Tab. 1, microwave frequency devices, reflects the trend in modern RF systems toward ever higher frequencies and ever widening signal bandwidths. Devices are now available to process the data up to 1 GHz from several manufacturers. This progress has primarily resulted from E-Beam photomask improvements. While further improvement is expected, the technology is approaching some limits in terms of propagation loss, surface defect density, and alignment tolerance for multi-level devices. One promising approach is to use other surface modes such as the Sezawa wave or surface transverse shear waves which have higher inherent propagation velocity. The fourth item on Table 1, programmable filters, continues to be area of major research effort. The most successful programmable devices to date are the elastic SAW convolvers, but many drawbacks remain. An interesting possibility in this area is the GaAs acoustic charge transport devices which use SAW for a low-power high-speed clock. The fifth and sixth items in Table 1 need little explanation. In many of the applications discussed above, there is a continuing desire for more accurate SAW filters, or more stable filters or even more reproducible filters. These can only result from improvements in design techniques and from better materials and from improved device fabrication techniques.

5. SUMMARY

In the author's opinion, the wireless SAW labels will likely be the largest SAW application. This market could be several times larger than TV IF filters within 10 years.

It is evident from reviewing the new applications that the majority of the SAW market will be for UHF devices. Even a large fraction of the current VHF SAW market will move to UHF because of new receiver architectures as described earlier.

SAW technology is now in its rapid growth phase which is characteristic of any successful new technology. This is based largely on the success of first generation SAW devices. Second generation devices (resonators, low-loss filters, convolvers, etc.) are now entering a phase of large scale use. This, coupled with the advent of even newer product generations will continue to fuel future growth.

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