PASSIVE MAGNETOSTATIC WAVE PULSE COMPRESSION LOOP

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ABSTRACT
A magnetostatic pulse compression loop using linear delay lines and passive FM chrip generation has been demonstrated. Sidelobe suppression of 30 dB has been achieved by using loop transducers for appropriate amplitude weighting.

INTRODUCTION

Pulse compression systems utilizing surface acoustic wave (SAW) dispersive delay lines have been under intensive investigation for the past 14 years. These studies have concentrated primarily on using the SAW linear dispersive delay line for downchirp phase coding with quadratic phase error less than one degree in the expander section of the SAW pulse compression system. The low time-sidelobes is achieved by appropriate amplitude weighting in the compressor section.The time-bandwidth products over 1000 with greater than 40 dB sidelobe suppression have been obtained for the SAW pulse compression system. The typical operating center frequency for SAW device is less than 1 GHz (due to the physical limit of the technology). For radar system of higher operating frequencies (in GHz region), mixing is required to convert the radar carrier frequencies to the operating frequencies of the SAW pulse compression subsystem.

A new technology based on "slow" magnetostatic wave (MSW) propagation in a magnetically biased epitaxial yttrium iron garnet (YIG) is emerging as a complementary signal processing technology to SAW at microwave frequencies (1-20 GHz). Three major propagating modes with the propagation direction in the film plane have been used in device applications. These three modes are magnetostatic surface wave (MSSW) mode in which the bias field is perpendicular to the direction of the wave propagation and in the plane of the film, magnetostatic forward volume wave (MSFVW) mode in which the bias field is perpendicular to the film and the propagation direction, and magnetostatic backward volume wave (MSBVW) mode in which the direction of the bias field is the same as the propagation direction . This modes are dispersive and characterized by a limited propagation passband width (.5 to 2.2 GHz) with the center frequency electronically tunable between 1 to 20 GHz by adjusting the bias field. The 1-20 GHz center frequency range of this MSW modes makes signal processing possible directly at radar carrier frequency and the typical group delays of these modes are between 50 nsec/cm to 1000 nsec/cm ,depending on the YIG film thickness and the bias magnetic field used. This dispersive slow wave structure of magnetostatic wave makes the investigation of MSW devices in pulse compression logical.

A MSW pulse compression loop using active expended chirp signal generation and a magnetostatic surface wave (MSSW) delay line with a non-linear delay characteristic, as the compression filter, was first demonstrated by K.W. Reed,et.al.(1). The "down chirp" signal was generated by a voltage controlled oscillator driven by a programmable sweep voltage with a matched non-linear phase characteristic appropriate to the intrinsic non-linearity of MSSW delay line. Phase predistortion techniques were used to achieve a 24 dB side/lobe ration with a time-bandwidth product of 30.

In this study a matched pair of quadratic phase MSW delay lines with center frequencies of 3.2 GHz and 3 dB bandwidth of 320 MHz have been used as expander and compressor devices for pulse compression loop. A schematic diagram of the MSW pulse compression loop is shown is Fig. 1. Appropriate amplitude weighting by using loop transducers in the MSSW device have allowed a 30 dB sidelobe suppression.

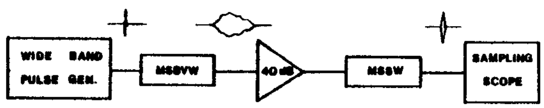

Fig.1 Block diagram of MSW PULSE COMPRESSION LOOP

PASSIVE GENERATION OF THE DOWN CHIRP CODED SIGNAL

A simple linear backward volume wave delay line, driven by a fast rise pulse generation, was used for the passive generation of the FM down chirp signal. The linear MSBVW dispersion characteristic was obtained in a straight forward manner by using a 50 uM thick layer of YIG spaced 250 uM above the ground plane (2).

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The linear dispersive curve of this delay line is shown in Fig. 2. The slope of this linear delay line is 9.1 nsec/100 MHz, with a deviation from quadratic phase less than 10 degree over 500 MHz bandwidth at 3 GHz center frequency. The insertion loss of this delay line is 12-15 dB over the 500 MHz bandwidth .

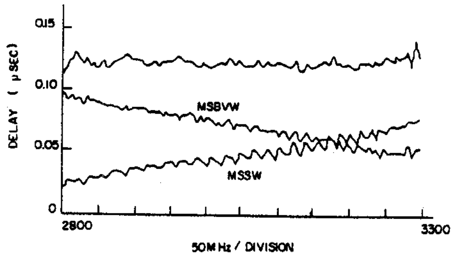

Fig.2 MSSW and MSBVW linear dispersive curves and their sum

MSSW LINEAR MATCHING FILTER

The "matched" filter required in this pulse compression loop is a delay line with a time-inverted replica of the expanded signal as its impluse respone. Since a linear MSBVW delay with a "down chirp" quadratic phase characteristic, is used to generate the down chirp signal, a linear delay with opposite delay slope must be employed as the matched filter. Variable ground plane spacing technique, recently developed by some of the authors, has been used to achieve the required quadratic phase "up chirp" characteristics in a MSSW delay line (3). The slope of dispersion characteristic, shown in Fig. 2, is 9.7 nsec/100 MHz with a R.M.S. phase error less than 12 degree over a 500 MHz bandwidth at 3 GHz certer frequency.

EXPERIMENTAL RESULTS

Initial experimental results, using single bar transducers in the MSSW delay line, showed 20 dB of sidelobe suppression due to incorrect amplitude weighting and because of the band edge phase distortion. The 3 dB pulse width is approximately 5.5 nsec with a time bandwidth product 24. An improved MSSW device was designed with a loop tranducer to achieve a better weighting function characteristic for the MSSW pulse response envelope. The deviation from the Hamming weihting function is +/- 2.5 dB over the 320 MHz bandwidth at 3.2 GHz center frequency for a loop tranducer of 250 uM loop spacing. The quadratic phase behave was still matched by adjusting the ground plane according to Kok Wai Chang, el.al.(3). A 30 dB peak/sidelobe ratio was obtained by using this loop transducer MSSW linear delay as the compressor in the MSW pulse compression loop with no phase predistortion. The recompressed pulse shown in Fig.3 has 8 nsec 3 dB pulse width and the time bandwidth product is 12.

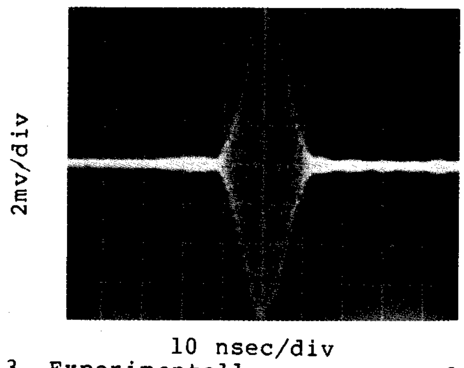

Fig.3 Experimentally recompressed pulse from loop transducer device.

CONCLUSIONS

A pulse compression loop using a pair of matched MSW delay lines with passive (impulse) generation has been demonstrated with -30 dB time sidelobes and a time bandwidth product of 12 over a 320 MHz bandwidth. While the compression gain are modest by SAW standards, significant potential for increase exist, as well as good pottential for better sidelobe supression. Work is underway to improve the loop performance.

ACKNOWLEDGEMENT

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