INCREASING DATA DENSITY ON 1/2 INCH CASSETTE TAPE

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ABSTRACT

Half inch Super VHS (S-VHS) tape is an exceptional media for recording telemetry instrumentation data. Due to high volume mass production for the commercial and industrial video markets, high quality S-VHS media is available at a low cost. Advances in head technology as well as data path electronics contribute to increased data densities recorded on this media. Present system capabilities of 50,000 bits per inch will soon be replaced with newer technology systems that will record at linear densities up to 100,000 bits per inch.

KEY WORDS

Telemetry Data Recording, Instrumentation Data Recording, Super VHS Tape

INTRODUCTION

An investigation by Metrum into increasing the performance of half inch, S-VHS, tape based helical scan recorders showed that significant increases were achievable by incorporating modern technical advances in magnetic heads and data path electronics. The study found that increases in both media capacity and recorder data transfer rate could be obtained while maintaining backward compatibility with Metrum's existing half-inch tape formats. The various methods available to increase performance were investigated and followed with a development program that incorporated these improvements into a new recorder that operates at double the data rate and double the capacity of Metrum's current line of VLDS half-inch cassette recorders.

RESEARCH AND DEVELOPMENT PROGRAM

Two primary methods were investigated to increase the media capacity of half-inch cassettes. It was determined that capacity could be increased by decreasing track-widths, thereby allowing more tracks to be written on each cassette or capacity could be increased by increasing linear packing densities which allows more data to be written in each data track. Each method has advantages and disadvantages. Some of them are illustrated below in Table 1.

TABLE 1

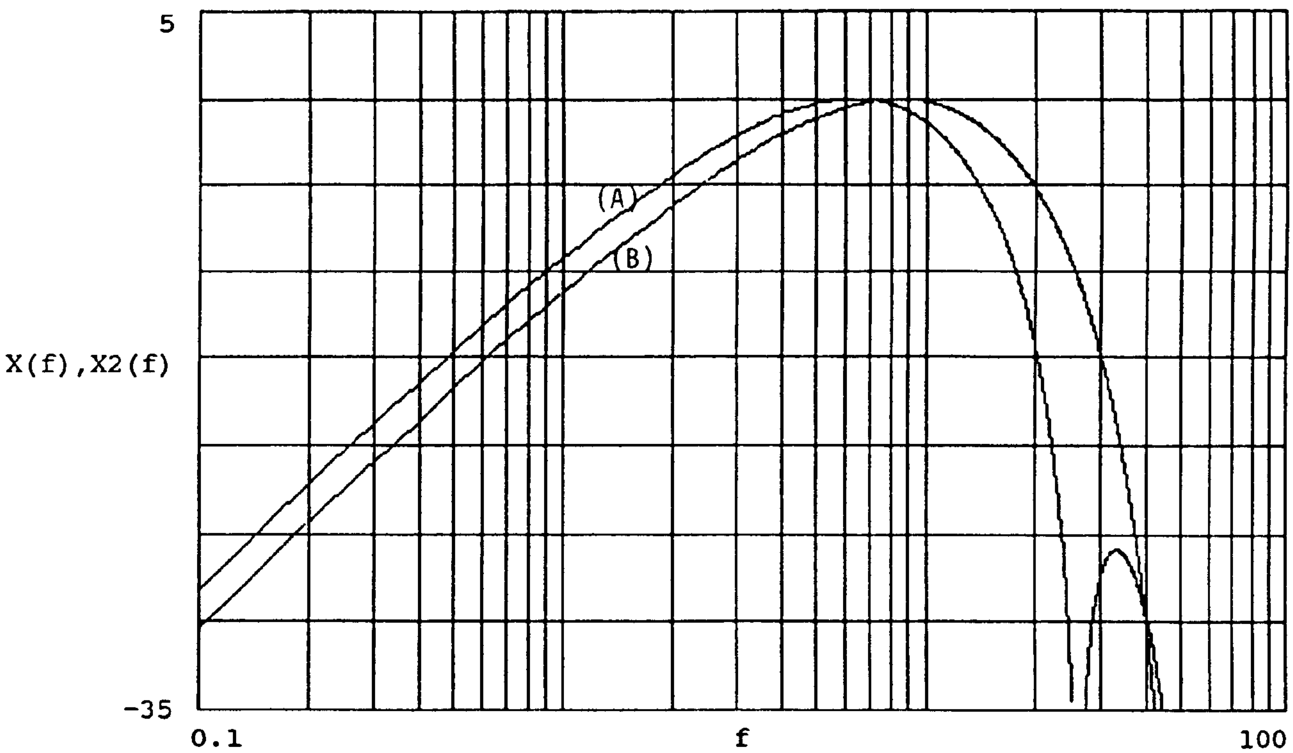
Decrease Track-width	Increase Linear Packing Density
Advantages	
More tracks written on each cassette	More data written in each track
Small circuitry change required	Increased transfer rate
	No change in tracking requirements
	No change in environmental tolerance
Disadvantages	
Lower SNR	Lower SNR
More accurate tracking required	Greater electronic modifications required
Lower environmental tolerance	

Analyzing the tradeoffs of these approaches led Metrum to the decision that increasing linear packing density was the better alternative. Results of the feasibility study showed that technology exists to reliably increase linear packing density to 100,000 bits per inch (100 Kbpi) on S-VHS media. Tests showed that S-VHS media could support the higher density and that electronics could be designed to work at the required frequencies. The primary technical hurdles to be overcome were found to be in the areas of heads, and front-end electronics.

Heads

Increasing linear density is dependent on writing smaller bit cells on tape. The key to this is increasing the data frequency while maintaining the head-to-tape speed. To increase the data frequency requires that the gap length of the record / reproduce head be reduced thereby concentrating the flux pattern written on tape. Figure 1 illustrates the relationship between data frequency and gap length. Head curve (A) represents the current line of VLDS recorders operating at a head-to-tape speed of 454 inches per second and a data bandwidth of 12.5 MHz. This frequency supports a linear packing density of 50 Kbpi. Head curve (B) represents the increased frequency required to achieve a linear packing density of 100 Kbpi. Recent advances in head technology coming from the broadcast video industry have led to the availability of heads and gap bars with shorter gap lengths. Metrum's head department manufactures high performance digital read / write heads from these new generation gap bars. Metrum is able to manufacture heads with all of the characteristics required for a system that can reliably operate at linear packing densities of 100 Kbpi.

FIGURE 1



	Head Curve (A)	Head Curve (B)
Gap Length	0.00048mm	0.00027mm
Head to tape speed	454 ip s	454 ips

Notes:

Head curves calculated with 0.001 degrees of azimuth error.
Peak to band-edge at 12.5 MHz = 3 dB (head curve A)
Peak to band-edge at 25.0 MHz = 8 dB (head curve B)

Tape

Super VHS tape was created as an extension to the VHS tape format. Super VHS tape is able to support the higher frequencies required for enhanced definition video images. Tests show the particle size of the media is sufficiently small to support

100,000 bits per inch packing density and the 920 oersted coericivity of the tape provides adequate signal to accurately recover the data on reproduce.

Transformer

Helical scan recorders use a pancake style transformer to couple data signals to the rotating read / write heads. Doubling recorder performance requires double the bandwidth to be passed through the transformer. Tests show that to pass these higher frequencies the current transformers needed to be modified to decrease the inductance, increase the coupling coefficient, and decrease the crosstalk between channels.

To achieve these required improvements Metrum needed a new transformer design. Pancake transformers in the current VLDS product line are manufactured from a single ferrite pancake. To decrease crosstalk in the new transformer it is manufactured with individual pieces of ferrite for each winding. Shorting bars have been installed between windings to improve the crosstalk. The new design has decreased channel to channel crosstalk by 9 dB.

Increasing the coupling coefficient adds to the increased SNR required to offset the loss in SNR incurred from increasing the linear packing density. The coupling coefficient has been increased by decreasing the spacing between the transformer rotor and stator windings. Precision manufacturing of the transformer assembly and lapping of the pancake surfaces allows the spacing to be reduced and the coupling coefficient to be increased for the desired increase in SNR.

Changing the turns ratio from the standard 2-to-1 turns ratio to 1-to-1 turns ratio decreases the capacitance and increases the resonant frequency of the transformer. Mounting the head driver and pre-amplifier circuitry physically on the stationary portion of the scanner assembly also decreases capacitance for increased bandwidth.

The combination of these design improvements has increased the resonant frequency of the rotary transformer from the 15 MHz of the current VLDS product line to 35 MHz for the new Metrum 64 recorder. This increase in bandwidth allows the Metrum 64 to easily operate at the targeted 100 Kbpi linear packing density.

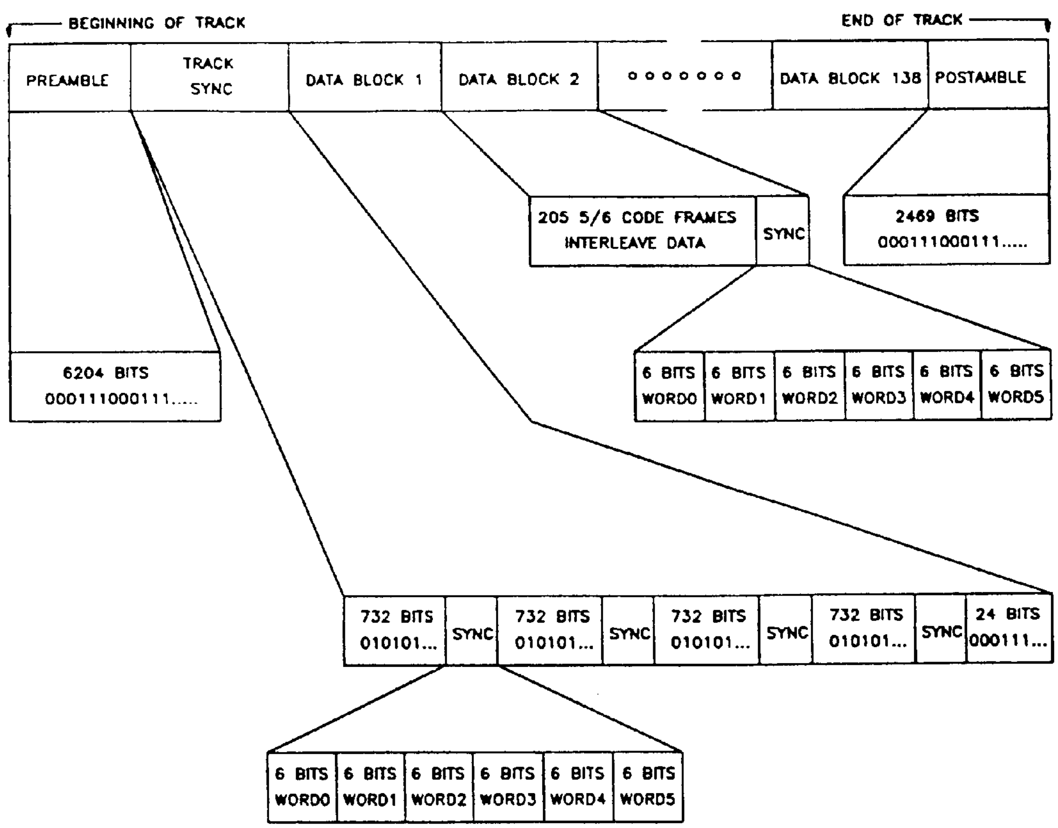
Equalizer / Bit Synchronizer

The disk drive industry has steadily increased disk capacity and data transfer rates. Hard disk data rates have now reached the point where the tape industry can benefit by borrowing Large Scale Integrated (LSI) chips developed for the mass market disk industry. Metrum found that using these LSI chips allow a higher band width data path to be built while simplifying the circuit design and reducing the amount of circuit calibration required. The end result of this design effort is a bit synchronizer and equalizer that occupy half of the board space required by the discrete design it replaces. The new design is capable of reproducing not only the increased data density tapes but also it can reproduce all previous VLDS tape formats and densities.

Tape Format

Figure 2. illustrates the VLDS track layout specified in the IRIG standard for digital recording on S-VHS tape. The new Metrum 64 recorder has built on this format by doubling the number of data blocks in each data track from 138 data blocks to 276 data blocks. This change doubles the amount of user data stored in each data track. The bit counts of the preamble and postamble areas have also been increased to maintain their physical length on tape.

Figure 2.



SUMMARY

Technological advances brought about in the broadcast and computer peripheral industries have made available the components necessary to develop the next generation of S-VHS tape based telemetry and instrumentation recorders. Metrum put in place a research and development program that has been successful in doubling the density and transfer rate of the IRIG standard line of VLDS recorders. The outcome of this program is the Metrum 64 variable speed digital recorder. Linear packing density has been increased to 100 Kbpi allowing 27.5 GB of data to be stored on a ST-160 cassette. Data transfer rates have also been doubled for a maximum streaming data rate of 64 Mb per second. The worldwide availability of high quality, low cost, S-VHS media combined with the high performance of the Metrum 64 recorder result in an exceptional system for recording telemetry and instrumentation data.