MAGNETIC RECORDING CHARACTERISTICS OF R-DAT AND ICS 2670 (F-4)

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Abstract

This paper describes about the magnetic recording characteristics and a front-end circuit of R-DAT. Some equivalent models are constructed to simulate these characteristics. Head amplifiers and the equalizers which comprize 3 taps transversal filter are optimized according to the results of simulations. The optimized characteristics are realized in two ICs.

One IC is AN7020S which includes head amplifiers, recording amplifiers and equalizers. Another is AN7021S which includes a high-speed comparator and envelope detectors.

1, Introduction

In R-DAT system, the front-end circuit is the part where signal is actually written into the tape and read from the tape. The characteristics of the front-end circuit have significant influence to the Block-Error-Rate of the digitally reproduced data. The front-end circuit consists of the tape, heads, head amplifiers and equalizers. After the consideration of these characteristics, new two ICs are developed.

Fig. 1 shows the block diagram of the front-end circuit. The analog audio input signal is converted to digital data, encoded to error correction scheme, time-compressed, added with sub-code data, converted by the 8-10 modulator and added with the ATF (Automatic Track Finding: tracking servo system) data in the signal processing block.

As the bit rate of the data sent to the head is 9.408MBPS and the relative speed of tape-to-head is 3.133m/s, the maximum flux reversal density on the tape becomes 76kFRPI and linear recording density is 61kBPI because of the 8-10 modulation. The minimum recording wave length is 0.67μm (frequency=4.704MHz) and the maximum is 24.1μm (f.=130kHz). Considering the spectrum of the 8-10 modulated data,

the required frequency range of the front-end circuit is about 50kHz ~ 8MHz.

2, Tape and Heads

MP (Metal Powder) tape which has 1500 Öe of Hc is used for R-DAT. The following frequency response is required for the tape and head; the output level at 4.7MHz (λmin=0.67μm) is sufficiently high and the recording level at 130kHz(λmax=24.1μum) is controllable in order to maintain the compatibility. The two composite heads of ferrite and amorphous with different azimuth angle are adopted. The effective head gap length of each head is about 0.28μm which is optimized for these frequency responses. Fig.2 shows the example of a frequency response. It has a differential characteristic at low freqency range and the output level at high frequency range decreases because of various losses.

3, Head Amplifiers

Since playback output level is a few microvolts and frequency range is very wide, the head amplifiers are required for large gain, low noise and wide band width. The equivalent circuit model of the head and head amplifier is used for simulations to optimize the circuit noise characteristics of the head amplifiers. Fig.3 shows the equivalent circuit model. In Fig.3 the main parameters mean as follows;

- L_h : Inductance of head
- R_h : Resistance of head
- V_h : Output voltage of head
- K_r : Transfer ratio of rotary transformer
- Rbb : Base resistance of top stage transistor
- C_i : Input capacitance of head amplifier
- R_d : Dumping resistance of head amplifier
- E_i : Output voltage of head amplifier

Fig.4 shows the results of the simulation. The noise is mainly occured by the impedance of head and resistance Rbb. Fig.5 shows an example of the noise spectrum. The total noise is reproduced by the recording of 4.7MHz square wave signal, this noise means the summation of the modulation noise and the background noise. The background noise is reproduced by the rubbing of bulkly erased tape and the circuit noise is generated by the head and the head amplifier. As the circuit noise level is 3~5 dB lower than the total noise level, this head amplifier

has sufficiently low noise level.

4, Equalizer

As the frequency response of the tape in Fig. 2 is not flat, the equalization must be applied to reproduce data from the playback signal. The integration circuits are used to compensate the differential characteritic of the tape and the head. The transversal filter is used to compensate the losses in high frequency range. This transversal filter is almost linear in phase response. The cosine roll-off characteristic, which satisfies the non-distortion criteria of digital data, is approximately satisfied by tuning the coefficients of the transversal filter. Fig. 6 shows the frequency response of an equalizer.

We have done the simulations with respect to the inter-symbol interference of the playback signals by using the models of these characteristics of the head, head amplifier and equalizer.

Fig. 7 shows the flow-diagram of the simulation. The inter-symbol interference is calculated by super-positioning the impulse response which is computed from the output of the equalizer using Inverse FFT. Finally the signal to noise ratio is computed considering the random noise given as the carrier to noise ratio, the crosstalk level by next track, the eye-closure and jitter caused by inter-symbol interference. Fig. 8 shows the results of the simulation. From Fig. 8, it is clear that the roll-off factor $k \simeq 0.5$ is optimum. Fig. 9 shows the eye-pattern of equalized output signal.

5, ICs

Fig. 10 shows the block diagram of the two ICs (AN7020S, AN7021S) newly developed this time. AN7020S has two current drive recording amplifiers, two playback head amplifiers and two equalizers to meet each channel. Each head amplifier has another top stage transistor to optimize the characteristics of low base resistance and low input capacitance independently of the IC technology. Each equalizer is adjustable separately according to corresponding head. The tuning is done by adding a DC voltage to the tuning pins. There are three tuning pins for each channel, one tunes the gain, another tunes the frequency response and the rest tunes the phase response. The output signal of the equalizer is sent to AN7021S.

AN7021S has a high-speed comparator to convert the analog signal to

digital level and two envelope detectors. One is used for detecting dropouts, another is used for detection of no data. Table 1 shows the outline of these ICs.

6, Conclusion

The front-end circuit of R-DAT is based on many new magnetic recording technologies i.e. MP tape, the composite heads of ferrite and amorphous, high S/N head amplifiers and the equalizers. These characteristics will be imploved better in the near future.

Acknowledgement

The authers express their thanks to the members of DAT development group for their kind advices.

References

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3) T. Arai et al. ,"DIGITAL SIGNAL PROCESSING TECHNOLOGY FOR R-DAT", IEEE Transactions on Consumer Electronics, Vol. CE-32, No. 3, August 1986

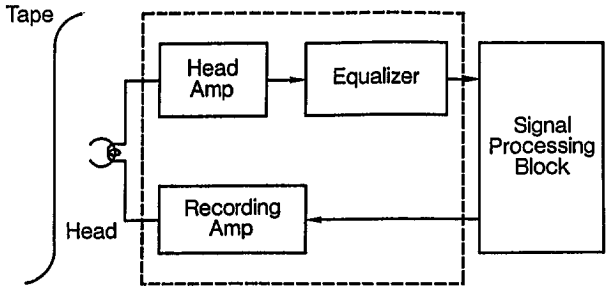

Fig.1 Block diagram of Front-end Circuit

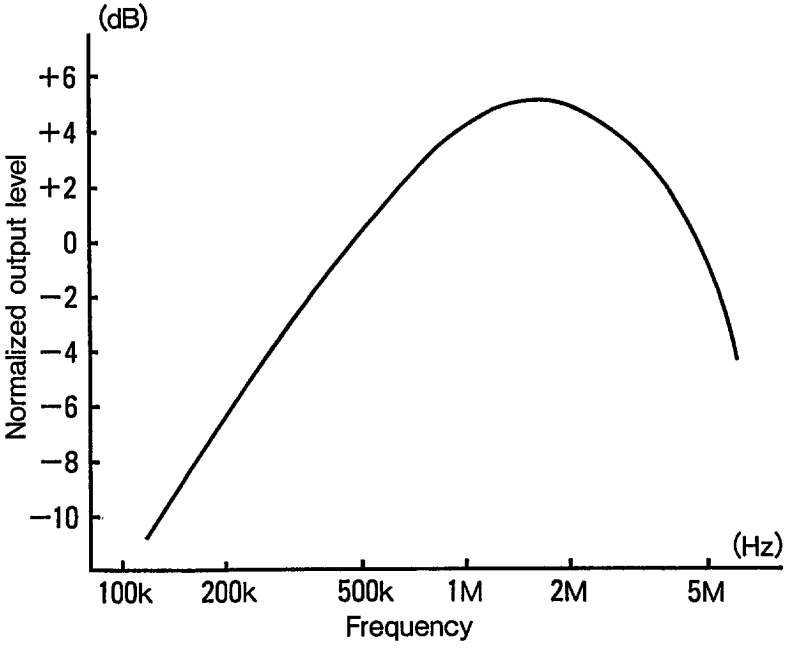

Fig.2 Frequency characteristic.

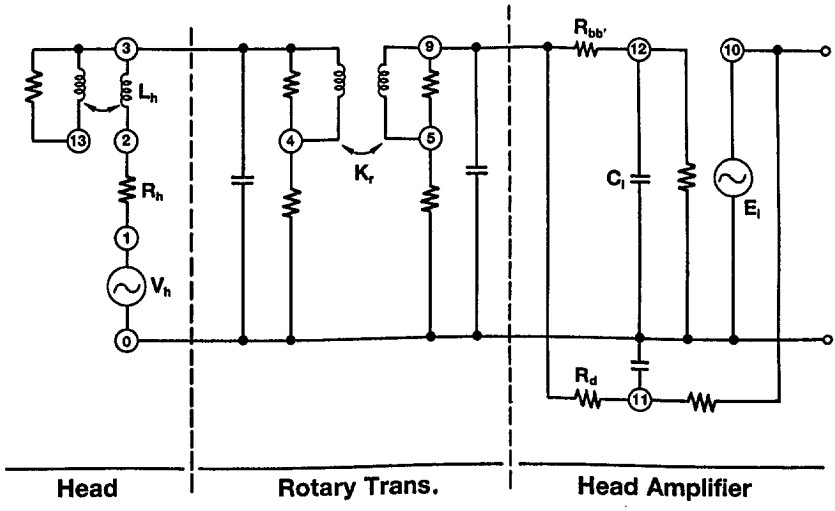

Fig.3 **Equivalent Circuit of PB Unit**

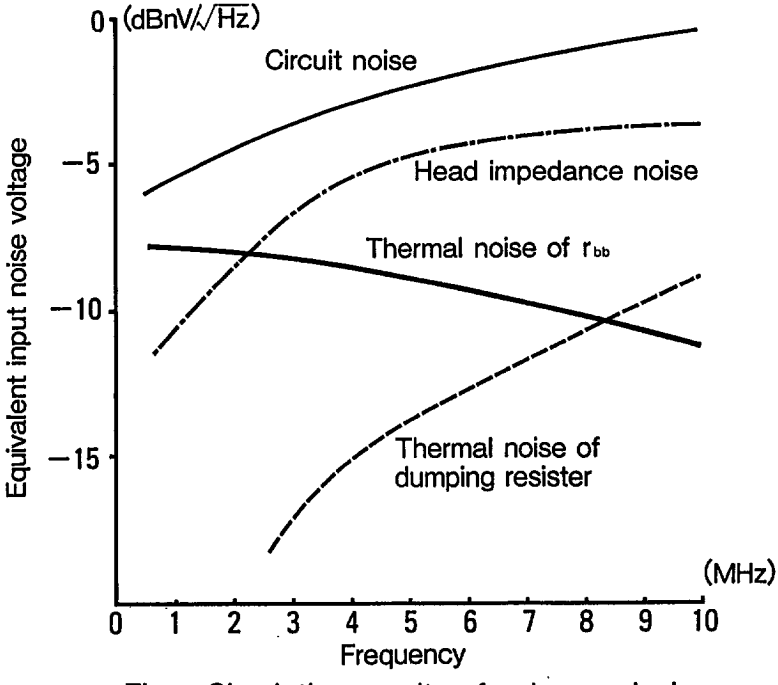

Fig.4 Simulation results of noise analysis.

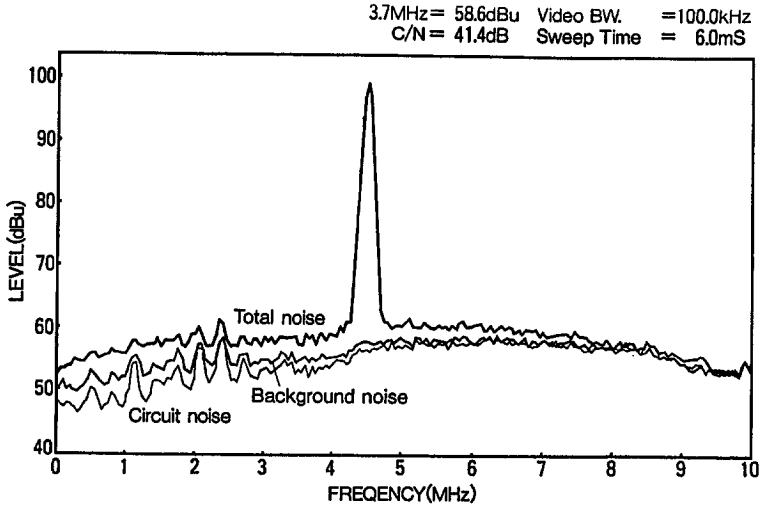

Fig.5 C/N Characteristic

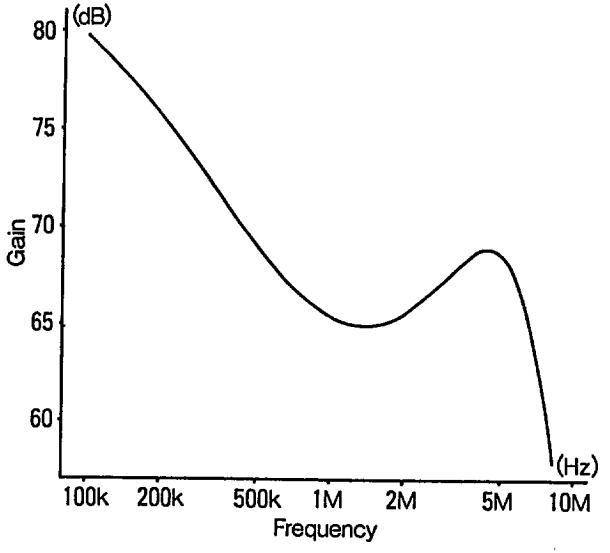

Fig.6 Frequency response of equalizer.

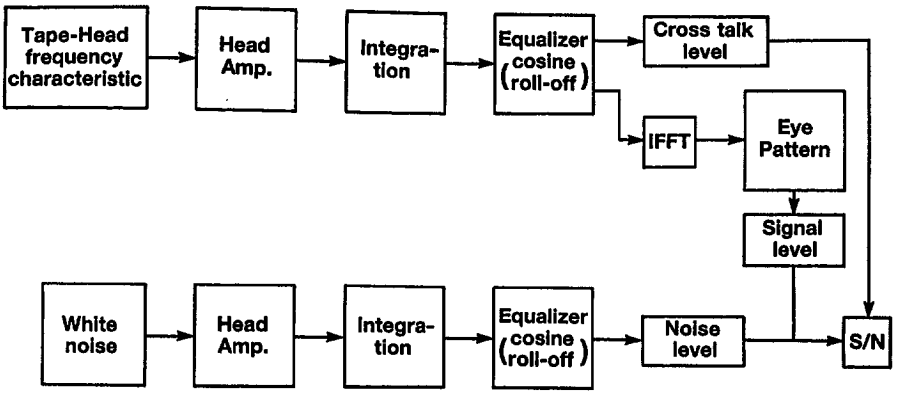

Fig. 7 **Block Diagram of S/N Simulation**

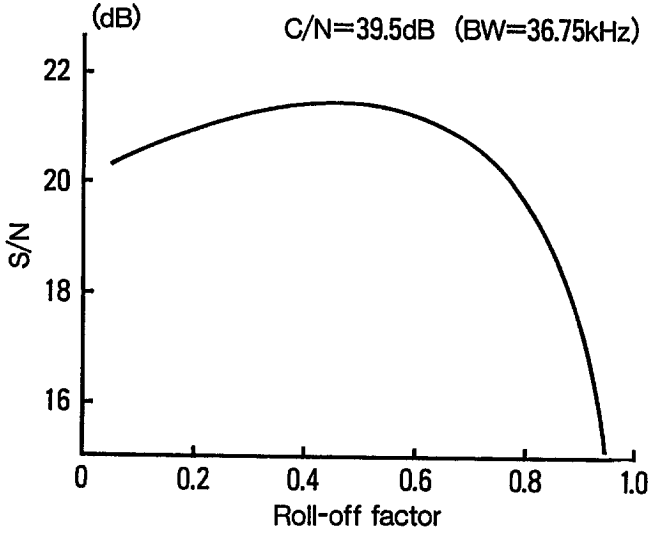

Fig. 8 S/N vs Roll-off factor.

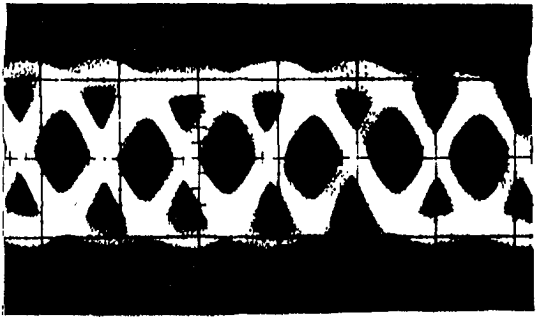

Fig. 9 Eye pattern.

DEVICE NO.	AN7020S		AN7021S
FUNCTION	DAT RF IC		DAT CMP IC
PACKAGE	42 pins SO		18 pins SO
OPERATING VOLTAGE (V)	+5	+9	+5
OPERATING CURRENT (mA)	30 (PLAY)	20 (REC)	10
FEATURES	Recording Amps. Head Amps. Equalizers		High-speed comparator Envelope detectors

Table 1 Outline of ICs

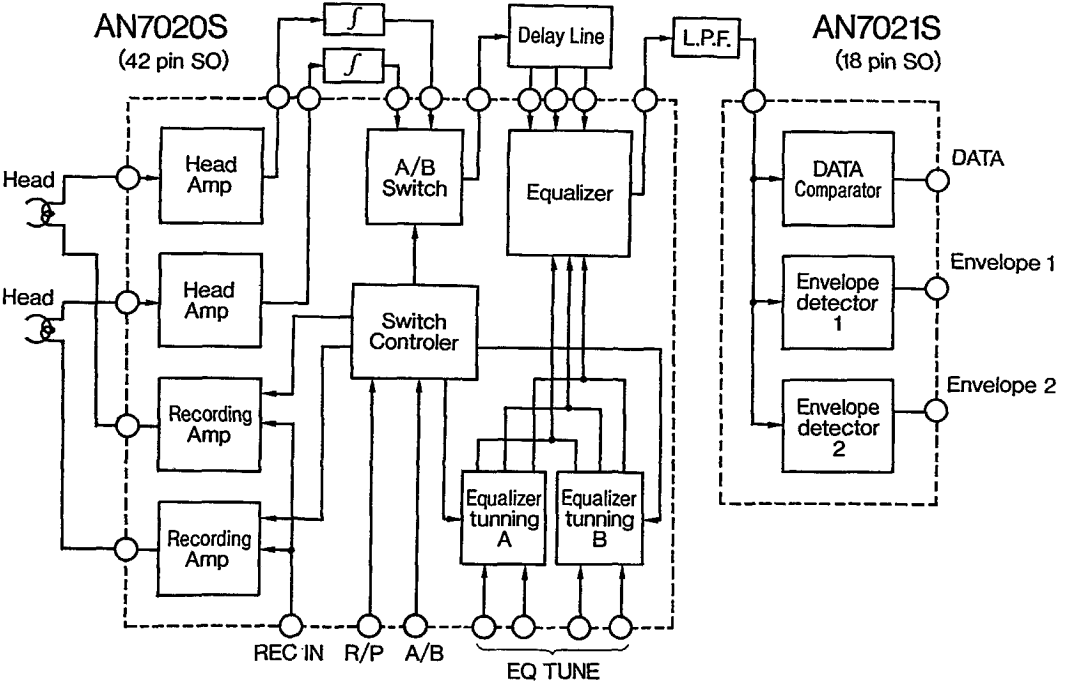

Fig.10 Block diagram of ICs.