Robustness and high recording speeds for CD-R

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1. Abstract

The key technology to achieve robustness in optical recorders and to stretch the speed limits of existing optical recording media is thermal balancing of the write strategy. A method is shown to determine the optimum thermal balancing parameters in a CD recorder by using trial writings with random EFM data.

2. Motivation

After the introduction of CD-Recordable (CD-R) in 1990 [1], the continuous efforts for increasing the recording speed resulted into market penetration and subsequent establishment as a standard data exchange medium for personal computers. The strong position is the result of the low price, the safety of archived data and the compatibility enforced by the standardisation policy.
In commercially available drives, the "X-factor", indicating the overspeed with respect to the standardised speed of CD-audio, has been increased to over 32X and is covered by the Multi-Speed CD-R standard [2]. At the Philips Research Laboratories, CD-R recordings of up to 40X have been demonstrated [3]. At such high recording speeds, a future drive can almost write as fast as it can read. From that moment on, recording speed itself is no longer the driving force, but robustness and media compatibility take over the focus of research.
This presentation describes how understanding thermal interference during writing is required to raise CD-R recording speeds, and how robustness is increased by adapting the write strategy to each individual disc.

3. Balancing thermal interference

On a Compact Disc, binary data is stored as variations in the edge positions of marks. This is implemented as data encoded along a spiral on a polycarbonate disc. The marks and spaces along the spiral have lengths of 3T up to 11T channel clock periods. For write-once discs, the recording process is based on irreversible deformation in the disc by heating a thin recording layer (dye). At low recording speeds, the accuracy of placing the mark-edges depends mainly on the steepness of the temperature gradient in the recording layer. Therefore, a write strategy with fixed write pulses suffices.
When a similar write strategy is used for recording at speeds higher than 8X, the positioning of mark-edges is affected by in-track thermal crosstalk in the disc due to the writing of adjacent marks. The amount of thermal crosstalk depends mainly on the length of the spaces between marks. Marks will be expanded with a random magnitude since the length of the neighbouring spaces is random.
The key to robust writing at high rotational speeds is the use of thermal compensation in the write strategy. An example of such a strategy is proposed in the Multi-Speed CD-R standard [2] and is repeated in Figure 1. A delay ΔT in the rising edge of a write pulse is adopted after short spaces of length 3T. In addition, for adjusting the temperature distribution within a mark, an increased power level ΔP is used for short marks of length 3T. Figure 2 shows the increased system margins as observed when replacing a conventional strategy with a thermally balanced write sequence. Figure 3 is the eye pattern of a successful thermally balanced recording at 40X.

4. Determining the optimum parameter settings

To have optimum benefits from thermal balancing, the optimum write strategy parameters must be determined for each disc individually. Thermal compensation parameters can be subjected to an optimisation performed just before the disc is written.
An algorithm for determining the optimum parameter settings after a few trial-write experiments in the OPC is developed. This method beneficially adopts the fact that jitter is affected as a second order curve within a certain range when thermal balancing parameters, like ΔT and ΔP as used in Figure 1, are changed. In Figure 4, the ΔT parameter clearly results into parabolic changes in the mark jitter. An algorithm for calculating the optimum settings is proposed which is scalable both in the number of parameters and the number of measurements. It requires only first order data manipulation to do a least-square parameter estimation. For fitting N parameters, at least 2N+1 measurements are needed while it appeared that twice the minimum amount of measurements is appropriate for solving all parameters with significant noise reduction.

Using this optimisation method, a drive can determine the optimum settings for thermal balancing parameters after a few trial-write sessions using random EFM data in the inner zone on the disc.

5. Conclusion

A method is described to find the optimum settings for the write strategy in an optical drive just before writing the actual data. When the write strategy is set-up to have proper grip on the real problems of high speed recording by means of thermal balancing, a significant increase in system margins is observed.

6. References

[1] Recordable Compact Disc Systems, Part II: CD-R, Volume 1: 1x/2x/4x, Version 3.1, System description, December 1998

[2] Recordable Compact Disc Systems, Part II: CD-R, Volume 2: Multi-speed CD-R, Version 1.0, May 2001

[3] B. Tieke, G.R. Langereis, E.R. Meinders, J.G.F. Kablau, R. Woudenberg and R.A.J. Kollenburg, Thermally balanced writing for high speed CD-R recording, Proc. ISOM 2001 conference, Taipei, Oct. 16-19, 2001

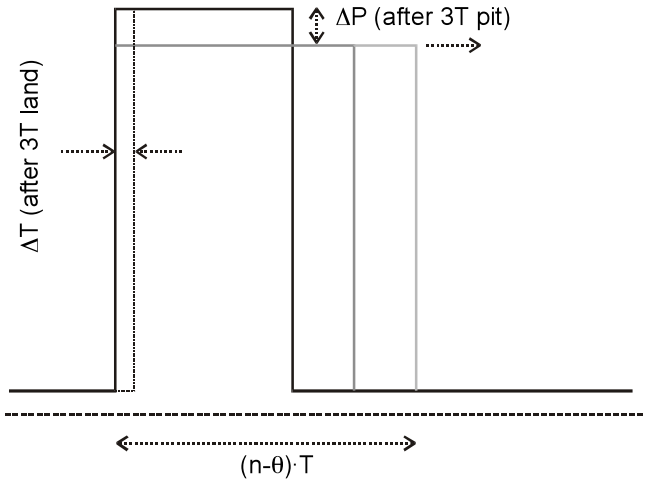

Figure 1: Write strategy test condition including thermal balancing as proposed in the Multi-Speed CD-R standard [2]

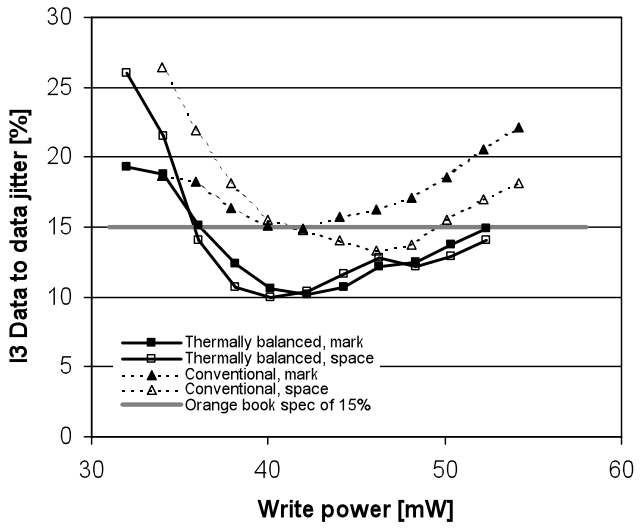

Figure 2 :Power margins when using a thermally balanced write strategy for 24X CD-R recording on a commercially available disc

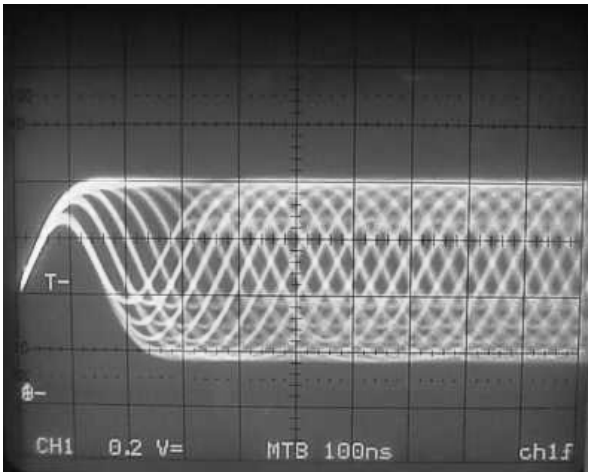

Figure 3 : CD-R Recording at 40X using a thermally balanced write strategy on a phthalocyanine disc

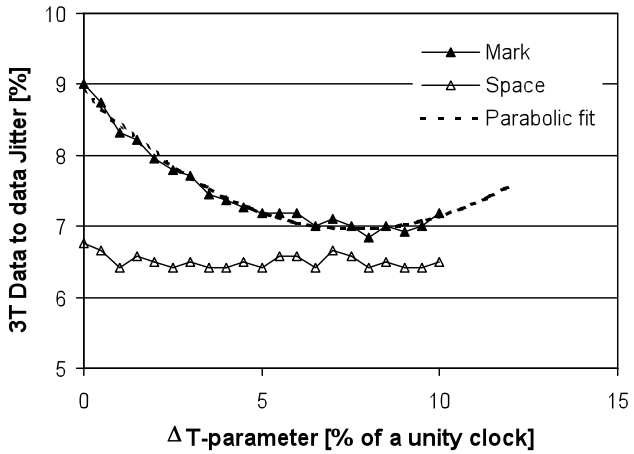

Figure 4: Adjusting the ΔT parameter in the write strategy of Figure 1