High Frequency Wobbles: A Write Clock Generation Method for Rewritable DVD That Enables Near Drop-In Compatibility with DVD-ROMs

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1 Motivation

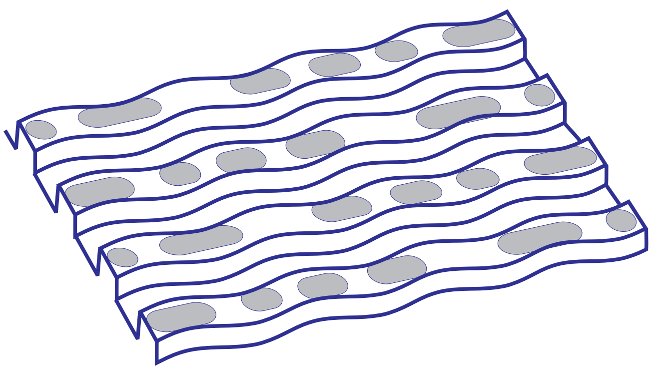

Figure 1: A perspective schematic of high frequency wobbles.

This paper presents an overview of a new method of write clock generation on rewritable DVD drives that eliminates many of the problems associated with reading rewritable disks in DVD-ROM drives. It is believed that such a format will provide tremendous benefits to the end user, making it possible to edit content on a rewritable DVD disk and then play that same disk in a conventional DVD-ROM player. From a large set of potential problems, it appears that the real issues can be reduced to two:

- smaller changes in reflectivity on phase-change media and
- a much tighter clocking requirement caused by the need to eliminate edit gaps.

Of these, the first is an issue for roughly half of the commercial DVD players in the world today. This issue can be overcome in the remainder rather trivially with a simple circuit change in the AGC of the reader. It is the latter issue which is a problem. As shown in Figure 2, DVD-ROM disks have no edit gaps or physical sector marks. This is in contrast to conventional rewritable formats which need these gaps to accommodate imprecision in the write clock which would otherwise cause data loss at the end of data fields [1, 2, 3, 4, 5].

2 High Frequency Wobble Clock

In order to eliminate these edit gaps a new clocking scheme was devised that uses high spatial frequency groove edge oscillations (wobbles) to generate clock signals. This has the advantage that it co-locates clock reference with data, yielding a high fidelity, high frequency clock reference. Using this, one can lock a narrow band phase-locked loop (PLL) to the oscillation frequency to generate the write clock. Addressing information can be encoded into the wobble itself using a variety of methods to eliminate the need for physical sector marks.

Having a continuous clock co-located with the data is more precise and robust than intermittent clocks. The PLL can average over many clock cycles to ignore defects more easily. Furthermore, spindle runout, disk eccentricity and thermal variations have far less effect on the write clock. This means that there is virtually no drift between clock samples, allowing for the elimination of edit gaps. By encoding address information in the wobble itself, the embossed sector information is "off to the side" of the data. This clears the way to make the data sector continuous, as in the DVD-ROM format [6].

3 Implementation Choices

While there are many possibilities for implementing such a scheme, the choice of the specific physical encoding method depends upon the available spatial frequencies,

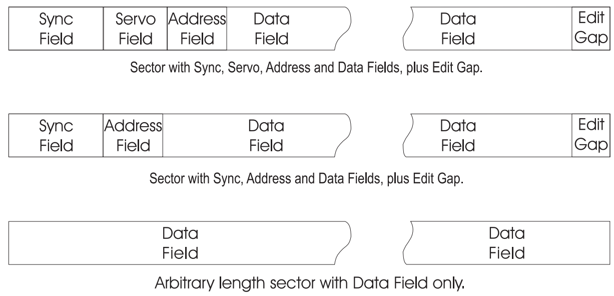

Figure 2: Optical disk formats on rewritable and ROM media. The top diagram represents sector formats on drives where synchronization, servo, and address fields as well as an edit gap are time multiplexed down the track with the data. This is the current norm in both sampled servo magnetic and optical disk drives. The middle diagram represents sector formats on drives which do not obtain their servo information from the sector header, but still time multiplex the remaining fields with the data. This was common in dedicated servo magnetic drives, which have fallen out of favor, and is the norm in optical drives where the grooves or pits provide a continuous pattern for the tracking servo. The top two formats are the prevalent methods used in rewritable magnetic and optical media. The bottom digram represents a typical format for ROM media. Because the media is mastered once at the factory, no physical sector marks are needed. Instead, logical synchronization and address fields are included within the data.

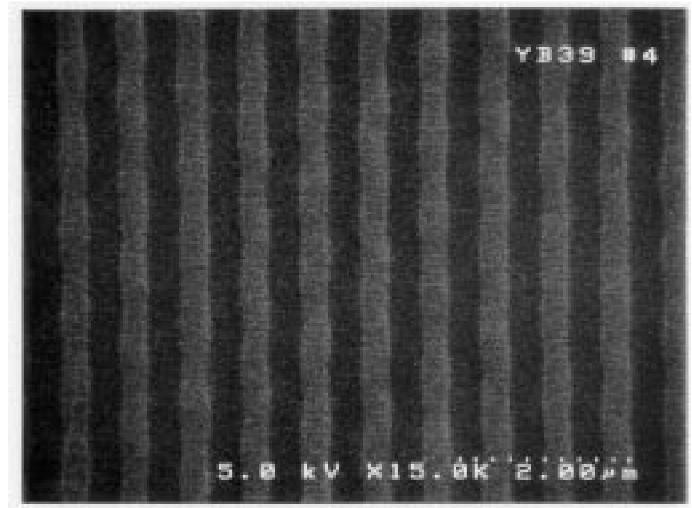

Figure 3: SEM Image of 4.7 GB, 30 nm Peak to Peak Wobble Disk

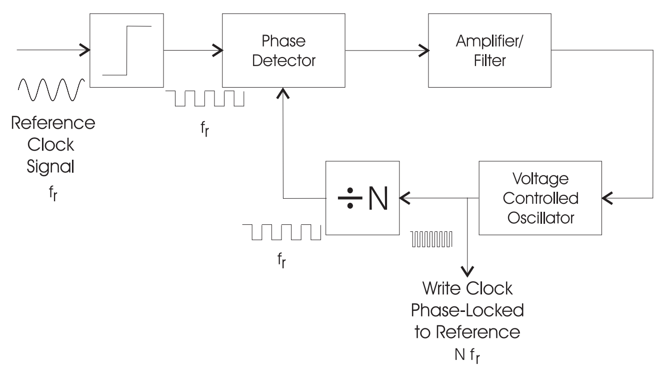

Figure 4: A Harmonic Locking PLL is used to generate the write clock.

the available signal detection methods, and a desire to avoiding interference between clock and data/servo signals.

Once it was decided that the highest probability of success for a product would be in a system with an industry standard set of optics (0.6 NA lens, 635-650 nm laser), the possibility of putting the clock frequency above the data frequencies was eliminated. Putting the clock frequency below the data frequencies would have resulted in a write clock with too much jitter. The solution is a high frequency wobble groove – an in-phase oscillation of the groove walls – as the method for encoding the reference clock. This has the advantage that it is nominally invisible to data detection in the central aperture mode, but yet easily detectable in the radial push pull servo signal outside of servo bandwidth. This allows the wobble signal to be encoded within the range of data frequencies with little interference between the two signals.

4 Results

The signal read back from the high frequency wobble becomes the reference clock signal for the system. The write clock is generated by using a harmonic locking PLL [7, 8] as shown in Figure 4 to boost the reference clock frequency to that of a write clock. The limiter preceding the loop makes it insensitive to amplitude changes resulting from laser power changes when switching between reading and writing.

The resulting system is one that makes bit accurate editing a reality. A typical example of this is shown in Figure 5, where a 6T pattern (6T mark, 6T space) is spliced into a 4T-8T pattern with negligible phase error.

Results such as this have been reliably repeated for a variety of edits and a variety of disturbance conditions. They indicate that the scheme has good robustness to radial and tangential tilt, offtrack, defocus, and modulation of the wobble for addressing.

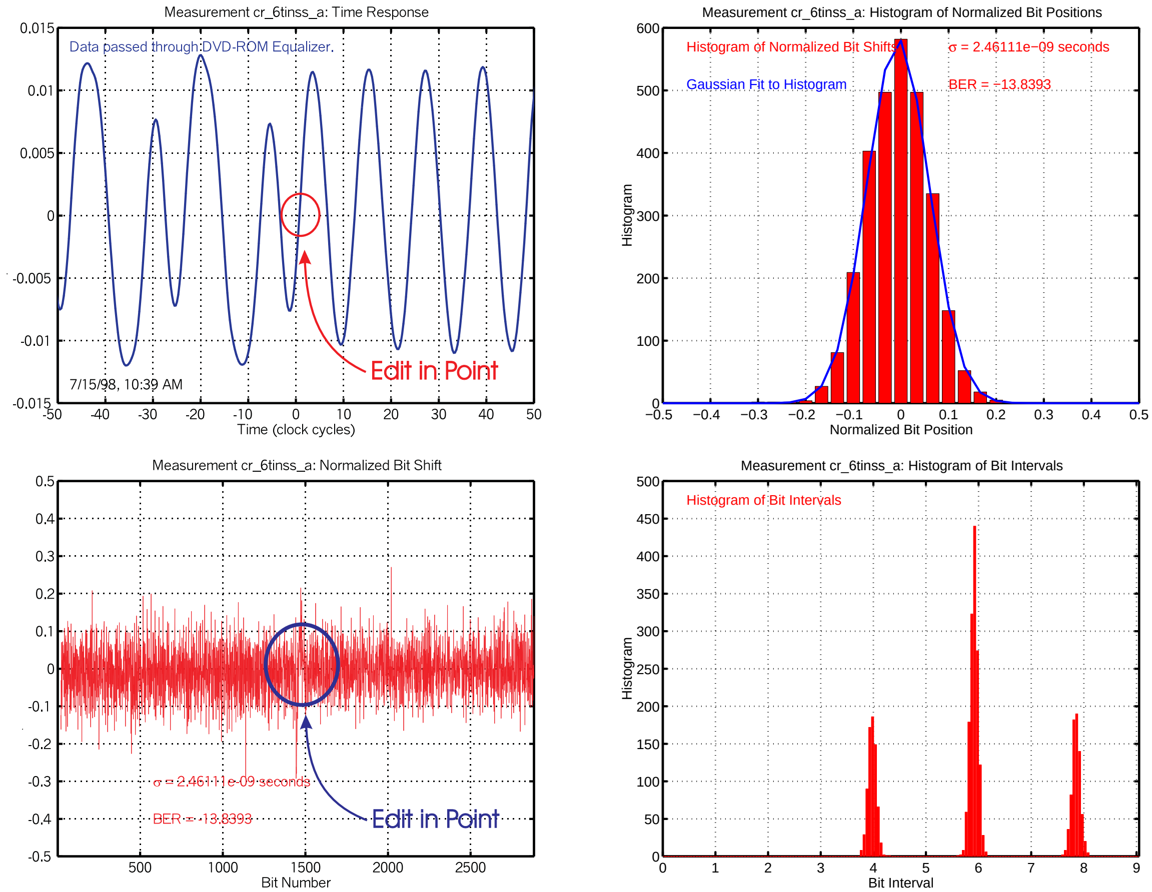

Figure 5: A 6T pattern spliced into a 4T-8T pattern. The upper left plot represents the time response at the edit-in point. The lower left represents the phase error for a data clock generated from the data. (Note the absence of any phase jumps.) The upper right plot is a histogram of the normalized bit positions from which a bit error rate can be computed. The lower right is a set of histograms of the bit intervals. The absence of any 5T or 7T bits is an indication that no bit errors have occurred.

References

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