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Limited-multilevel optical recording

Implementation of limited-multilevel (LML) modulation, via pits and lands of reduced signal amplitude, in the CD format has resulted in an extra data capacity of up to 24%.

With most optical recording techniques, only two amplitude levels are used for storing information in the medium: pits and lands. However, more levels can be handled by the detecting electronics. With LML pits and lands, additional data channels can be provided to existing CD or DVD formats. In a laser beam recorder for mastering of ROM discs, an LML pit can be created by reducing the laser beam current in the middle of a pit; an LML land by switching on the beam in the middle of a land.

Write strategies for LML mastering in the CD format have been optimized at the Optical Disc Technology Centre (ODTC) of Philips Components (*A. Spruijt*). One essential condition was that the quality of the standard CD channel did not deteriorate, which implies that the jitter of the main CD channel should not increase. Therefore, LML modulation is restricted to a subset of the runlengths in the channel bitstream: applying more amplitude levels for very short runlengths (3 or 4 times the channel bitlength T) would lead to an unacceptable jitter.

At the Nat.Lab., the work has been done for the hardware implementation (*G. Langereis*), general format (*W. Coene*) and error correction (*C. Baggen* and *M. van Dijk*). The method developed for adaptively retrieving the threshold level from which the LML bits are determined does not need additional channel coding, resulting in an efficient ratio between channel and user bits. The LML channel is created on top of the main CD channel, and is thus stochastically dependent on the latter: LML bits can only be accommodated in runlengths that are long enough. Typical problems result from this hierarchy of the CD and LML channel, e.g. erroneous insertion or deletion of LML bits due to normal-type channel errors of the standard CD channel (before error correction), and poor synchronization. These problems have been solved by designing a specific error-correction code for stochastic channels.

The extra data capacity, depending on the recording medium and the system tolerances, is presently up to 24%. Implementation of LML effects in existing formats is also interesting for copy management, since they cannot easily be copied with commercially available recorders. For new recording formats, the LML modulation can be integrated with the standard channel coding, e.g. for the next generation of optical drives.

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Figure caption:

LML pit on a CD and the corresponding eye pattern