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The Inventor's Notebook

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METERS AND MEASUREMENTS

HOW TO SET RECORDING LEVELS

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One of the most important quality measurements of a tape is its dynamic range or signal-to-noise ratio. This specification describes in decibels the difference between the two limits which confine all tape—the maximum acceptable signal (the maximum output level or MOL) and the inherent noise level of the tape (Fig. 1). When recording, one must set the levels high enough so that the program masks the tape hiss but not so high that the signals overload the tape and create excessive distortion. If the recording level is too low, a steady hiss will be audible throughout the program; if the recording level is too great, the sound will be harsh and grating with "spitting" sounds on sudden musical changes and a loss of high frequencies. The proper recording level is determined by reading the meters on the recorder. Since different types of meters measure in different ways, each type must be read in its proper way to interpret the information correctly.

All meters on tape recorders measure the amount of signal being delivered to the tape so that the recording level can be set as high as possible to mask noise but low enough to avoid excessive distortion. (The maximum "tolerable" distortion in tape recording is generally agreed to be 3% third harmonic distortion of a low frequency—315 Hz for cassette recorders, for example—or 3% intermodulation distortion of two high frequencies.) The meters have a scale in decibels above and below a reference level marked by a zero. The "positive" area above the zero is usually marked in red to indicate the danger of increasing distortion.

VU Meters

The most common meter with a needle-type pointer is the VU (volume unit) meter. A true professional VU meter conforms to very rigid specifications and is quite expensive. The VU-type meters found on consumer recorders are not as accurate, but they work well enough for home use. The purpose of the VU meter is to measure ***average*** or over-all signal levels. The scale typically runs from -20 to **+**3 with the 0 to **+**3 section marked in red. The point of **3%** third harmonic distortion is usually 6 to 8 decibels above the zero reference point, so keeping the average reading at 0 allows 6 to 8 decibels to be used as "headroom" for peak signals occurring 6 to 8 dB higher than the average level.

Most open-reel decks use the VU-type meter. Recording levels are set so that the meter barely goes into the red, indicating that the average signal is at 0-VU with peaks at 6 to 8 dB above. Peaks can occur so quickly that sometimes VU-type meters will appear completely motionless even when the sound is easily audible. At high average levels around 0-VU, the inability of the meters to show peaks is no problem for an open-reel deck because its fast speed provides a lot of tape for peaks; and the meters are designed around this capability. Cassette tape, however, moves at one half the slowest open- reel speed commonly used. With much less tape running past the record head, the 6 to 8 dB of headroom is cut down considerably. VU-type meters should not be adjusted to register 0-VU on a cassette deck because the peak signals would be severely distorted if the average level were at the 0-mark. Many cassette decks use a VU-type meter in combination with a light emitting diode (LED) that flashes instantly when a sudden peak reaches the danger point. The meter might be registering -12 on the scale or even nothing at all, but the fast-acting LED will still show a very brief peak. Recording levels on these meters should be set so that the LED rarely and only faintly flashes. VU-type meters without LED'S should be set conservatively until experience and practice familiarize the recordist with interpreting musical dynamics through averaging meters.

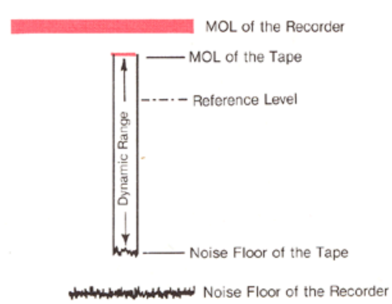
Peak-reading Meters

Peak-reading meters, especially the LED strings or fluorescent light types have become commonplace on cassette decks. These meters concentrate on the peaks rather than average readings, although some are switchable between the two modes. Their scales can run from -40 to +10**;** and they need the expanded scale because the meter or display is almost always moving, in contrast to the slower, averaging meter. The peak meter is generally easier to use for cassette applications because slow tape speeds reduce tapes' headroom capabilities, and one should be more concerned about peak levels than average levels. The only drawback to some of the LED or fluorescent-type peak meters is that the accuracy of definition depends on the number of light elements. A light meter with a scale of -30 to +10 over only six LEDs makes it quite difficult to distinguish -4 through +4 dB when the same LED is lit for the entire range. The greater the number of light elements, the greater the definition of the meter.

The actual recording level set on the meters depends not only on the tape, but also on the content of the program. Premium Type I normal bias tapes generally have excellent headroom at low frequencies, that is, their maximum output is so good that they do not reach 3% distortion until a +6 or more on peak meters. Type II tapes generally do not do as well, but their much lower noise floor more than makes up for any MOL difference, and they often provide better high frequency SOL ("Saturated Output Level") than Type I tapes. Type IV metal tapes have the best MOL values at both high and low frequencies at least theoretically, but much depends on the quality of the recorder. In many cases a Type I tape can outperform a much more expensive Type IV at low frequency MOL if the record head cannot handle the extra bias current required for Type IV tape, and a true chrome Type II tape is much quieter than any metal formulation.

A professional recording engineer knows not only how much headroom his mastering tape has and at which frequencies it varies, he also knows the approximate energy levels across the frequency spectrum of the program about to be recorded. Recording a piano concerto, for example, would require slightly lower levels than recording a song with a heavy drum beat because the transient peaks of the piano are more likely to create tape distortion at a given level than the low frequency energy of a drum. Cassette tape has far greater restrictions than open-reel tape, especially at high frequencies; so even more caution is in order. Unless the person recording can read a 1-3 decibel difference in a rapidly moving meter and knows what kind of energy—high or low frequency—is moving the meter or flashing the LEDs at any particular moment, in addition to knowing how much headroom exists on the tape at that frequency, it is best to be conservative, It is important to preview the program material or conduct a microphone test to determine the loudest passages the tape will have to handle and to set the meters accordingly. One should practice with different formulations, intentionally over- and under-recording to gain familiarity with the limits of distortion and noise and the levels that best fit each tape. It is quite difficult to utilize a tape's full maximum output level to the last dB.

Fig. 1



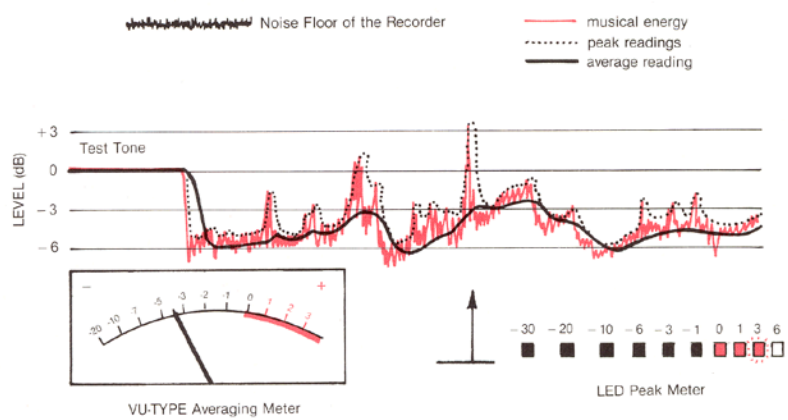


Fig. 2: Dynamic Range

Unfortunately, many “improved” tapes have boosted MOL at a sacrifice in noise so that the dynamic range, the difference between MOL and noise, is exactly the same. These “improvements” demand that the user increase recording level by each 1 dB gain in MOL or lose that 1 dB in increased noise. BASE’S true chromium dioxide PRO II cassette, on the other hand, has the lowest noise level possible today and improves MOL without sacrificing noise. Since PRO II cassettes have the least noise of all cassette tapes, there is less need to record at levels so extreme that they are always on the brink of excessive distortion. Every improvement in dynamic range is a true and practical benefit for the user.

In setting recording levels one must keep in mind several points: 1.) the type of meter in use, its reference level (see below), and how to read it; 2.) the type of tape in use and its headroom characteristics in the recorder; and 3.) the dynamics of the program to be recorded, that is, whether the peak energy is in the low or high frequency range. The choice of levels based on these considerations should result in the best sounding recordings possible.

The graph of music energy in Figure 1 shows particularly strong peak signals which would not appear on a VU-type averaging meter but which would be resolved by the faster peak display. The point marked by the arrow above reads -4dB on the VU-type meter, but the LED peak shows its instantaneous value as + 3dB. The steady-state nature of the test tone will produce exactly the same reading on both meters because the peak and average values are the same.

The numbers marked on meter scales express the number of decibels above or below a 0-reference point. The 0-point can represent various levels of magnetic flux (strength) depending on the design of the recorder. The Dolby calibration mark (DD) is a good guide in relating one cassette meter to another because it represents a defined flux level of 200 nanowebers per meter (nWb/m) of magnetic energy.

Meter Type	**Flux level at 0 dB point**	**Difference from (DD) mark**
Cassette VU-type with (DD) at +3 dB point	140 nWb/m	-3.10 dB
Cassette peak meter with (DD) at O-dB point	200 nWb/m	0.00 dB
Consumer open-reel deck with VU-type	185 nWb/m	-0.68 dB*
Professional open-reel deck with VU-type	250 nWb/m	+2.62 dB

*A consumer open-reel deck with Dolby NR encoding and decoding would use its own 0-dB point at 185 nWb/m as its Dolby reference level rather than the 200 nWb/m level used in cassette decks.