DESIGN NOTE

Smooth Tape Handling Increases Cassette Drive Reliability

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Mechanical simplicity takes many forms; here, in the shape of separate drive motors, standing-start capstans, and reliance on electronic control, it increases the reliability of a cassette drive and extends the life of the tape in the cassettes

In magnetic tape cassette drives, lengthened tape life and increased performance may be achieved by combining electronic capstan control with zero-speed capstan engagement. Reduced magnetic head penetration and elimination of the conventional pressure pad also substantially increase tape life. The mechanical simplicity of the overall system is best judged by its mean time between failures, as supported by field experience.

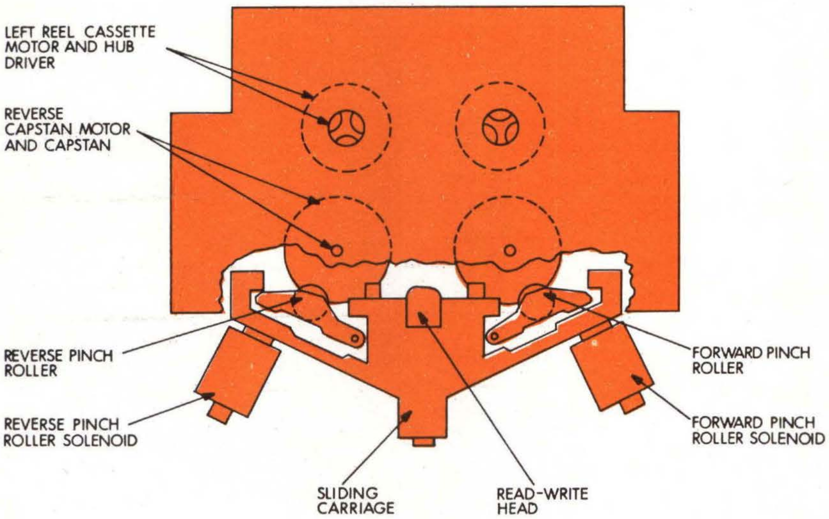
Possibly the most important requirement made of a cassette-drive tape deck is that it carry out its intended function, accurately and reliably, over its specified service life. Considering the advanced state-of-the-art of today's electronic systems, the principal limitations to achieving required accuracy and reliability are mechanical. Yet it is in the mechanical area that OEM users of peripheral equipment such as tape decks are most deficient.

However, although there is a certain amount of "black magic" in the mechanical design and manufacture of tape decks, the user can go a long way toward obtaining a reliable product by exercising reasonable judgment, and by asking the right questions. An example based on a particular approach to tape deck design illustrates these points.

Although maintaining mechanical simplicity is a common goal when striving for reliable mechanical design, it is not always easy to define. One rough guide is the number of parts, or perhaps the number of moving parts. However, certain parts—clutches and brakes, for example—are far less reliable than others. In spite of some parts' reputation for unreliability, a strong initial awareness of their problems by the designer may lead to the extra margins and testing required to overcome this handicap. This, of course, is a tradeoff for special benefits to be derived from use of the less reliable part.

Probably the best indicator of mechanical simplicity is the mean time between failures (MTBF) for all critical components. Test programs, combined with continuous production sampling, are essential to the determination and maintenance of a satisfactory MTBF.

The process of design simplification is integrally intermeshed with performance requirements. Obviously, the more stringent performance requirements are, the greater the likelihood of failure is, all other factors being equal.



Simple cassette drive design. Four motors, though more complex by some yardsticks than one or two motors, are still more reliable than the mechanical linkages needed when the one or two motors must be connected to both reel shafts and both capstans in a bidirectional tape cassette drive. Head penetration into the cassette, controlled by the sliding carriage, is less than in some other machines, extending head life and improving tape guidance

Thus, performance—as determined by the manufacturer to meet his concept of market requirements—is an important element in tape deck reliability. Consequently, OEM tape deck users should limit performance specifications (with sufficient margins) to realistic needs.

As an example of these points, consider Raymond Engineering, Inc's Raycorder (see diagram). While the manufacturer emphasizes the mechanical simplicity and consequent high reliability of the unit, by many criteria the package is not simple. There are four motors—more than in most tape decks—and two solenoids, generally among the less reliable control components.

Nevertheless, the manufacturer can boast of high reliability, because he identifies the reliability problem primarily in terms of tape handling without tape damage. Net result is an MTBF of 5000 hr and a system that meets performance requirements over many thousands of tape passes. This is achieved with a capstan drive, and results in exceptionally uniform tape speed, and high and constant data packing density without clock tracks.

Two of the four motors drive the capstans, while the other two control tape tension. During fast forward or reverse operation, only the tension control motors operate. One turns the takeup shaft, which in turn winds the tape inside the cassette; the other maintains tension on the supply reel with a small torque in the opposite direction. This controlled tension prevents slack loops and tape stretching, and substantially increases tape life and reliability. The capstan motors are stationary.

During reading or writing, one of the two pinch rollers is engaged, depending on the direction of tape motion. The capstan is stationary at the moment of engagement. This avoids the "slamming" start characteristic of cassette drives with continuously rotating capstans (*Computer Design*, Aug 1974, pp 127-138). Capstan acceleration and deceleration are precisely controlled by electronic motor drivers, reducing tape stretching and wear, and eliminating one cause of oxide abrasion and flaking—difficulties found in other cassette drives, which limit tape life to a few hundred passes. Gentle tape handling leads, in addition, to simple tape guiding and less wear on the read/write head.

A properly designed capstan-driven machine may stress the tape less severely than reel-driven types. Capstans distribute drive forces more evenly, and the takeup reel motor's function is to get only the reel, not the entire system, up to speed. Therefore, acceleration forces in the takeup reel are much lighter; their magnitude depends upon the amount of tape on the reel.

There are two drawbacks to the use of standing-start capstans: they reduce tape acceleration compared to that of systems using uniformly but oppositely rotating capstans, and the capstan motors may exhibit the motion irregularities characteristic of conventional dc motors.

Obviously, systems with continuously rotating capstans are faster, since their speed is limited primarily by the response time and impact characteristics of the solenoid, and by possible stretching of tape. However, high tape stresses are inherently present in such systems, indicating a tradeoff of tape life for response time.

When the capstans are driven at a relatively high uniform speed, rotational smoothness is limited only by the precision of the mechanical system; capstan inertia tends to smooth out most fluctuations. However, for start/stop operation, inertia must be low, so that some irregularities in motor speed may be transmitted to the tape. Fortunately, these irregularities can be minimized by using newer types of dc motors.

In addition, departures from smooth rotation do not necessarily indicate low quality in a digital tape drive. Certain data encoding techniques, such as phase encoding, allow time base instabilities of up to ±25%. Therefore, the wow and flutter exhibited even at low speeds may not concern the system designer. Although minimizing the mass in the system may introduce larger instantaneous speed variations, it will also achieve greater capstan control of acceleration and deceleration rates. An optimum acceleration rate, in terms of quick response versus gentle handling, is 250 in./s^2.

Most tape wear results from motion of the tape across the read/write head. In the Raycorder, such wear is minimized by reducing the depth of head penetration into the cassette, and by omitting the pressure pad in the cassette. Pressure pads compensate for gross variations in dynamic characteristics, such as tape tension, and in static characteristics, such as head penetration. If both static and dynamic parameters can be held sufficiently constant *and* repeatable, the pressure pad may no longer be required. The Raymond drive will operate with cassettes either with or without pressure pads. However, those with pads are more popular and more easily obtainable.

The Raycorder can use cassettes without pads because the drive applies constant forces, and hence maintains constant head-to-tape contact. As a result, it requires less head penetration, with consequent benefits of reduced misguiding and skew caused by the squeegee effect of the pressure pad. Head life is also significantly extended. Head-to-tape contact area, in fact, is only one-third that of conventional cassette drives.

The lighter pressure also decreases wear so substantially that error-free tape life is considerably lengthened. Individual tapes sometimes last for 5000 to 10,000 passes. In addition, the lower friction permits freer, more uniform tape motion, which in turn reduces edge wear on the tape guides. □