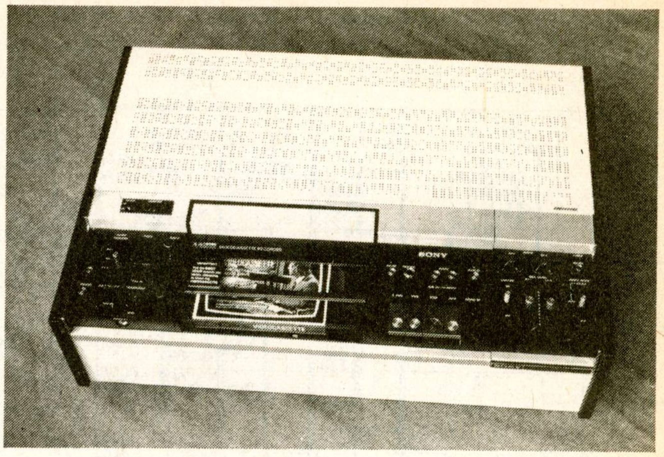
The SONY VO1810 VCR



Part 2

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SERVO systems for videotape recorders can follow either of two basic design patterns. If very high stability of playback information is required then two separate servos are employed, one to control the speed of the capstan and the other the speed of the head drum. This enables the vertical period off tape to be phased so that it coincides with the studio vertical sync, thus allowing the video recorder to be used as a vision source which is synchronous with the studio field pulses but nonsynchronous with the line pulse information.

A much simpler servo system is used on the less expensive recorders. This controls the speed and phase of the head drum only. A synchronous motor driven by the mains is used to determine the speed of the capstan, and the head drum servo has the task of phasing the VTR head with respect to the capstan.

In their VO1810 VCR Sony use the later of these two systems, and though the playback stability could be much improved the results produced are more than satisfactory for the applications intended for the machine.

When considering the operation of any videotape servo system it is important to stress exactly what the servo is trying to achieve before discussing the various electronic functions and operations of the system. Any tape servo system must have two signals, (1) a reference that is known to be correct, (2) a feedback signal which is to be compared with the reference. In both the record and playback modes of this VCR the vertical sync is used as the servo reference – in the form of separated vertical sync pulses during the recording and vertical sync pulses from the control track during playback. In both the record and playback modes the speed and phase of the head drum is compared with this vertical reference signal.

Summary of Servo Operation

The servo's vertical drive reference signal in the record mode is obtained by separating the field sync period from the video signal which is being recorded on the tape. This 50Hz signal is amplified, shaped and then recorded as a separate signal on the tape's control track. It is also used (see Fig. 1) as the reference information for the head drum servo system, a second pulse derived from the head drum itself providing the feedback signal. Phase comparison of these two signals produces a d.c. correction voltage which is amplified and applied to an electronic brake which either slows down or speeds up the head drum rotation. When the servo is locked the feedback pulse is coincident with the reference pulse.

The timing of the feedback signal to the servo is of great importance. For stable conditions it must coincide with the beginning of the scan which video head (a) makes of the tape.

During playback the servo has the task of reproducing the exact tape transport conditions that were present during recording. A vertical drive reference signal has been recorded on the tape's control track, and this signal is used as the servo reference during playback (see Fig. 2). The feedback signal from the head drum is phase compared with this signal and the resulting error voltage amplified and used to control the speed of the head drum itself.

Record mode

The record mode is simpler so we'll take this first. The following description is based on the block diagram published in the first part of this article – see pages 34-35 of the November issue.

A separated vertical sync signal obtained from the video input to the machine is available at the output of sync separator Q1-Q6 on board G1. This VD (vertical drive) signal is coupled directly to the input of IC3002C on the servo section of board B1. The VD signal triggers this monostable multivibrator (MMV).

The vertical drive signal is clipped before being applied to this MMV. The clipped signal is also coupled to the control

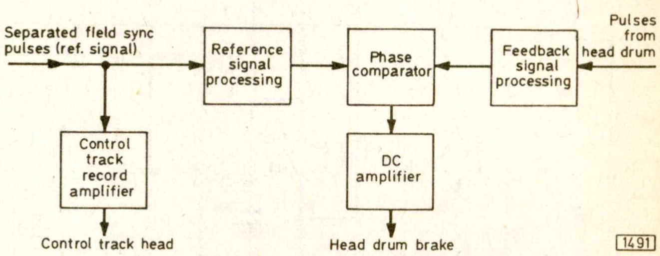


Fig. 1: Block diagram of the basic head servo system in the record mode.

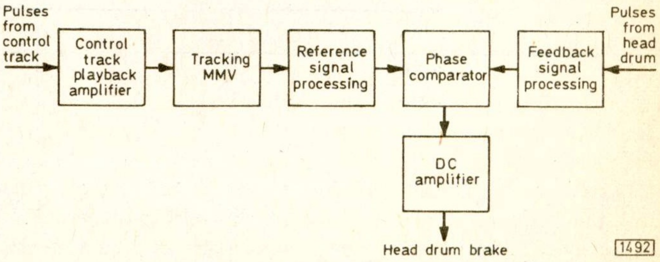


Fig. 2: Block diagram of the basic head servo system in the playback mode.

track record amplifier Q3001. This amplifier is muted during the lacing and unlacing of the videocassette. The main function of the control track is to indicate that a field sync period is being recorded, so the presence of the VD signal on the control track is of paramount importance to the operation of the machine.

Distortion of the recorded VD pulse is not so important because all that is required is that an *accurately timed* pulse is layed down on the tape. As an economy, h.f. bias is not applied to the control track head (this applies even in high cost broadcast VTRs). Hence the output of the control (CTL) track record amplifier is fed directly to the record/playback head. When this signal is replayed a considerable amount of distortion is present, but because the playback control track signal is applied to a switching amplifier which only conducts on the positive half cycle this distortion makes little difference.

Head Drum Servo

MMV IC3002C produces from the vertical drive pulse at its input a squarewave which is fed to the Miller integrator Q3012. The integrator converts this squarewave into a sawtooth ramp whose slope is proportional to the mark-space ratio of the squarewave. Q3013 (sampling hold) is the stage where the reference and feedback signals are phase compared, the ramp signal from Q3012 being the reference and the head drum pulse the feedback signal.

Production of the feedback pulse takes place as follows. The "30/25" (depending on the mains frequency) PG (pulse generator) coil A receives an induced voltage from a small pole piece mounted on the head drum every time video head (a) commences scanning the tape. This pulse is coupled to the servo electronics where it is amplified by Q3009. A negative-going output from this pulse amplifier is used to trigger two multivibrators, IC3002A and Q3018/19.

The latter of these two is also triggered by the output of pulse amplifier Q3005 which produces a similar negative-going pulse every time video head (b) commences its scan of the tape. Hence the output of the MMV Q3018/19 will consist of a positive-going pulse which will be present every time either head starts to scan the tape. When the servo is locked, these pulses will coincide with the vertical sync period of the record/replay waveform. They are used to inhibit the DOC on board K1.

The second output from pulse amplifier Q3009 is fed to MMV IC3002A which introduces a short delay in the waveform. The amount of delay determines the playback switching point between the two video heads before the field sync period (normally 6·5 lines).

One output from this MMV is fed directly to the next MMV IC3002B, a second is coupled to the video switching pulse generator Q1420/21 (B1 board, r.f. section) which inititiates the change over between the f.m. feeds of the two video heads. The additional delay inserted by IC3002B is required to position the feedback pulse from the head drum accurately in the correct part of the reference ramp.

Compensation to reduce the effect of head drum jitter is also included at this point by altering the mark-space ratio of the MMV. A separate phase-locked loop is used for this purpose, consisting of an integrator network followed by transistors Q3020/21/22. Description of this second servo loop is given later.

Now that the feedback signal from the head drum has been correctly delayed and corrected for variations in head drum speed it is coupled to Q3014 where it is amplified before being phase compared with the reference ramp voltage. In fact this feedback signal opens a gate that passes

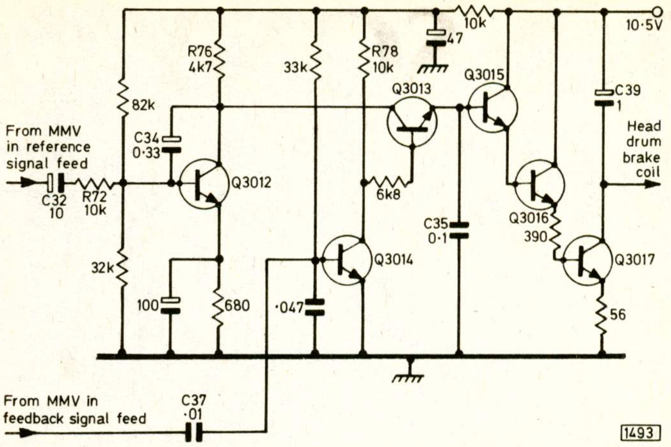


Fig. 3: The head drum brake control circuit. Q3012 integrates the reference signal to produce a ramp waveform for the phase comparator gate stage Q3013 which is switched on by the feed-back pulses at its base from Q3014 to sample the ramp. The control voltage is developed across C35 and is then amplified before being used to control the head drum brake.

the corresponding voltage of the reference ramp. The gated voltage is stored in a large capacitor which smooths the signal to produce a d.c. correcting voltage. The complete circuit of this stage is shown in Fig. 3.

Q3012 forms the Miller integrator, the reference squarewave from IC3002C being coupled via C32 and R72 to the base of this transistor. Heavy negative feedback provided by C34 is responsible for the integration of the input signal and the resulting ramp output is taken from the collector of the transistor. The feedback signal from IC3002B is coupled to the base of Q3014 for amplification and is then applied to the base of the gate Q3013. This transistor conducts only during the positive gate pulse period, and when it conducts the low resistance between its emitter and collector enables the reference ramp potential to be coupled to the storage capacitor C35. When Q3013 is cut off C35 holds its charge, thus producing the d.c. control voltage.

If the feedback pulse arrives early the ramp gating is advanced and the voltage stored by C35 rises; on the other hand if the feedback pulse arrives late the control voltage falls. Q3015/16 form a Darlington pair with a high input impedance to prevent the storage capacitor being loaded. Q3107 is a current amplifier which supplies the brake coil on the motor with the correcting current.

Phase-Locked Loop

Errors caused by rapid variations in head or tape speed are too quick for mechanical correction by the head drum servo and if left uncorrected would appear as horizontal jitter on the playback picture. To minimise this error electronic compensation is used in the form of a phase-locked loop which compares the feedback pulse from IC3002B with the reference vertical drive signal present at the input to IC3002C. Any errors produced by short term tape transport variations, i.e. head to tape pressure or head speed, are detected and the correcting voltage used to alter the mark-space ratio of MMV IC3002B. The method of phase comparison is very similar to the system used in the main servo, so a second description is unnecessary.

During the playback mode the control track signal is used instead of the reference vertical drive signal, and in this condition the correction will be for variations in tape speed rather than head speed.

Integration of the control voltage ensures that the error

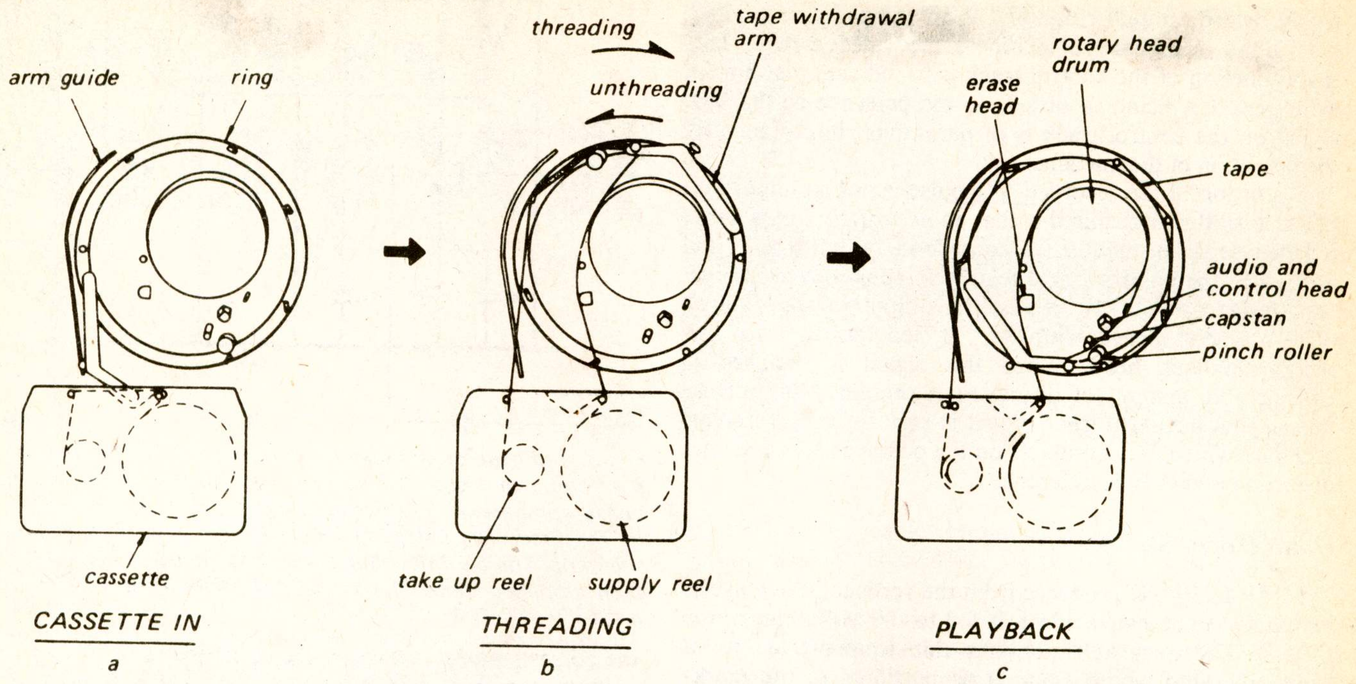


Fig. 4: How the tape is automatically threaded around the rotating video head drum by the tape withdrawal arm.

voltage produced is stored for a long time interval and therefore it's the *average* error that is corrected.

Playback Mode

We have seen that in the playback mode the servo reference is the prerecorded control track signal, and it might be assumed that all that's required is simply to switch the reference input to the servo system from one source to the other. Unfortunately it's not as simple as that, because if the machine is to be compatible with others of the same type it's necessary to compensate for small variations in the spacing between the video and control track heads from one machine to the other: this requires a manual control. Apart from this, it is quite possible that heat and other physical variables have stretched the tape slightly so that the spacing between the video and control track signals has changed on the tape rather than on the machine! To compensate for these problems provision is made to alter the timing of the control track reference pulse so that it can arrive earlier or later than its correct position. The rest of the servo electronics is the same as in the record mode, apart from the reference signal to the phase-locked loop previously described.

The output from the control track head is amplified and clipped by Q3002/3/4 to produce a clean negative-going 25Hz pulse which is then applied to the delay MMV IC3001B. IC3001C acts as a second delay stage, but in this case the mark-space ratio is adjustable so that the correct tracking can be obtained. A tracking on/off switch is provided so that tapes recorded on the machine can be played back with the switch in the off position, but if a tape recorded on another machine is used the tracking facility can if required be switched in. Should the control track be missing during playback the inhibit circuit Q3026 becomes operational, muting the video playback electronics completely to leave a blank raster on the screen of the receiver.

Time-constant switches are provided on the following i.c. multivibrators: IC3001A and B and IC3002A and C. These are included to alter the delays for 60Hz N.T.S.C. operation.

The Tape Path

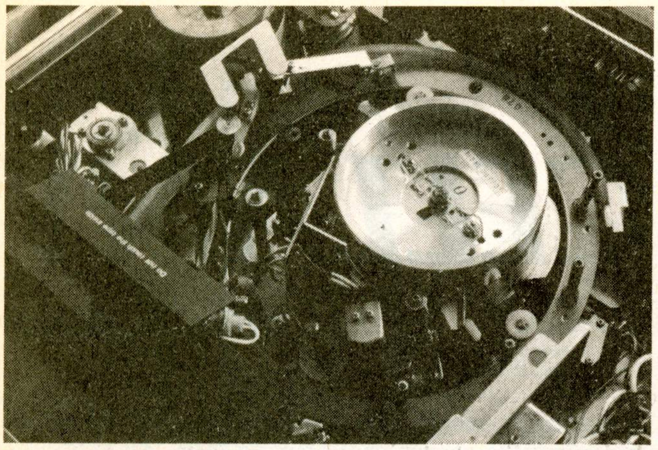
All videocassette recorders have to lace and unlace the tape around the head and other parts of the transport system automatically, and as the width of the tape increases so do the tape handling problems. Two inch broadcast cassette machines have to be seen to be believed! The Sony VO1810 uses $\frac{3}{4}$ inch tape and to watch the machine lace and unlace the tape makes many a service engineer stare in disbelief. The electronics involved in this process are even more mind boggling and would take the best part of six pages to describe. So the description which follows deals with the mechanical aspects and is much simplified. In the author's opinion it would be a very brave man who sat down and attempted to describe fully the operations that take place when the tape is threaded in the machine. Even Sony don't do it!

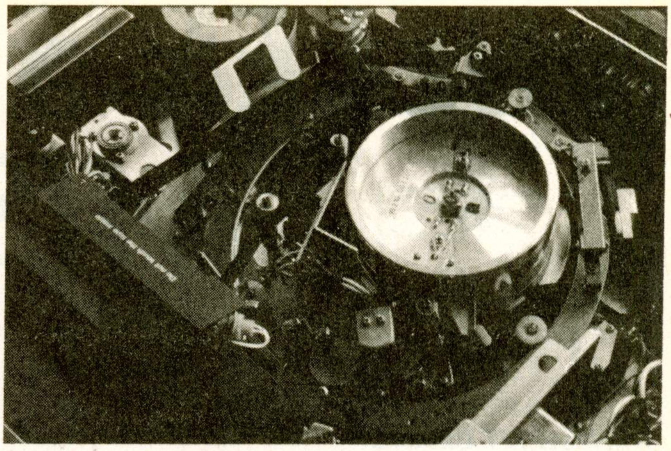
The mechanical operating modes of the VCR can be subdivided into two main sections: (a) Those that take place with the tape laced in the machine, i.e. playback and record. (b) Those that take place with the tape stored in the cassette, i.e. forward and reverse wind.

A photograph of the cassette was shown on page 32 of the November issue, and as you can see it is very similar in design and appearance to the normal audio cassette.

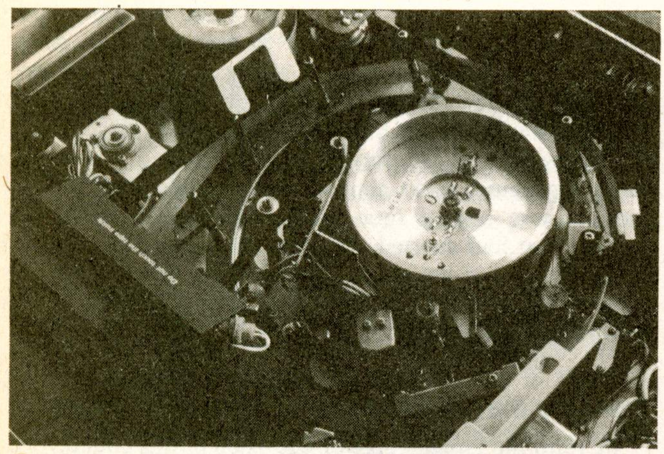
The tape remains inside the cassette, as shown in the photograph, during the wind and rewind modes. If this operation took place with the tape laced there would be a very great danger of the tape spilling when travelling at high speed, due to the large amount of tape outside the cassette. So every time the wind/rewind buttons are depressed the machine stops, unlaces the tape, and rewinds the tape inside the cassette. When the tape is rewound and the stop and forward buttons are depressed the machine stops, laces the tape, and then goes into the playback mode. Should the operator want to find a particular part of a prerecorded programme, and have to shuttle through the tape between wind and forward therefore, the process of lacing and unlacing the tape between each wind becomes rather a frustrating business!

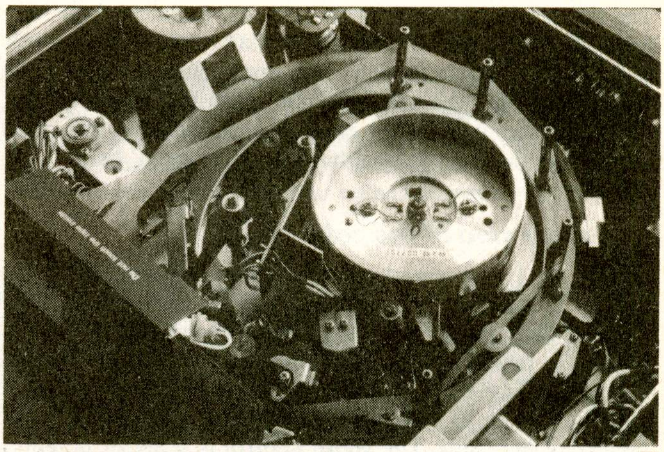
During all the other modes of operation the tape is laced





A *Photographs showing the interior of the machine as the tape starts to leave the cassette.* B





C *Photographs showing the concluding stages of the tape lacing action.* D

around the head drum. This operation takes places as follows. When the cassette is lowered into the machine a tape withdrawal arm is positioned behind the tape inside the cassette. See Fig. 4(a). The other end of this arm is mounted on a large ring which rotates in a clockwise direction as the tape is laced. When this ring starts to rotate, tape is pulled from the cassette, passes the erase head, and wraps around the video head drum. This situation is shown in Fig 4(b). Guide pins on the ring ensure that the tape follows the correct path. These can be seen more clearly in photographs A and B which show the interior of the machine as the tape starts to leave the cassette.

As the lacing process continues the ring completes one revolution of the head drum, pulling more tape from the cassette past the audio and control track heads and finally past the capstan. During this operation the brake on the feed spool in the cassette is released and back tension is applied to the take-up spool so that as the tape is laced in the machine it's kept taut. Fig. 4(c) shows diagrammatically the complete tape path when the lacing process is finished, while photographs C and D show the concluding stages of tape lace inside the machine. Note that the pinch roller is mounted on the outer ring with the tape withdrawal arm, and when the ring stops rotating the pinch roller is positioned opposite the capstan.

During the unthreading operation the reverse procedure takes place, the only difference being that the brake on the supply reel is engaged and as the tape is unlaced it's rewound on the take-up reel inside the cassette.

An auto rewind facility is employed every time the machine is put into the stop mode and the tape placed inside the cassette. This is necessary because the unlacing process effectively advances the tape, i.e. if the machine was made to lace the tape and then unlace the tape without going into play or record, the length of tape required to lace the machine would have been transferred from the feed spool to the take-up spool. To compensate for this effect the tape is automatically rewound for one second so that when relacing occurs the original section of the tape is around the drum.

At each end of the tape there is a transparent leader which enables a light source to shine through it on to a phototransistor. When this happens the machine automatically stops, unlaces the tape back into the cassette and then rewinds the tape back to the beginning. After this operation a repeat sequence can be used in which following the tape rewinding the machine relaces the tape and then goes back into the play mode: an ideal situation for lectures and demonstrations.

As the reader can see from the diagrams and photographs the mechanics of this VCR are highly complex. The section of the manual dealing with the mechanical adjustments is twice as long as the complete electronic line up procedure! If the complexity of the mechanics in VCRs advances as quickly as the electronics then the situation is going to be reached where the service engineer is going to need a degree in mechanical as well as electrical engineering!

The author would like to express his thanks to the technical staff of Tom Molland Ltd., Plymouth, for their help in the production of this article. ■