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tech tips

Testing Capstan Servos With The VC93 and Waveform Analyzer

This Tech Tip explains how to use the Sencore VC93 All Format VCR Analyzer and the Waveform Analyzer to troubleshoot VCR capstan servo problems. The step-by-step procedures will help you quickly isolate capstan servo problems to the defective circuit or component. If you need additional information on how servos operate, ask for a copy of Tech Tip #176. If you are unfamiliar with how the VC93 Servo Analyzer Tests work, ask for Tech Tip #186.

Servo Functional Analyzing

The main difficulty in troubleshooting servo problems is to determine which servo loop is at fault. Defects in one servo loop can produce symptoms that may suggest a problem elsewhere. In addition, non-servo related problems can sometimes appear as a servo problem. Functional analyzing using the VC93 and the Waveform Analyzer takes the guesswork out of servo analyzing.

Servo functional analyzing is a three step process:

1. Use the VC93 Servo Analyzer Tests to determine if the problem is servo related.
2. Use the same VC93 Servo Analyzer Tests to localize the problem to the defective drum or capstan servo section.
3. Use the Waveform Analyzer to check key signals to isolate the defective component or circuit within the bad servo section.

The first two steps of this three step servo functional analyzing process is covered in Tech Tip #186. The third step, as it pertains to capstan servo troubleshooting are covered in the remainder of this Tech Tip. Tech Tip #188 covers the third step as it pertains to drum servo troubleshooting.

Identifying Capstan Servo Problems

The VC93 provides five Servo Analyzer Tests that quickly pinpoint drum and capstan servo problems. You should do all five Servo Analyzer Tests to ensure that you have narrowed the problem down to the most likely defect. See Tech Tip #186 on how to perform and interpret these tests.

There are four possible capstan servo defect areas that the VC93 Servo Analyzer Tests identify:

I. Reference Frequency Defects
II. Capstan Phase Loop Defects
III. Capstan Speed Loop Defects
IV. Mechanical Defects

After you have tested the VCR with the VC93 and have determined fom the chart shown in Figure 1 that the defect area is the capstan servo, refer to the appropriate section in this Tech Tip to isolate the problem to the specific component or circuit.

SERVOS LOCKED	CAPSTAN SPEED ERROR	CAPSTAN JITTER	DRUM SPEED ERROR	DRUM JITTER	MOST LIKELY DEFECT	DEFECT AREA
GOOD	GOOD	GOOD	GOOD	GOOD	NO SERVO DEFECTS*	
GOOD	GOOD	GOOD	GOOD	BAD	DRUM MECHANICAL	
GOOD	GOOD	GOOD	BAD	N/A	REFERENCE FREQUENCY	
GOOD	GOOD	BAD	GOOD	GOOD	CAPSTAN MECHANICAL	IV
GOOD	BAD	N/A	GOOD	GOOD	REFERENCE FREQUENCY	I
GOOD	BAD	N/A	BAD	N/A	REFERENCE FREQUENCY	I
GOOD	BAD	N/A	GOOD	BAD	REFERENCE FREQUENCY	I
BAD	GOOD	GOOD	GOOD	GOOD	CAPSTAN PHASE LOOP or DRUM PHASE LOOP	II, III
BAD	BAD	N/A	GOOD	GOOD	CAPSTAN SPEED LOOP or CAPSTAN MECHANICAL	III, IV
BAD	GOOD	BAD	GOOD	GOOD	CAPSTAN PHASE LOOP or CAPSTAN MECHANICAL	II, IV
BAD	GOOD	GOOD	BAD	N/A	DRUM SPEED LOOP or DRUM MECHANICAL	
BAD	GOOD	GOOD	GOOD	BAD	DRUM PHASE LOOP or DRUM MECHANICAL	
BAD	BAD	N/A	BAD	N/A	REFERENCE FREQUENCY	I
BAD	BAD	N/A	GOOD	BAD	REFERENCE FREQUENCY	I

*NOTE: A noise bar that occurs periodically at a rate of one minute or greater could be a capstan or drum phase problem.

Fig. 1: Several VC93 Servo Analyzer Test results point to a potential capstan servo problem.

I. Locating Reference Frequency Defects

In the playback mode, the capstan and drum servos must lock to a reference 30 Hz (29.97 Hz) signal. This reference signal is derived from a higher frequency master oscillator such as the 3.58 MHz oscillator used by the color circuits.

NOTE: Some VCRs and camcorders do not use the 3.58 MHz color oscillator for its servo reference source. Refer to the manufacturers' service literature for the specific frequency of the servo reference oscillator in these VCRs and camcorders.

In most cases, the reference divider circuits are located inside the servo IC and the final reference 30 Hz signal cannot be directly measured. Instead, the master oscillator is the only signal available for testing. There are two essential parameters of the master oscillator that should be checked. They are its frequency and its amplitude. Use the Waveform Analyzer to quickly check both of these parameters.

The master oscillator must have sufficient amplitude to ensure that the count-down circuits inside the servo IC will properly generate the reference 30 Hz signal. Use the Waveform Analyzer to first check the amplitude of the master oscillator signal. Simply connect the Channel A probe to the master oscillator test point and press the CHAN A VPP button. Read the digital display and compare the results to the level given in the manufacturer's service literature.

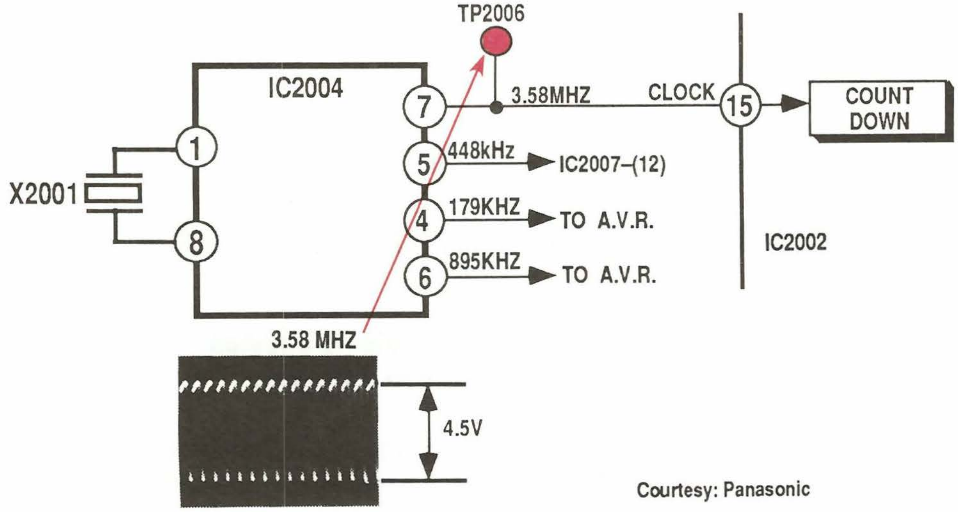

Fig. 2: Check the reference signal generator output for proper amplitude and frequency. If it is a 3.58 MHz color oscillator, the frequency should be within +/- 100 Hz of the correct frequency.

The master oscillator must also operate at the correct frequency to ensure that the servos operate correctly. In most VCRs, this signal is the 3.58 MHz color oscillator. Even an error as small as 100 Hz in the 3.58 MHz signal can cause problems in the servos and/or color circuits. Use the Waveform Analyzer to check the master oscillator frequency. Select the "CH A" position of the TRIGGER SOURCE switch, and the "Auto" position of the TRIGGER MODE switch. Leave the TRIGGER LEVEL control set to "0". Now press the CHAN A "FREQ" button and read the digital display. The frequency should read between 3.57945 and 3.57965. If it is outside this range, suspect a bad crystal or digital oscillator stage.

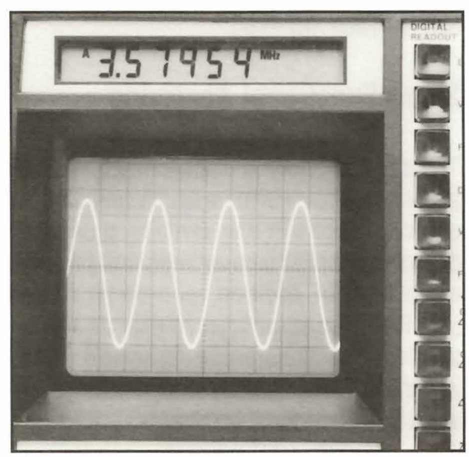

Fig. 3: Use the Waveform Analyzer to check the frequency of the 3.58 MHz reference.

II. Locating Capstan Phase Loop Defects

The SERVOS LOCKED test is one of the key tests in identifying whether a servo phase loop problem exists. The SERVOS LOCKED test, done alone however, will not isolate a problem down to the capstan phase loop. You need to perform the other four tests to determine if the problem is in the capstan phase loop or not. If the CAPSTAN JITTER test is also "bad" but the capstan speed test is good, then the VC93 has conclusively proved that a capstan phase loop problem exists.

Occasionally, you may test a VCR that reads "bad" on the SERVOS LOCKED test but "good" on all other tests. These test results occur when a marginal phase loop problem is not sufficiently bad for the other Servo Analyzer Tests to pick up. In this case, the problem is either in the capstan or the drum phase loop. To troubleshoot a marginal type of phase loop problem like this, start by troubleshooting the capstan phase loop following the procedures given here. If all capstan phase loop tests are good, then troubleshoot the drum phase following the procedures given in Tech Tip #188.

Also, a VCR may have an audio flutter or warble, leading you to believe it has a capstan servo problem, but the VC93 Servo Analyzer Tests indicate the servos are good. This tells you that something is causing jerky tape movement past the audio head, yet the electrical servos, which are working properly, are unable to correct the problem. In this case, a mechanical problem is causing the unstable tape movement.

Typical problems found here have been oxide buildup on the upper head cylinder causing inconsistent drag and take-up reel drive problems. If the problem is marginal, it may only be apparent in the slowest playback speed (SLP/EP). The VC93 servo tests are correctly indicating that the electrical servo circuits are working properly and do not need to be troubleshot. Instead, isolate the mechanical problem causing unstable tape movement.

There are several potential reasons why a capstan phase loop fails to operate. They are:

1. Control Track Logic (CTL) pulse is missing or weak.
2. Capstan servo IC is defective.
3. Low pass filter circuit is defective.

Troubleshooting of capstan phase loop problems is best done in the following sequence:

1. Check the CTL feedback signal:
Since a properly operating capstan phase servo circuit needs a feedback signal to tell it what the tape is doing, this is the first signal to check. The VC93 Troubleshooting Test Lead gives a check of the CTL signal. If the signal is missing or very weak in amplitude, the VC93 Servo Analyzer Display will show dashes when the SERVOS LOCKED, CAPSTAN SPEED ERROR and CAPSTAN JITTER tests are performed. This is an immediate indication of a CTL signal problem.

The amplitude of the CTL signal must be large enough to allow the servo circuits to see it. If the CTL pulse is too small, erratic operation will result. Check the manufacturer's service literature for the correct amplitude of the CTL pulse. Be sure to check the CTL pulse right at the CTL input pin on the capstan servo IC.

The Waveform Analyzer can be used to check the amplitude of the CTL pulse. First, connect the Channel A probe to the CTL

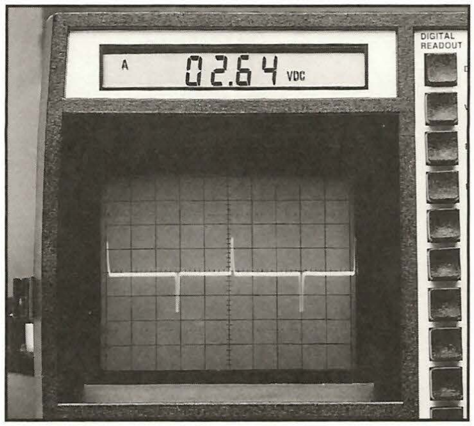

Fig. 4: The key feedback signal for the capstan servos is the CTL pulse. Check to be sure the amplitude is sufficient for proper operation.

input pin on the capstan servo IC. Next, press the CHAN A VPP button. Read the results on the digital display and compare to the manufacturer's service literature. If the signal is too small, inspect the CTL head for oxide buildup. Also check to be sure the alignment of the CTL head is correct.

2. Check the pulse width modulator (PWM) signal:
Most VCRs presently use pulse width modulators to create the servo correction voltages. Use the Waveform Analyzer to verify the operation of the PWM circuits. Connect the Waveform Analyzer to the capstan phase PWM output pin, ahead of the low-pass filter. Adjust the TIMEBASE-FREQ control on the Waveform Analyzer until you see two or three squarewave cycles.

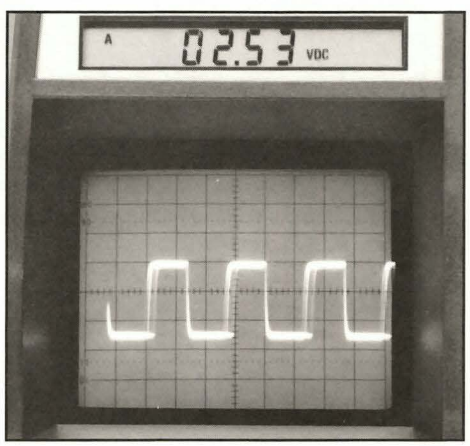

Fig. 5: The output of the pulse width modulator should vary slightly in duty cycle. Placing a light drag on the motor should change the duty cycle of the pulse.

The duty cycle of the PWM signal will constantly vary in a normally operating capstan servo. Confirm normal servo correction by increasing the physical drag on the capstan motor or capstan pulley. You should see the duty cycle of the PWM signal change as it attempts to correct for the drag on the capstan.

With a defective capstan servo, the PWM output will vary wildly, or remain steady. The steady condition may produce a squarewave with constant duty cycle, a narrow pulse, or a constant DC near the supply level or ground. If any of these conditions are observed and you have already confirmed that the capstan phase servo is receiving a proper CTL pulse and reference signal, then the servo IC is defective and should be replaced.

3. Check the low pass filter circuit:
The output of the capstan phase PWM must be filtered to supply a DC correction voltage for the motor control IC. A simple filter circuit is used to create this voltage. Move the Waveform Analyzer probe to the output of the low-pass filter circuit. Place the input coupling switch to DC, the VOLTS/DIVISION switch to .2, and the TIMEBASE-FREQ to 1m sec. Again, increase the physical drag on the capstan motor or capstan pulley and watch for up or down movement of the trace. If no movement is seen, or the DC voltage fluctuates wildly, then check the low-pass filter. Filter capacitors in these circuits sometimes develop high ESR or open up, preventing proper filtering of the capstan phase PWM signal.

III. Locating Capstan Speed Loop Defects

If the VC93 CAPSTAN SPEED ERROR test reads "bad", it indicates that the capstan speed circuits are not functioning properly. There are several reasons why the capstan speed circuits can fail. They are:

1. Frequency Generator (FG) signal is missing or weak.
2. Capstan servo IC is defective.
3. Low pass filter circuit is defective.

Troubleshoot a capstan speed problem in the following sequence:

1. Check the FG feedback signal:
Since a properly operating capstan speed circuit requires a feedback signal to monitor the speed of the capstan, this is the first signal to check. If the FG signal is missing, the capstan speed detect circuits will not function and the VCR may play at the wrong speed. Use the Waveform Analyzer to check for the presence of the capstan FG signal.

The amplitude of the FG signal must be large enough to allow the servo circuits to respond to it. If the FG pulse is too small, erratic operation will result. Use the Waveform Analyzer to check the amplitude of the FG pulse by first connecting the Channel A probe to the FG input pin on the capstan servo IC. Next, press the CHAN A VPP button. Read the results on the digital display and compare to the manufacturer's service literature. If the signal is weak or missing, check the FG sensor. If the sensor is a hall-effect type, verify that the sensor is receiving its required DC power. If the DC power is present at the sensor, then replace the hall-effect sensor.

2. Check the pulse width modulator (PWM) signal:
Most VCRs use a pulse width modulator followed by a low-pass filter to create the speed error correction voltages. Use the Waveform Analyzer to monitor the operation of the PWM output by connecting the Waveform Analyzer probe to the capstan speed PWM output pin, ahead of the low-pass filter. Adjust the TIMEBASE-FREQ control until you see two or three cycles of the FG pulse.

The duty cycle of the PWM signal will constantly vary in a normally operating capstan servo. Confirm normal servo operation by increasing the physical drag on the capstan motor or capstan pulley. You should see the duty cycle of the PWM signal change as it attempts to correct for the drag on the capstan.

With a defective capstan speed servo, the PWM output will vary wildly, or remain steady. The steady condition may produce a squarewave with constant duty cycle, a narrow pulse and reference, or a constant DC near the supply level or ground. If any of these conditions are observed and you have already confirmed that the capstan speed servo is receiving a proper FG pulse and reference, then the servo IC is defective and should be replaced.

3. Check the low-pass filter circuit:
The output of the capstan speed PWM must be filtered to supply a DC correction voltage to the motor control IC. A simple filter circuit is used to create this voltage. Move the Waveform Analyzer probe to the output of the low-pass filter circuit and monitor the output for a DC voltage. Place the input coupling switch to DC, the VOLTS/DIVISION switch to .2, and the TIMEBASE-FREQ switch to 1m sec. Adjust the VERTICAL POSITION control until the trace is in the center of the screen. Again, increase the physical drag on the capstan motor or capstan pulley and watch for up and down movement of the trace. If no change is seen, or the DC voltage fluctuates wildly, then check the filter. Filter capacitors in these circuits can sometimes exhibit high ESR or open up preventing proper filtering of the capstan speed PWM signal.

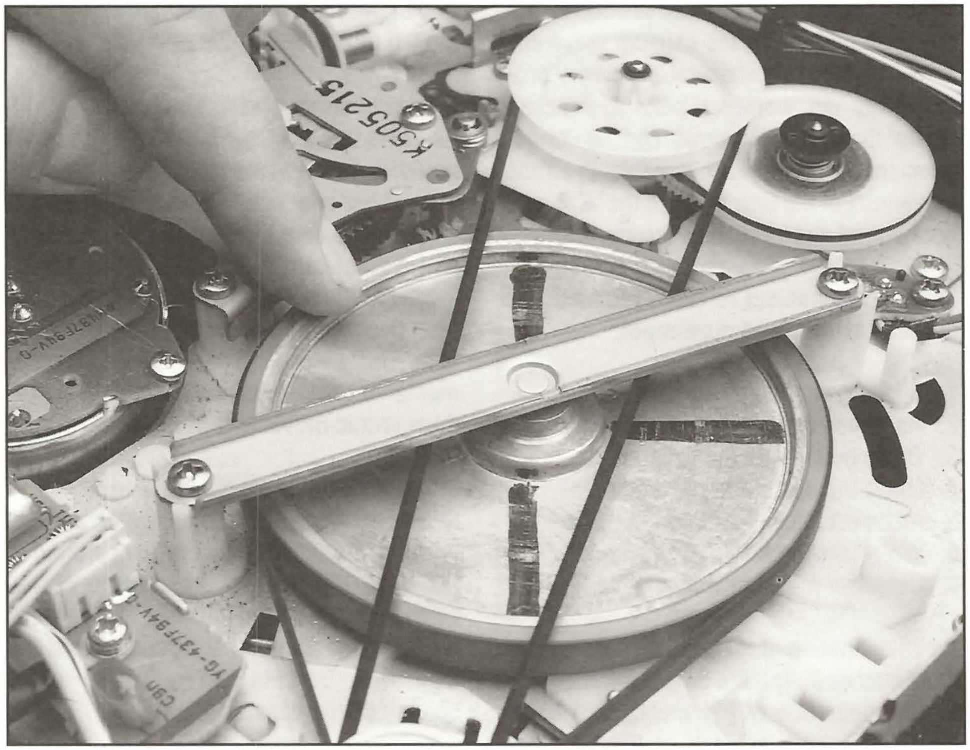

Fig. 6: Lightly touch the capstan motor with your finger to create a slight drag. You should see a change in the signals and voltages in the servo circuit in response to this drag.

IV. Locating Mechanical Defects

Minor capstan mechanical problems are compensated for by the capstan servo circuits. As these mechanical problems progressively get worse, a point is reached where the capstan servos can no longer compensate for them. This results in erratic movement of the tape through the VCR, and poor sound and/or picture quality.

Several mechanical related problems produce erratic tape movement:

1. Slipping capstan drive belt.
2. Hardened or glazed capstan pinch roller.
3. Oxide buildup on the capstan.
4. Oxide buildup along the tape path.
5. Incorrect back tension on the tape
6. Worn takeup reel drive clutch.
7. Defective motor or motor driver.

Troubleshooting of mechanical problems is most successfully done by carefully observing the operation of key mechanical functions. Let's look at each of the potential mechanical problem areas identified.

1. Slipping capstan drive belt:
Some VCRs, particularly older models, use a rubber belt to connect the capstan motor to the capstan drive shaft. Check to see if the belt has stretched due to age. Also verify that the belt is clean and dry. Oil from other mechanical parts of the VCR, for instance, can get on the belt and cause slippage as the oily part of the belt comes in contact with the smaller capstan motor pulley. Also check to be sure no foreign material has become lodged on the belt or the pulleys.

2. Hardened or glazed pinch roller:
All VCRs use a rubber pinch roller to apply pressure between the tape and the capstan. The rubber idler can become hardened and glazed with time. This produces inconsistent pressure on the tape and capstan resulting in random slippage. The pinch roller can also become coated with oxide from the tape. This will often cause the tape to momentarily stick to the pinch roller and produce erratic movement of the tape.

3. Oxide buildup on the capstan:
Good contact between the capstan and the tape is critical to the successful operation of the VCR. Capstans often become coated with loose oxide from the tape. This reduces the gripping ability of the capstan and the tape slips. Be sure to remove any oxide coating on the capstan shaft.

4. Oxide buildup along the tape path:
Oxide material from the tape can also build up anywhere along the tape path. This buildup produces tape drag. If the buildup becomes excessive, it increases the tape drag until the tape slips on the capstan.

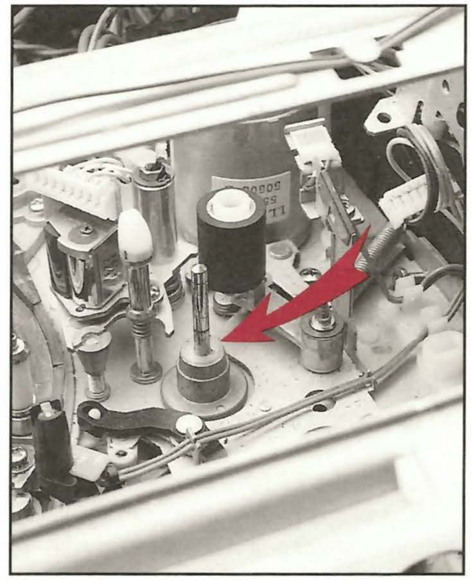

Fig. 8: A build-up of oxide on the capstan will cause the video tape to slip.

5. Incorrect back tension on the tape:
Excessive back tension on the tape produces the same result as an oxide buildup. It creates a drag on the tape that ultimately causes the tape to slip on the capstan. Use a tape tension gauge and adjust the back tension to the manufacturer's specifications.

6. Worn take-up reel drive clutch:
Often, the take-up reel's felt clutch assem-

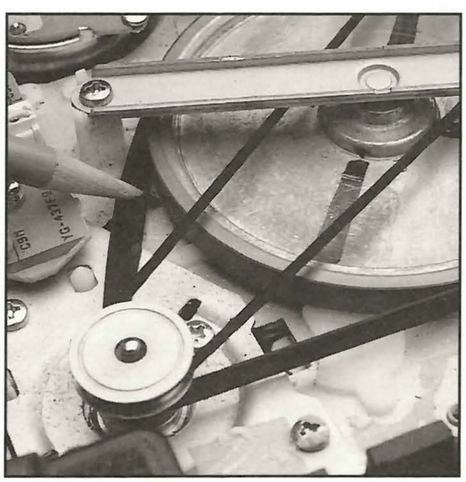

Fig. 7: Replace the capstan drive belt if it has become hard with age or has residue on it.

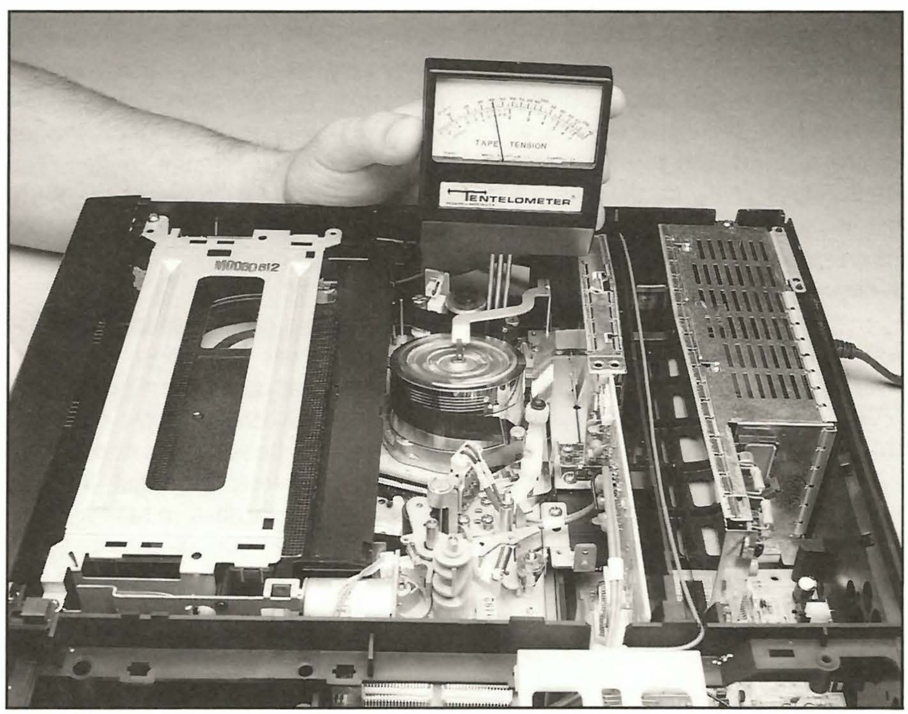

Fig. 9: Check the tape tension on the supply reel using a tension gauge.

bly becomes worn, causing it to grab or "chatter" instead of slipping smoothly. This causes the tape speed to fluctuate at a high enough amplitude and rate that the capstan servo circuits are unable to totally correct the problem.

7. Defective motor or motor driver:
A bad bearing, defective motor winding or missing drive signal can also cause erratic tape movement. Use the Servo Sub Bias on the VC93 to inject a DC voltage into the motor driver control input. The way the motor responds to this voltage tells a lot about the operation of the motor and motor driver. Changing the Servo Sub Bias voltage should cause the motor to change speeds, but the motor should turn smoothly at any speed.

You will not be able to get the motor to lock at its exact operating speed because the motor driver has extremely high gain. It is normal for variations of only a few tenths of a volt from the normal "zero correction" level to drastically change the motor speed. Careful control of the DC voltage should let you get the speed near normal. If the motor fails to turn, or continues to turn too quickly or too slowly with a normal DC input, the problem is in the motor driver or the motor.

If you suspect the motor driver circuits are at fault, continue to feed the substitute DC voltage into the driver IC while you trace the two or three phase AC motor drive signals with your Waveform Analyzer. Confirm that each driving signal has the same waveshape, frequency, peak-to-peak level, and DC bias as the others. Observe the CRT and press the appropriate digital readout selector buttons one at a time. If one signal differs from the others, the driver circuits are at fault, or the motor has a bad winding. If the signals are all the same and the motor has a jerking motion, stop the VCR and manually turn the capstan motor. Feel for any catching as you rotate the capstan motor. A sudden catch is an indication of a bad motor bearing.

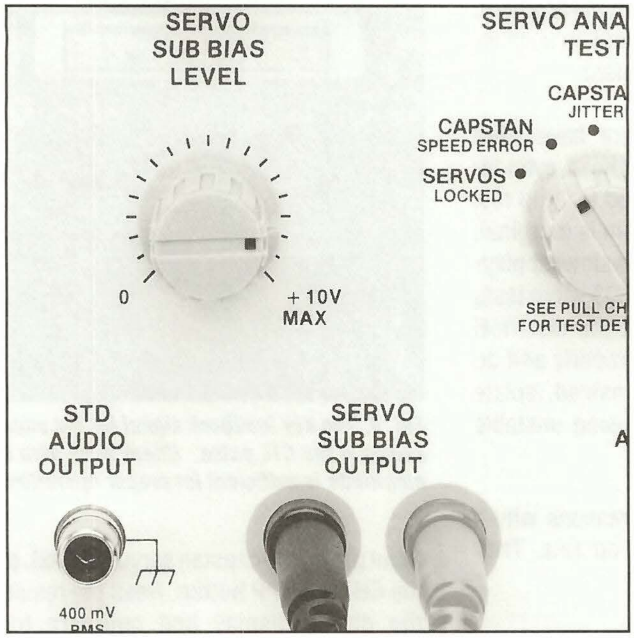

Fig. 10: Use the Servo Sub Bias supply on the VC93 to supply a substitute control voltage for the servo motor IC.

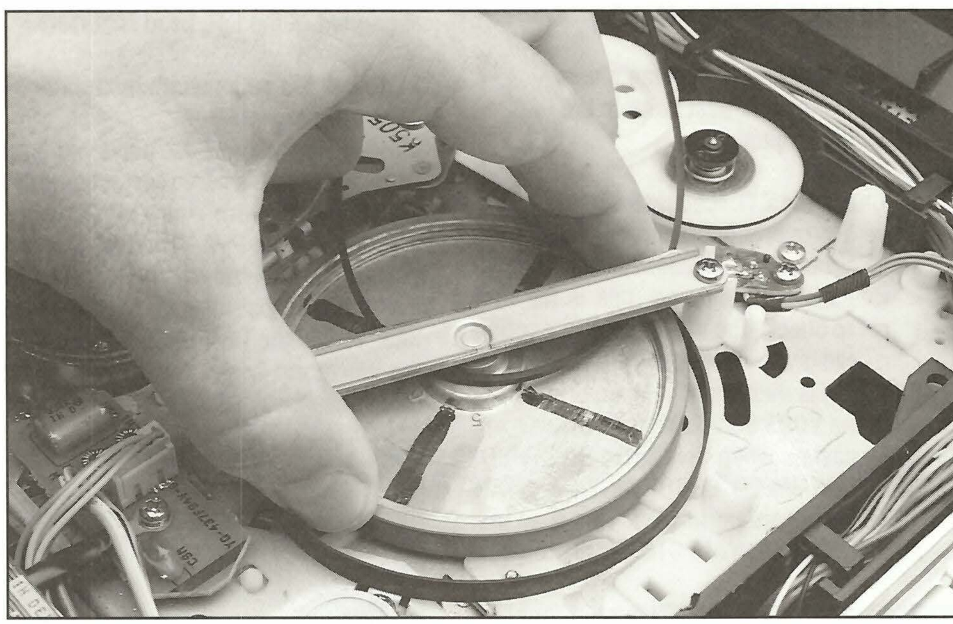

Fig. 11: Place a slight down pressure on the capstan motor as you turn it. Feel for a catch that is caused by a bad motor bearing.

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