Understanding compact disc troubleshooting concepts—Part 1

By Marcel R. Rialland

Compact disc technology was introduced in 1982, with the idea of greatly improving audio recordings. The compact disc has now become a widely accepted medium for audio recordings. Because of its large storage capacity, the compact disc is now used for applications other than audio; including CD-ROM (compact disc read-only memory), photo-CD, and CDI (compact disc interactive).

Laser Vision is also becoming more popular and new developments in optical recording devices, such as Sony's Mini Disc, have recently been introduced. All this new technology means expanded opportunities and challenges for the service technician.

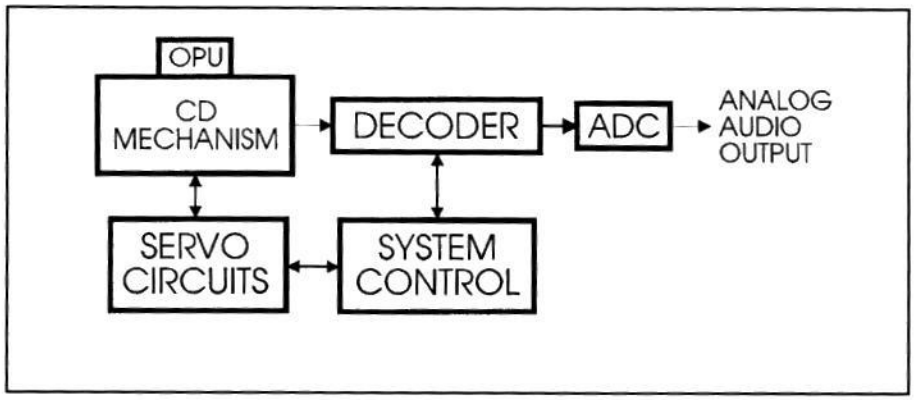

Figure 1. CD player block diagram.

The troubleshooting challenge

Troubleshooting compact disc players (or other laser read and write systems) can be quite a challenge. A thorough knowledge of the theory of operation can help a technician become more effective in diagnosing compact disc player faults. Also, there are some tools, test jigs, test discs, and test equipment (oscilloscope and DVM) that are needed to simplify service procedures.

The required equipment is usually listed in the service manual; which is also needed to service a compact disc player. The service manual contains service procedures, such as how to enter the test modes that assist in diagnosing the player. In many players, the test modes are used to check the condition of the laser pen (optical pick-up unit) as well as the status of the servo circuits.

Basic CD operation

The simplified block diagram, shown in Figure 1, illustrates the process of reading and decoding a compact disc. This process must be followed in all CD systems. First there must be a means of retrieving the data from the disc. This is accomplished by the optical pick-up unit (OPU), which is part of the CD mechanism. The CD mechanism provides the means for the OPU to track the disc.

Normally the spindle or turntable, which is used to spin the disc, is also part of the CD Mechanism. The position of the OPU, focus, tracking, and the data retrieval rate (spindle motor speed) are controlled by the servo circuits. The system control block controls the status of the servo system (including the start-up sequence), and interprets and initiates commands received via the remote control or local keypad.

The data from the disc must also be decoded. At the least, decoding includes: EFM demodulation, deinterleaving, error correction, interpolating unrecoverable data, digital to analog conversion, and filtering. Most of these processes are performed by the LSI ICs and there is little that a technician can do about what goes on internally. However, there are signals (clock and data) as well as control lines that one should be familiar with in order to become proficient in troubleshooting the CD player.

The data includes more than just digital audio samples. The data also includes

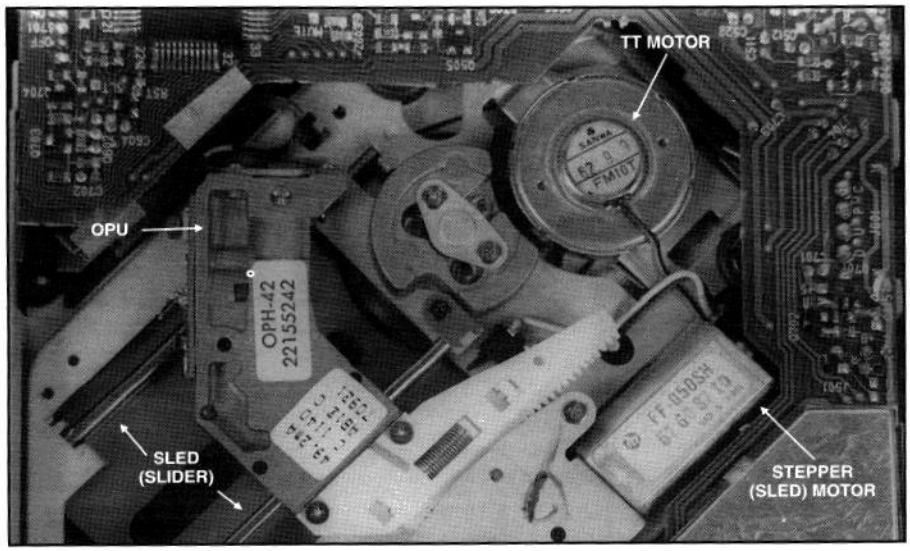

Figure 2. Three-beam servo CD mechanism (bottom view).

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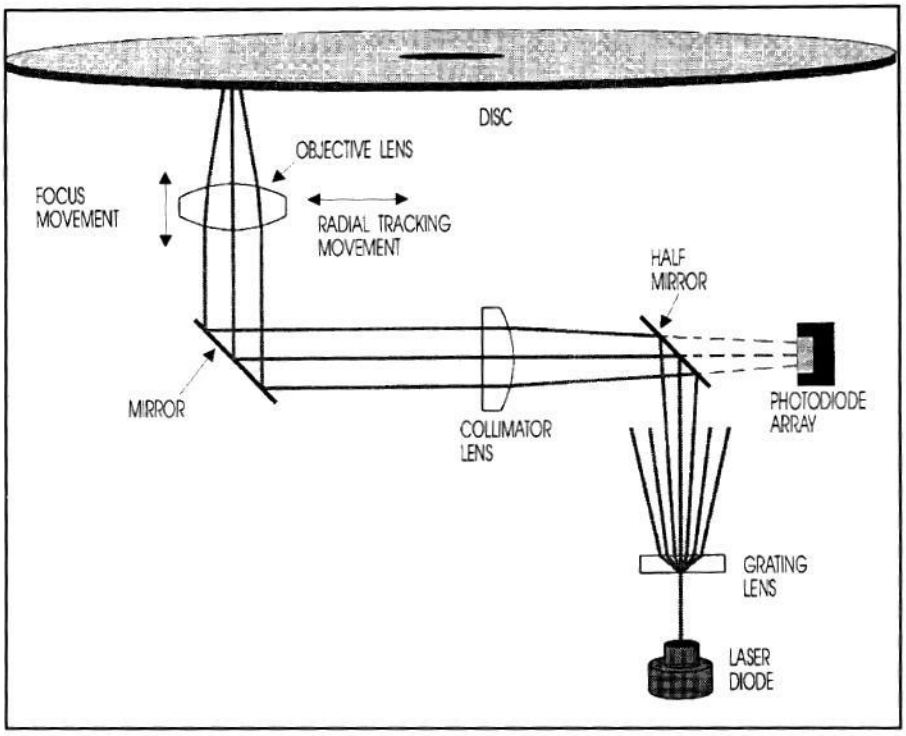

Figure 3. Three-beam optical pick-up unit.

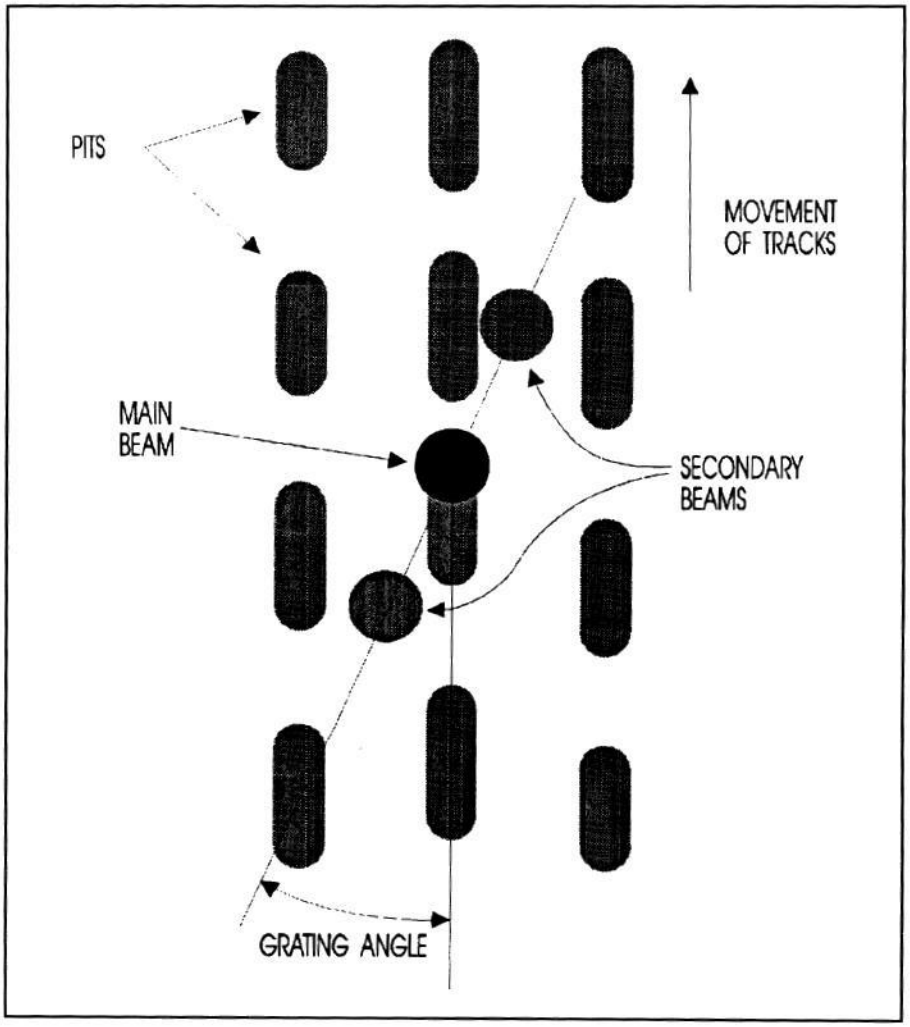

Figure 4. Grating angle.

parity bits (data for detecting errors), and control and display symbols. The decoder deinterleaves the data and uses the parity bits to recover unreliable data.

The control and display information is retrieved and used by the system control circuit for controlling the CD player system, and for displaying data related to the disc that is playing, such as elapsed time and the current track. The right and left audio 16-bit samples are converted to analog audio by the analog to digital converter (ADC).

Two types of servo systems

There are basically two types of servo systems, the single beam system and the three beam system. Most CD players contain three servo loops: the spindle (turntable) servo, focus servo, and tracking servo (radial tracking).

In addition, the laser beam intensity is controlled by a feedback control circuit. The servo loops must be operating before the data from the disc can even be retrieved (read) and decoded. The three beam system is examined in this article.

The three beam servo system

The bottom view of a CD mechanism for a three-beam servo system is shown in Figure 2. The CD mechanism can be divided into three main sections corresponding to their respective servo circuits: focus, turntable and tracking.

The focus servo circuit controls the focus movement of the objective lens (the objective lens is not shown).

The turntable servo (TT servo) controls the speed of the turntable motor.

As the compact disc spins, the tracking servo causes the OPU to follow the track. The tracking servo controls the position of the OPU in two ways: one for small (high frequency) radial corrections caused by the eccentricity of the disc and one for greater (low frequency) tracking corrections as the OPU tracks across the disc.

The first servo controls the movement of the OPU via radial tracking coils which control only the radial movement of the OPU. This loop allows fast response to the tracking servo. The second moves the entire OPU assembly on a sled via a stepper (sled) motor and gears.

The optical pick-up

The optical pick-up unit is a complex electromechanical device designed to op-

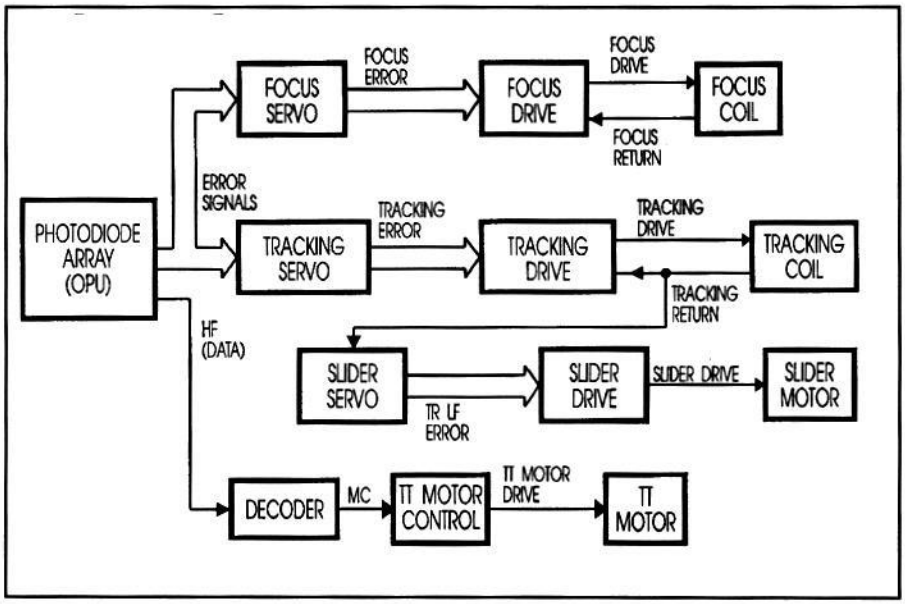

Figure 5. Three-beam servo system block diagram.

tically read and track the compact disc's spiral tracks. As illustrated in Figure 3, the three-beam optical pick-up unit is generally composed of lenses, mirrors, a laser diode and photodiodes.

A single beam, emitted from a laser diode, is split into several beams of which only three are used; the three in the center. The center or main beam is the most intense beam used for focus and reading the pits on the disc. The secondary or radial beams are used strictly for tracking.

The light bundle (three beams) is reflected by the half mirror toward the collimator lens (all three beams are placed in parallel by the collimator lens). The beams are then directed by another mirror up through the objective lens.

When the player is placed in a service mode to initiate a start-up, the lens can be seen moving up and down several times. The OPU should also move inward to locate the lead-in track.

If a disc is detected, the light bundle (modulated by the pits in the disc) is reflected back through the objective lens, mirror, and the collimator lens. Some of the reflected, modulated light bundle passes straight through the half mirror to strike the photodiode array.

Alignment is critical

The alignment (grating angle) of the three beams is very critical in the three-beam optical pick-up system as shown in Figure 4. An improper grating angle results in poor tracking or, in severe cases, tracking may not be possible at all.

In many cases, the grating angle is factory set and cannot be adjusted. Where there is an adjustment, the manufacturer's grating angle adjustment procedure as outlined in the service manual must be followed. Normally the adjustment is only made when replacing the optical pick-up unit.

The three beam servo block diagram is shown in Figure 5. The photodiodes provide focus and tracking error signals to the focus and tracking servo circuits. The focus error signal is developed by the focus servo circuit and is fed to the focus drive circuit. The focus drive provides the drive signal to the focus coil on the compact disc mechanism (CDM) to keep the laser beam focused on the disc.

The tracking servo circuit

The tracking servo circuit similarly receives tracking error signals from the photodiodes and develops the tracking (TR) error signal. The tracking error signal is fed to the tracking drive circuit, which applies drive to the tracking coil on the pick-up mechanism.

The coil provides the tracking (TR) return to the tracking drive and to the slider servo circuits. The slider servo provides low frequency (LF) tracking corrections. The TR LF (tracking low frequency) error signal is sent to the slider drive circuit to drive the slider motor.

The rotational speed of the turntable (TT) motor is controlled by detecting the data (detected from the HF) coming into the decoder block. This is done in the process of bit clock regeneration and decoding the incoming data. The decoder develops the motor control (MC) signal to regulate the speed of the motor and thus keep the demodulated data coming at the correct speed (4.3218 Mb per second).

Starting the disc

Every CD player must go through a start-up procedure in order to start playing a CD. It is important to know the start-up sequence when troubleshooting a condition where the disc will not play. The start-up sequence is initiated by the microprocessor when it receives a command to detect the presence of a CD or to start playing the disc.

The start-up initiates as follows (note: some of the steps occur simultaneously):

1. Turn the laser diode on.
2. Focus the laser beam (the objective lens will move up and down until focus is achieved).
3. Start the disc turntable motor (TT servo locks when data is detected).
4. Move OPU to the lead-in track and read the table of contents.

Although there are variations in the start-up sequence between makes and models, all CD systems must find focus and find the control and display data (especially the table of contents in the lead-in track) to play a disc.

Once the CD starts, all the servos remain locked, until a jump track command (skip track or fast forward or reverse) is received. In this case, the servo microprocessor works with the tracking servo to allow skipping of tracks until the desired selection has been located.

A laser power meter can be used to check the status of the laser beam. The laser power meter is also used to adjust the laser power level following the service manual's instructions for the unit under test. This check or adjustment is usually performed while the player is in the service mode.

In some players, the intensity of the laser diode is measured by checking a reference voltage in the laser diode control circuit. This voltage is proportional to the intensity of the laser diode.

Part two will take a closer look at some troubleshooting techniques for the three-beam servo circuit and introduce the single-beam servo system. ■