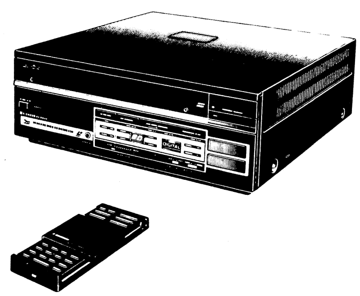
PIONEER®

Technical Information



ORDER NO.
VRT-051-0

COMPACT DISC/LASERVISION PLAYER

CLD-900

NTSC

CONFIDENTIAL

CONTENTS

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1. SPECIFICATIONS

1. General

System .... LaserVision video disc system and Compact disc digital audio system

Power reguirement

KU model .... AC120V, 50/60 Hz

S/G model..................... AC 110V/120V/220V/240V (switchable), 50/60 Hz

Power consumption .... 45 watts

Dimensions .... 420 (W) x 447 (D) x 168 (H) mm. 16.5 (W) x 17.6 (D) x 6.6 (H) in.

Net weight (without package) .... 15.6 kg (34.5 lbs.)

Operating temperature .... +5°C to +35°C

Operating humidity .... 0 to 95% (There should be no moisture condensation)

2. Disc

LaserVision video disc

*Maximum playing time

12-inch standard play disc .... 30 min/side

12-inch extended play disc .... 60 min/side

8-inch standard play disc .... 14 min/side

8-inch extended play disc .... 20 min/side

Spindle motor speed

Standard play disc .... 1,800 RPM

Extended play disc .... 1,800 RPM (inner circumference) to 600 RPM (outer circumference)

Compact disc

Disc .... Diameter: 120 mm, Thickness: 1.2 mm

*Maximum playing time .... over 60 minutes (stereo)

Linear speed .... 1.2 ~ 1.4 m/sec

**Actual playback time differs for each disc.*

3. Video characteristics

Format .... NTSC specifications

Video output

Level .... 1 Vp-p nominal, sync. negative, terminated

Impedance .... 75 ohms unbalanced

Terminal .... RCA jack

VHF output

Channel .... Channel 3 or 4 (switchable)

Impedance .... 75 ohms unbalanced

Terminal .... F-type jack

4. Audio Characteristics

Disc	AUDIO OUTPUT 1	AUDIO OUTPUT 2
LaserVision Disc	YES	YES
LaserVision with Digital Sound Disc	YES*	YES**
Compact Disc	YES	NO

* *Digital Sound/Analog Sound switching possible.*

** *Only Analog Sound output.*

Terminal .... RCA jacks

Channel

LaserVision disc playback .... Two channel: stereo or two individual channels

Compact Disc playback .... Two channel: stereo

Digital sound characteristics (AUDIO OUTPUT 1)

Frequency response .... 5 Hz to 20 kHz, ±0.5 dB

S/N (signal to noise ratio) .... 96 dB (1 kHz)

Dynamic range .... 96 dB (1 kHz)

Channel separation .... 94 dB (1 kHz)

Wow and Flutter .... Quartz oscillator accuracy

Total harmonic distortion .... 0.003% (1 kHz, 0 dB)

Level

AUDIO OUTPUT 1

Analog sound playback .... 260 mVrms (1 kHz, 40%)

Digital sound playback .... 260 mVrms (1 kHz, –20 dB)

AUDIO OUTPUT 2

Analog sound playback only .... 260 mVrms (1 kHz, 40%)

5. Functions

Functions possible with the Remote Control Unit CU-900:

Functions	LaserVision Disc Standard Play Disc	LaserVision Disc Extended Play Disc	Compact Disc
PLAY	YES	YES	YES
STOP (EJECT)	YES	YES	YES
PAUSE	YES	YES	YES
SCAN (Forward, Reverse)	YES	YES	YES
INTERVAL REPEAT	YES	YES	YES
FAST (Forward, Reverse)	YES	NO	–
STILL/STEP (Forward, Reverse)	YES	NO	–
MULTI-SPEED PLAY (Forward, Reverse)	YES	NO	–
MULTI-SPEED DISPLAY	YES	NO	–
FRAME NUMBER DISPLAY	YES	NO	–
TIME NUMBER DISPLAY	NO	YES	–
CHAPTER NUMBER DISPLAY	YES*	YES*	–
FRAME NUMBER SEARCH	YES	NO	–
TIME NUMBER SEARCH	NO	YES	–
CHAPTER NUMBER SEARCH	YES*	YES*	–
CHAPTER STOP	YES*	YES*	–
SINGLE-TRACK REPEAT	–	–	YES
ALL-TRACK REPEAT	–	–	YES
SKIP SEARCH	–	–	YES
TRACK SEARCH	–	–	YES
INDEX SEARCH	–	–	YES
PLAYBACK INFORMATION DISPLAY	–	–	YES

Functions possible with the function buttons and switches on the player.

Functions	LaserVision Disc		Compact Disc
	Standard Play Disc	Extended Play Disc	
PLAY	YES	YES	YES
EJECT	YES	YES	YES
AUTO REPEAT ON/OFF	YES	YES	YES
CX NOISE REDUCTION ON/OFF	YES**	YES**	—

** Only for discs recorded with chapter codes.*
*** Effective when using LaserVision discs with the CX mark.*

Other functions (LaserVision video disc playback only)
AUTOMATIC PICTURE STOP .... Only for discs recorded with picture stop code.
DIGITAL SOUND/ANALOG SOUND SELECTION .... Only for LaserVision with Digital Sound Disc playback.

6. Other terminals

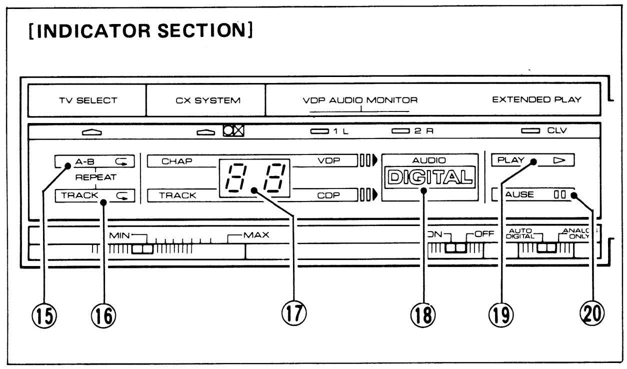
I/O port .... 8-pin, DIN
PHONES .... Stereo headphones jack

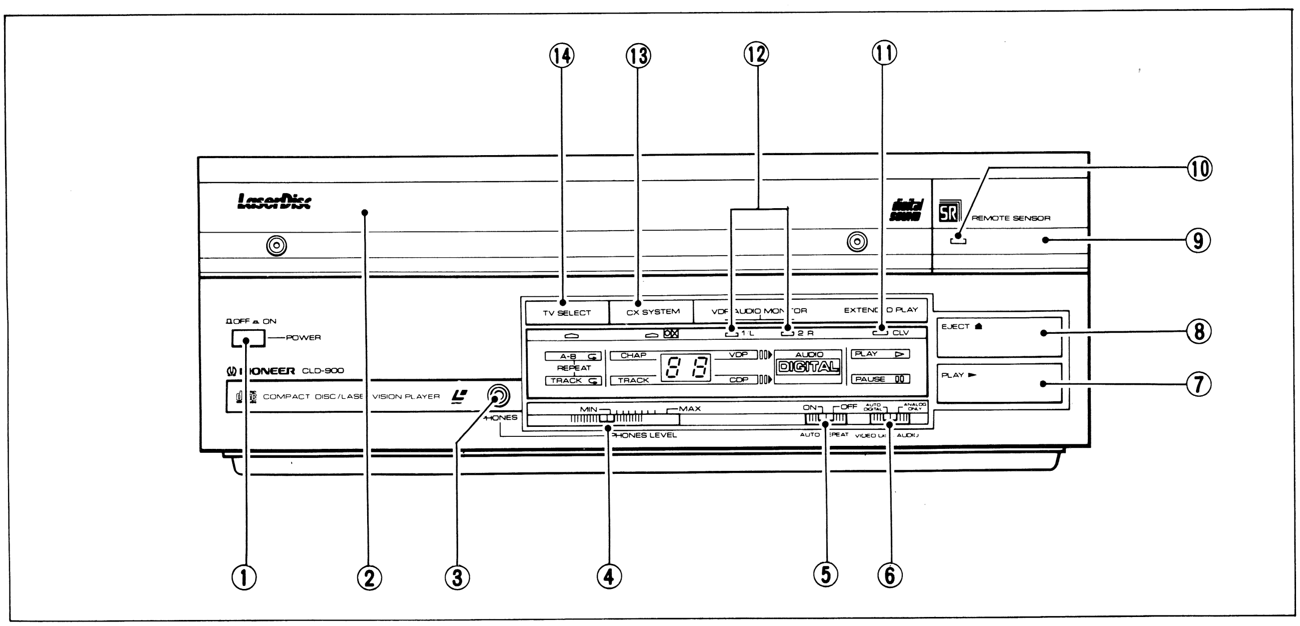
7. Furnished Accessories

Remote control unit (CU-900) 1
Size "AA" dry batteries 2
VHF connecting cable with F-type plugs 1
Audio connecting cords with RCA-plugs 1
Video connecting cable with RCA-plugs 1
300-ohms to 75-ohms F-type plug 1
75-ohms F-type plug adaptor 1
Operating instructions 1
Warranty card 1

NOTE:
Specifications and design subject to possible modifications without notice, due to improvement.

2. FACILITIES





① POWER

② DISC TABLE

After turning on the POWER switch, press the EJECT button ⑧ and the disc table will open slightly towards the front. Then, pull the disc table out by hand to load discs.

③ PHONES jack

Connect stereo headphones here.

④ PHONES LEVEL

Use to control the volume level of headphones connected to the PHONES jack.

⑤ AUTO REPEAT ON/OFF switch

When set to ON, repeat playback of one side of the disc will be performed. When set to OFF, disc rotation will stop after one side of the disc has been played.

⑥ VIDEO DISC AUDIO: AUTO DIGITAL/ANALOG ONLY

This switch is used to select the audio mode when playing back LaserVision with Digital Sound Discs. By setting this switch appropriately, the audio output from the rear panel "AUDIO OUTPUT 1" terminals can be switched between Digital Sound and Analog Sound.

AUTO DIGITAL
When set to this position, if playing back the LaserVision with Digital Sound Discs, those Digital Sound will be reproduced.
When playing back the LaserVision Discs recorded with Analog Sound only, the Analog Sound will be reproduced.
ANALOG ONLY
No matter what the LaserVision disc (with Digital Sound or not), the Analog Sound signals only will be played back.

This selector switch is unrelated to the rear panel "AUDIO OUTPUT 2" terminals since those terminals constantly output Analog Sound signals only.

⑦ PLAY ►

Press to begin playback.

⑧ EJECT ▲

Press to stop playback and remove a loaded disc. The disc table will open slightly to the front.

⑨ REMOTE CONTROL receiver

The infrared signals from the remote control unit are received here.

⑩ REMOTE CONTROL indicator

This indicator lights when the remote control unit's buttons are pressed.

⑪ EXTENDED PLAY DISC indicator

This indicator lights automatically when playing extended play (CLV) discs.

⑫ VDP AUDIO MONITOR indicator

Indicates the audio output channel (1/L, 2/R) when playing LaserVision discs.

⑬ CX SYSTEM

Use for turning the CX noise reduction system ON and OFF.

⑭ TV SELECT

Use for switching between LaserVision disc or Compact Disc playback and VHF television broadcast reception. When the indicator goes out, LaserVision disc or Compact Disc playback is possible; when lit, TV broadcasts can be watched.

[INDICATOR SECTION]

⑮ A—B (interval) REPEAT indicator

Lights when performing repeat play of an interval between two selected points.

⑯ TRACK REPEAT indicator

Lights when performing repeat playback of a single track on a Compact Disc.

⑰ Numeric display (CHAP./TRACK)

When playing back a LaserVision disc, displays the "chapter" number presently being played back.
When playing back a Compact Disc, displays the "track" number presently being played back.

When playing back LaserVision discs without recorded chapter numbers, no chapter numbers are displayed.

⑱ DIGITAL indicator

Lights when playing LaserVision with Digital Sound Discs, or when playing Compact Discs.

⑲ PLAY indicator

Lights when the player is in the play mode. When time is required between the pressing of the button and actual beginning of playback (for example, when first beginning play, or when performing search), this indicator will flash during that interval.

⑳ PAUSE indicator

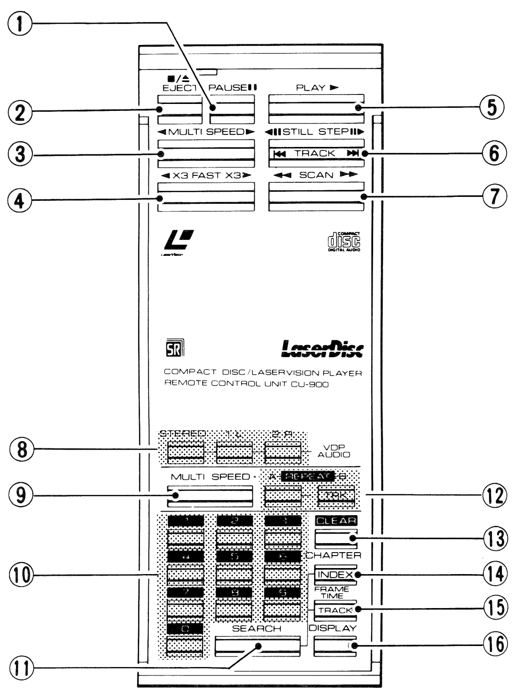
Lights to indicate player is in the pause mode.

The accessory remote control unit can be used during playback of both LaserVision discs and Compact Discs. Some buttons have different functions when used with LaserVision discs and Compact Discs; these buttons appear in the following colors when used with the two disc modes:

Blue: Function used only with LaserVision discs.
Green: Function used only with Compact Discs.

Buttons appearing in other colors have same functions with both kinds of discs.

[WHEN PLAYING BACK VIDEO DISCS]



The actual remote control unit has a slide cover; move it up and down when using the unit.

① PAUSE (▮▮)

Press to temporarily halt playback.
To release the player from the pause mode, press once again.

② EJECT (■/▲)

When this button is pressed, playback is stopped, and the disc rotation ceases. When pressed once again, the disc table will open after the disc stops rotating.

③ ◄ MULTI-SPEED ► (Standard play discs only)

When the right side (►) of the button is pressed, the video image will be sent forward at the speed set with the −MULTI-SPEED+ button.
When the left side (◄) of the button is pressed, the video image will be sent backwards.

④ ◄x3 FAST x3► (Standard play discs only)

During the time the right side (x3►) of the button is held depressed, the video image will advance at three times normal speed. When the left side (◄x3) is held depressed, the video image will be sent backwards at three times normal speed.

⑤ PLAY ►

Press to begin playback.

⑥ ◄▮▮ STILL/STEP ▮▮► (Standard play discs only)

When either the right or left side of the button is pressed, the video image will be shown as a still picture. Then, each time thereafter that the right side (▮▮►) is pressed, the image will be advanced by one frame; each time that the left side (◄▮▮) is pressed, the image will be reversed one frame.

⑦ ◄◄ SCAN ►►

While right side of the button (►►) is held depressed, the video image will be advanced at high speed.
While left side of the button (◄◄) is held depressed, the video image will be reversed at high speed.

⑧ VDP AUDIO

Use to select the audio channel. When the power is first turned on, the audio will be reset automatically to both 1/L, 2/R.
When one of the buttons 1/L, 2/R is pressed, the audio channel corresponding to that button only will be heard. The other channel will be suppressed, and its indicator on the player's front panel will go out.
When the STEREO button is pressed, both channels will return to their original play condition.

NOTE:
- *Audio reproduction is only possible in the normal play mode.*
- *When only one audio channel is in use, the sound is still fed to both audio output terminals (1/L, 2/R).*

⑨ −MULTI-SPEED+

Use to select the playback speed during multi-speed playback.

⑩ Numeric buttons

Use when performing search (random access).

⑪ SEARCH

Use when performing search (random access).

⑫ REPEAT
Use when performing repeat playback between two selected points.

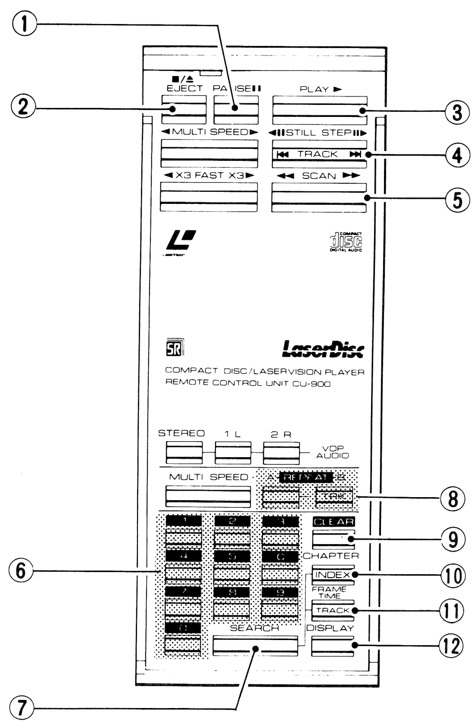
⑬ CLEAR
Use when correcting input numbers during the search procedures, or cancelling the search procedures. Also, use to cancel the repeat play back mode.

⑭ CHAPTER
Use when performing search by means of chapter numbers.

⑮ FRAME/TIME
Use when performing search by means of frame numbers (time numbers on extended play discs).

⑯ DISPLAY
Use to display and erase chapter numbers and frame numbers (time numbers on extended play discs) on the TV screen.

[WHEN PLAYING BACK COMPACT DISCS]



The actual remote control unit has a slide cover; move it up and down when using the unit.

① PAUSE
Use to temporarily halt playback.

② EJECT
When this button is pressed, playback is stopped, and the disc rotation ceases. When pressed once again, the disc table opens to the front after the disc has stopped rotating.

③ PLAY ►
Use to begin playback, and to cancel the pause mode.

④ ⏮ TRACK ⏭
Use when skipping tracks search. (Skip search operation).

⏭: Playback moves forward to the beginning of the next track.
⏮: Playback moves backwards to the beginning of the presently playing track.
By pressing repeatedly, any desired number of tracks can be skipped.

⑤ ◄◄ SCAN ►►
While the ►► side is held depressed, the playback will be advanced at high speed.
While the ◄◄ side is held depressed, the playback will be reversed at high speed.
During the scan operation, the audio will be heard at a reduced level.

⑥ Numeric buttons
Use to designate specific track numbers, and index numbers within tracks when performing search.

⑦ SEARCH
This is the command button pressed to execute track and index search.

⑧ TRK. REPEAT, A–B REPEAT
Use when performing single-track repeat playback, or repeat play of the interval between two designated points on the disc.

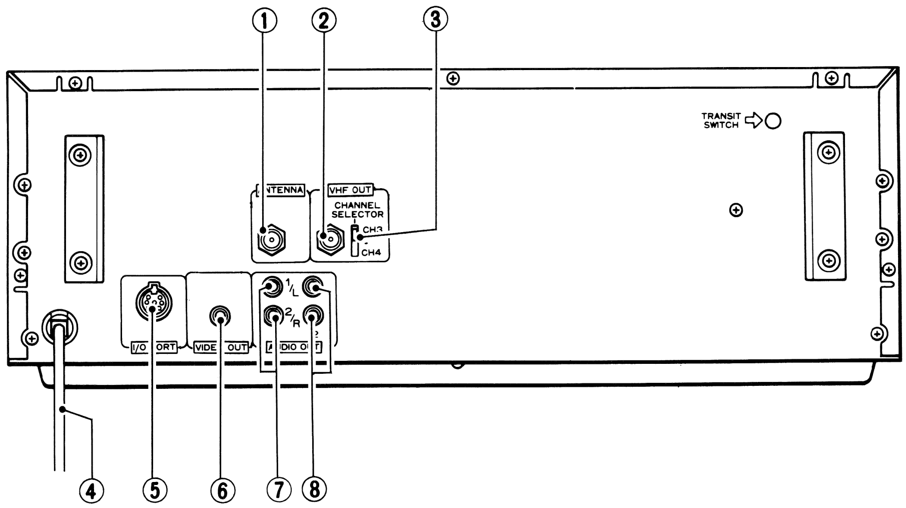
⑨ CLEAR
Use to cancel single-track or interval repeat playback, to correct numbers used for search, and to cancel the search procedure itself.

⑩ INDEX
Use when performing search by means of index numbers within the track currently playing.

⑪ TRACK
Use when performing search by track numbers.

⑫ DISPLAY
Use for selecting the information to be displayed on the TV screen when playing a Compact Disc.

* *INDEX refers to signals which are previously recorded on a disc and which indicate sub-divisions within a track.*



① ANTENNA

The coaxial cable (75 ohm) from a VHF television antenna is connected here.

② CH. 3/4 VHF OUT

Connect to a television's VHF antenna input terminal.

③ VHF CHANNEL SELECTOR

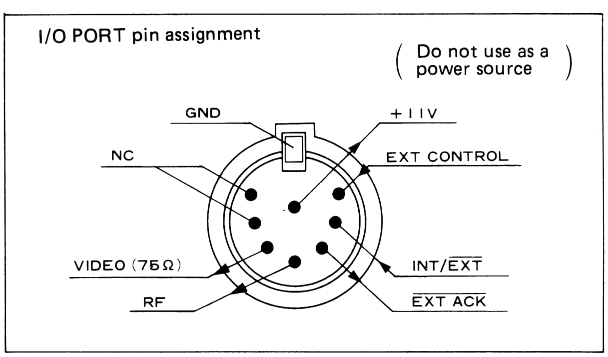
This selector is for switching the internal VHF converter. Set to the channel which is not used for TV broadcasts in your area.

④ POWER CORD

Plug this into an electrical outlet.

⑤ I/O PORT

This is the I/O port used when performing external control of the player.



⑥ VIDEO OUTPUT

When using a video TV monitor to play back the video image, connect this terminal to the TV monitor's video input terminal.

⑦ AUDIO OUTPUT 1

Connect to your stereo amplifier's AUX, CD, or TUNER input terminals.
When playing back the LaserVision with Digital Sound Discs, select the front panel's VIDEO DISC AUDIO switch to AUTO DIGITAL (Digital Sound output) or ANALOG ONLY (Analog Sound output).
The audio signals of the Compact Disc are output from these terminals only.

⑧ AUDIO OUTPUT 2

Connect to your stereo amplifier's AUX, CD, or TUNER input terminals.
These terminals output only the LaserVision disc's Analog Sound signals.

3. DESCRIPTION OF OPTICAL PATH SYSTEM

The optical path of the CLD-900 pick-up is basically the same as that of the conventional LD-700 Laser Vision player.
Fig. 3.1 shows the arrangement of the optical parts used in the pick-up and a brief description of their operation follows.
The light from the semiconductor laser has a wavelength of approximately 780nm and this light is output radially from the emission point located in the microchip. The light spreads out from the emission point in parallel with the junction layer of the chip and it starts spreading out at the end face of the chip in the perpendicular direction. For this reason the apparent emission point differs from the horizontal direction and astigmatism is caused.
A cylindrical lens is employed to compensate for the astigmatism and this is positioned so that the perpendicular emission point appears to coincide with the horizontal emission point.
The radial light, which has passed through this cylindrical lens becomes converged by the following coupling lens into a parallel beam.
When the beam passes through the grating plate, it is separated into a multiple number of beams by diffraction. These beams are known in sequence from the center beam (0th order beam) as the ±1st order beams, ±2nd order beams and so on. The ±1st order beams are employed for detecting the tracking error.
The beam splitter in the outward path of the beam simply allows the beam to pass through but on the return path it reflects the beam in a 90-degree direction.
In other words, the action of the 1/4 wavelength plate serves to provide the beam reflected from the disc with a 1/2 wavelength (180-degree) delay over the return path beam and the beam splitter serves to reflect this beam in the 90-degree direction.
The toric lens is installed in order to detect the focus error and it serves to focus the reflected beam onto the photo-detector array.
The direction of the beam of light, which has now passed through both the beam splitter and the 1/4 wavelength plate, is now changed by the reflection of the tracking and tangential mirrors, and the beam focused by the objective lens and directed onto the disc.

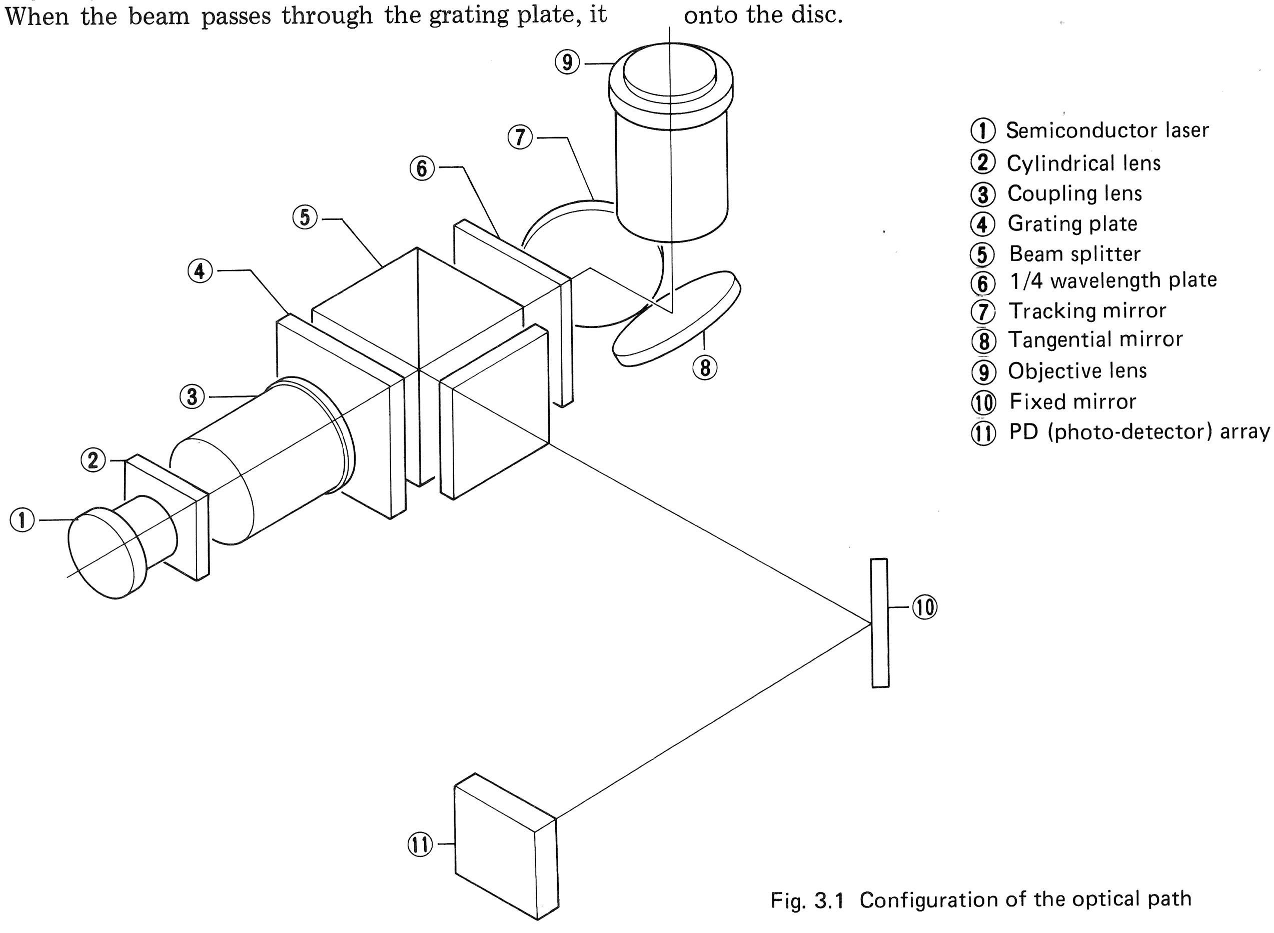


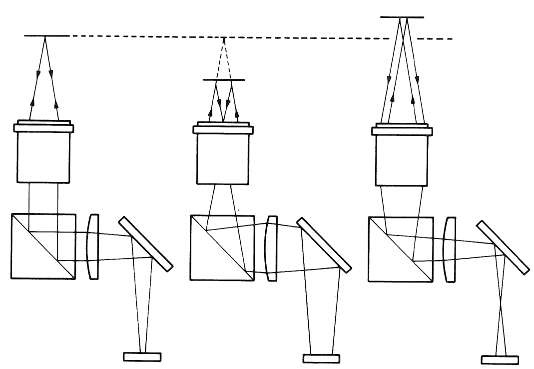
Fig. 3.1 Configuration of the optical path

3.1 FOCUS ERROR DETECTION

The reflected light which is directed onto the photo-detector from the signal surface of the disc differ with the distance between the objective lens and disc as shown in Fig. 3.2.

In the figure, (1) shows an example when the light is properly focused on the signal surface (in-focus state), (2) shows an example where the disc is too close and (3) shows an example where the disc is too far.

Fig. 3.2 shows the focal point in one direction only and the toric lens provides astigmatism in the focal point in the horizontal and perpendicular directions. Fig. 3.3 shows the characteristics of the toric lens.



(1) In-focus (2) Disc too near (3) Disc too far

Fig. 3.2 Light reflected by the disc position

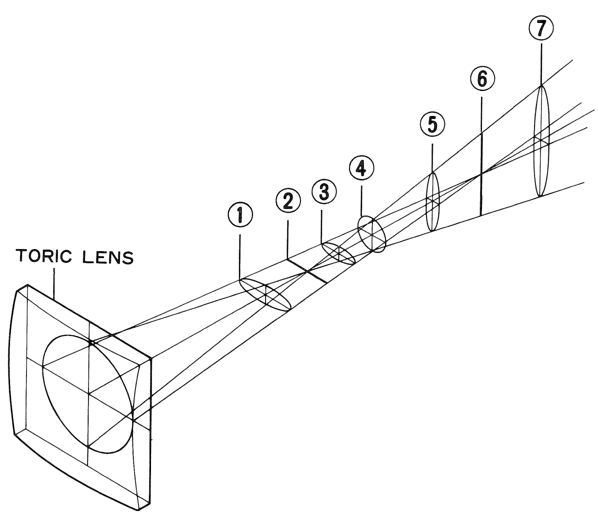


Fig. 3.3 Characteristics of the toric lens

If it is now assumed that a parallel beam of light which is neither radiated for focused is directed onto the lens as in (1) of Fig. 3.2, then the photo-detector will be positioned at ④ in the figure and the reflected light will appear as a circle on the photo-detector.

If it is supposed that the disc is too close to the objective lens, the reflected light will differ from the in-focus state, it will spread out and be directed onto the toric lens so that the focal point will move from the position shown in Fig. 3.3 further away from the lens. In other words, it can be considered that, in relative terms, the photo-detector approaches the lens and that its position moves in the sequence of ④ → ③ → ②.

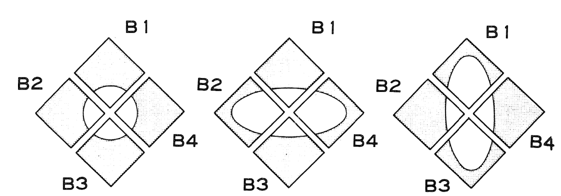
The reflected light on the photo-detector appears as an oval, as shown in the figure.

When the disc is distanced from the objective lens, it can be considered that the photo-detector moves in the sequence of ④ → ⑤ → ⑥ and that the reflected light appears as an oval in the opposite direction.

Fig. 3.4 shows the states of the reflected light projected onto segments which are divided into four on the photo-detector.

These four dividing devices, B1 to B4, each output a current which corresponds to the amount of light projected in each case.

By subtracting (B1+B3) from (B2+B4), a signal corresponding to the distance between the objective lens and disc, or in other words the focus error signal, can be provided.



(1) In-focus (2) Disc too near (3) Disc too far

Fig. 3.4 Reflected light on the photo-detector

3.2 RF SIGNAL PICK-UP

The microscopic projections called pits on the signal surface of the disc are connected in the form of tracks in the circumferential direction of the disc. Because the laser beam is focused at the surface where no pit exists, the light from the laser directed onto the pits is diffused and only the light directed on the parts which are not pits is reflected back. In other words, the amounts of light reflected from the disc serve as information which indicates the presence or absence of the pits with spots directed by the beam.
If the "sum" of all the outputs of the 4 sectional devices of the photo-detector is now considered, as described with the focus error detection, then the value achieved in the low-frequency range as with the focus error signal is virtually constant provided that the in-focus state is maintained stably, and the signals which denote the presence or absence of the pits, or in other words the RF signals, are included in the high-frequency range.

3.3 TRACKING ERROR DETECTION

The laser beam is divided up by the grating plate and the ±1st order beams adjoining the 0th order beam are used to detect the tracking error. As with the 0th order beam, these two beams are condensed into microscopic spots on the disc's signal surface.
The distance from the 0th order spot to the two spots is, in principle, equal and the beams are directed onto the position shown in Fig. 3.5. (The actual distance is much greater than that shown in the figure.)
This reflected light returns to the special-purpose detection devices, A and C, on the photo-detector. If the output of these two devices is the same, the 0th order spot is directed accurately onto the track.

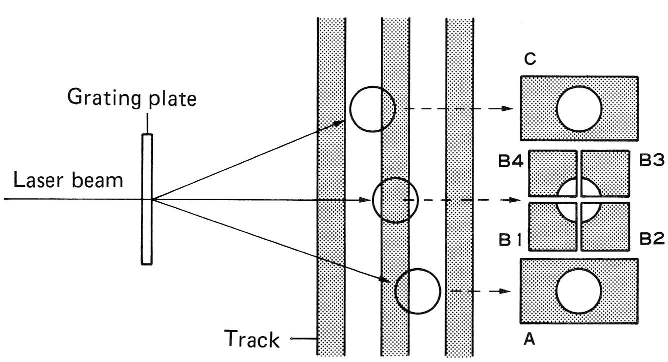


Fig. 3.5 Detecting the tracking error

4. DESCRIPTION OF FOCUS SERVO SYSTEM

As has already been mentioned in the description of the optical path system, the focal point must be precisely formed on the disc's signal surface. This task is performed by the focus servo which automatically controls the position of the objective lens by the focus (FOCS) error provided by the photo-detector in the optical path.
Operation is as follows: first, the objective lens is brought close by the start command from the control circuit, the in-focus (IN FOCS) position is detected, the servo loop is closed, the position of the objective lens is moved up or down by the FOCS error amount and the in-focus state is maintained.
Although both the operation and functions are basically the same as those for the conventional LD-700 Laser Vision player, a brief description is given below for each block.

4.1 FOCUS ERROR CIRCUIT

This section describes the signals, included among the signals produced by the HEAD and PREB circuit boards, which are employed by the focus servo.
The output currents of each of the photo-detector's four dividing devices are converted into voltages by the HEAD circuit board and sent to the PREB circuit board.
The (B1+B3) and (B2+B4) signals are produced by Z1 (BA715) on the PREB circuit board while the difference signal, (B2+B4)−(B1+B3), is produced by Z2 (BA715) 2/2. Furthermore, at Z2 2/2 the imbalance (focus error balance, VR2) in the arithmetic signals caused by differences in the sensitivity of the photo-detector's four dividing devices as well as offset (focus offset, VR6) of the output voltages caused by the operational amplifier is cancelled out by adjusting the VRs mentioned.
The Z2 2/2 output is sent as the FOCS A-B signal to the SRVB circuit board. In addition, adjustment (focus loop gain, VR3) determining the loop gain of the focus servo is first made and then the output is sent as the FOCS ERROR signal to the SRVB circuit board.

If the loop gain adjusted by VR3 is too high, this will create problems such as increased noise which is generated by the drive of the focus motor; conversely, if it is too low, it will not be possible to converge a high focus error.
This is why a circuit composed of D1 and D2 is connected in series to VR3. When a high-level error is generated, the impedance falls with the saturation of D1 and D2, the closed loop gain increases and the error is thus converged.
The outputs of the tracking error detection devices A and C pass through the Z3 (BA715) buffer and they are added by resistance to become the TRKG SUM signal. When the distance between the disc and objective lens are far from the in-focus state, a very small amount of reflected light returns as far as the photo-detector but when the in-focus state is approached, the light returning to the photo-detector increases rapidly.
That the focusing is sufficiently close to the in-focus state is thus known from the DC value of the TRKG SUM signal.

4.2 FOCUS EQUALIZER CIRCUITS

The FOCS ERROR signal sent to the SRVB circuit board enters two equalizer circuits: the equalizer circuit for LD playback composed of Z402 (BA4558DX) 2/2 and the CD equalizer circuit composed of Z406 (BA4558DX) 1/2 and 2/2. Depending on the disc which has been installed in the player, one of these two circuits is selected. Q412 is driven into conduction with an LD disc while Q411 is driven into conduction with a CD disc.
The frequency response in each case is determined by taking into consideration the stability in the closed loop from the requirements of the respective disc specifications.
The switch composed of Q406 is installed in order to discharge the C443 charge and it is actuated when the servo loop opens.

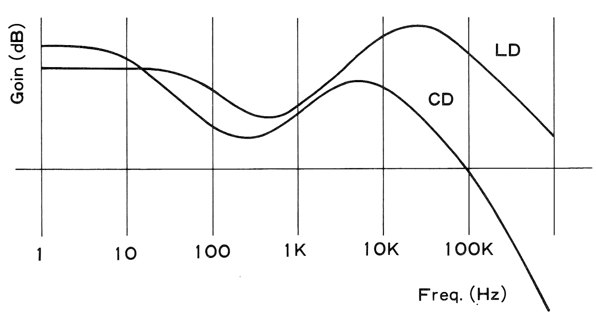


Fig. 4.1 Focus equalizer characteristics

4.3 IN-FOCUS CIRCUIT

The in-focus circuit serves to bring the objective lens from the neutral position close to the in-focus position and to close the focus servo loop.
A brief description of the circuit's operation follows.

1. Pin 21 of Z401 on the SRVB circuit board is set low.
When the PLAY key is pressed, the start command ($\overline{\text{RUN}}$ signal) of the focus servo is sent from the SRVB's CONT section to the FTS section. This signal is provided with a specific delay by R544 and C448 and it enters pin 21 of Z401.
2. Pin 23 of Z401 returns to a positive voltage from its previous negative voltage.
3. The objective lens rises toward the disc.
4. The voltage of the TRKG SUM signal rises as the reflected light returns to the photo-detector.
5. The FOCS A-B signal changes into what is called an S-curve. If it is considered in Fig. 3.3 of the optical path system description that the photo-detector position moves from ⑦ to ①, the focus error will change as in Fig. 4.2. The shape formed is known as an S-curve which is important in expressing the characteristics of the focus error signal.
6. Pin 25 of Z401 is set to a negative voltage.
7. Q402 goes off and the loop switch based on Q401 closes.
8. The TRKG SUM signal is raised by D410 to a positive voltage.

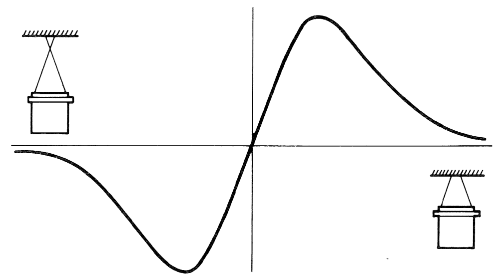


Fig. 4.2 S-curve

A positive voltage is added to the TRKG SUM signal when the servo loop is closed to safeguard against malfunctioning of the in-focus circuit, caused by microscopic scratches or marks on the disc, while the focus servo is operating regularly.
If the servo is slipped off for any reason such as a large scratch or mark on the disc, the loop is opened by the falling voltage of the TRKG SUM signal.
Next, pin 23 is set to a negative voltage and the objective lens is lowered. The lens itself may pass through the in-focus state and a stable in-focus operation may not necessarily be performed. This is why the FOCS A-B signal input is inhibited by D404 and the in-focus state is not detected.

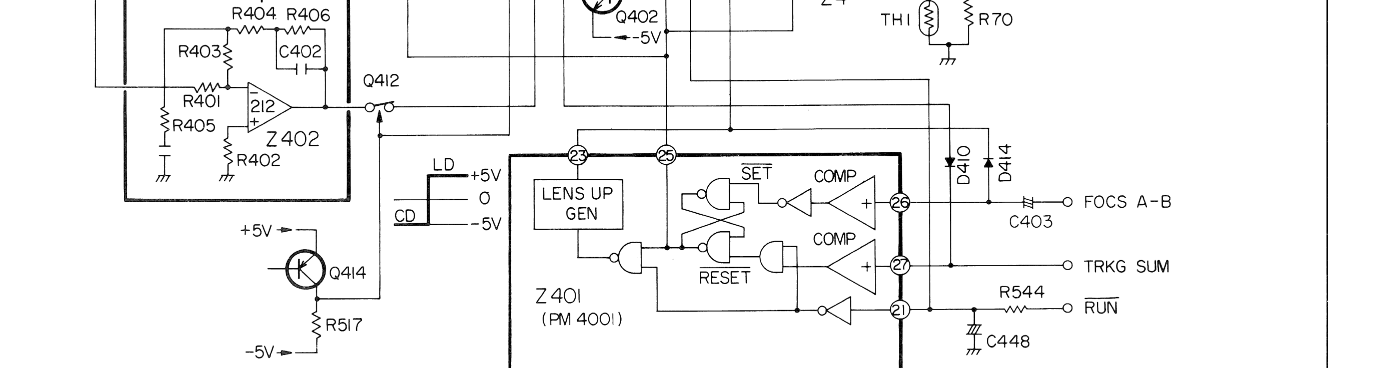


Fig. 4.3 Focus servo circuitry

Thereafter, the servo loop returned to being closed through the same operation as with start.
Since pin 23 is initially set to a positive voltage, Z407 is driven into conduction when the $\overline{\text{RUN}}$ signal is high and this stops the signal from being applied to the objective lens.

4.4 FOCUS MOTOR DRIVE CIRCUIT

The signal (FOCS DRV signal) which drives the objective lens is sent to the DRVB circuit board from the equalizer circuit through the loop switch. On this circuit board, the signal is amplified by the drive circuit composed of Z2, Q12 and Q13, and it is then applied to the focus motor.
In order for the objective lens to rise stably with the in-focus operation, it must be moved at a constant speed. This is why the counter electromotive force generated by the movement of the focus motor is detected by the bridge circuit and compensated for. This force is temperature-compensated and adjusted by VR5 and TH1 so that any changes due to initial fluctuations or to the ambient temperature can be ignored.
The compensation circuit is prevented from operating by the Q11 switch when the servo is functioning regularly.

5. DESCRIPTION OF TRACKING AND SLIDER SERVO

The position at which the laser beam is directed on the disc is controlled in the radial direction of the disc by the tracking servo so that the beam traces accurately the tracks on the disc. It is composed of circuits which control the opening and closing of the servo loop and which control the jumping of the beam onto adjoining tracks.
The slider servo functions to move the slider in the inner and outer circumferential directions of the disc.

5.1 TRACKING ERROR CIRCUIT

The TRKG ERROR signal and FOCS SUM signal, included among the signals produced by the HEAD and PREB circuit boards, are used by the tracking servo.

The outputs of the photo-detector's A and C devices pass through the Z3 (BA715) buffer and (C-A) is arithmetically processed by Z4 (BA715) 1/2. Imbalance in the (C-A) signal, caused by differences in the sensitivity of the A and C devices, is cancelled by VR4 (tracking error balance). Adjustment (tracking loop gain VR5) which determines the loop gain of the tracking servo is provided for the signal which is then amplified by Z4 2/2 and sent to the SRVB circuit board.
The FOCS SUM signal is the sum of all the outputs of the photo-detector's four dividing devices, B1 to B4, and it serves as the information advising whether the beam (0th order) is directed on the disc track or not.

5.2 TRACKING EQUALIZER CIRCUITS

The TRKG ERROR signal which has been sent to the SRVB circuit board enters the two equalizer circuits as in the case of the focus servo.
These circuits are the equalizer circuit for LD playback composed of Z403 (BA4558DX) 2/2 and the CD equalizer circuit composed of Z404 (BA4558DX) 1/2 and 2/2.
If an LD disc has been placed on the player, the Q418 switch is allowed to be driven into conduction by D416; when a CD disc has been similarly placed, the Q420 switch is allowed to be driven into conduction by D411.

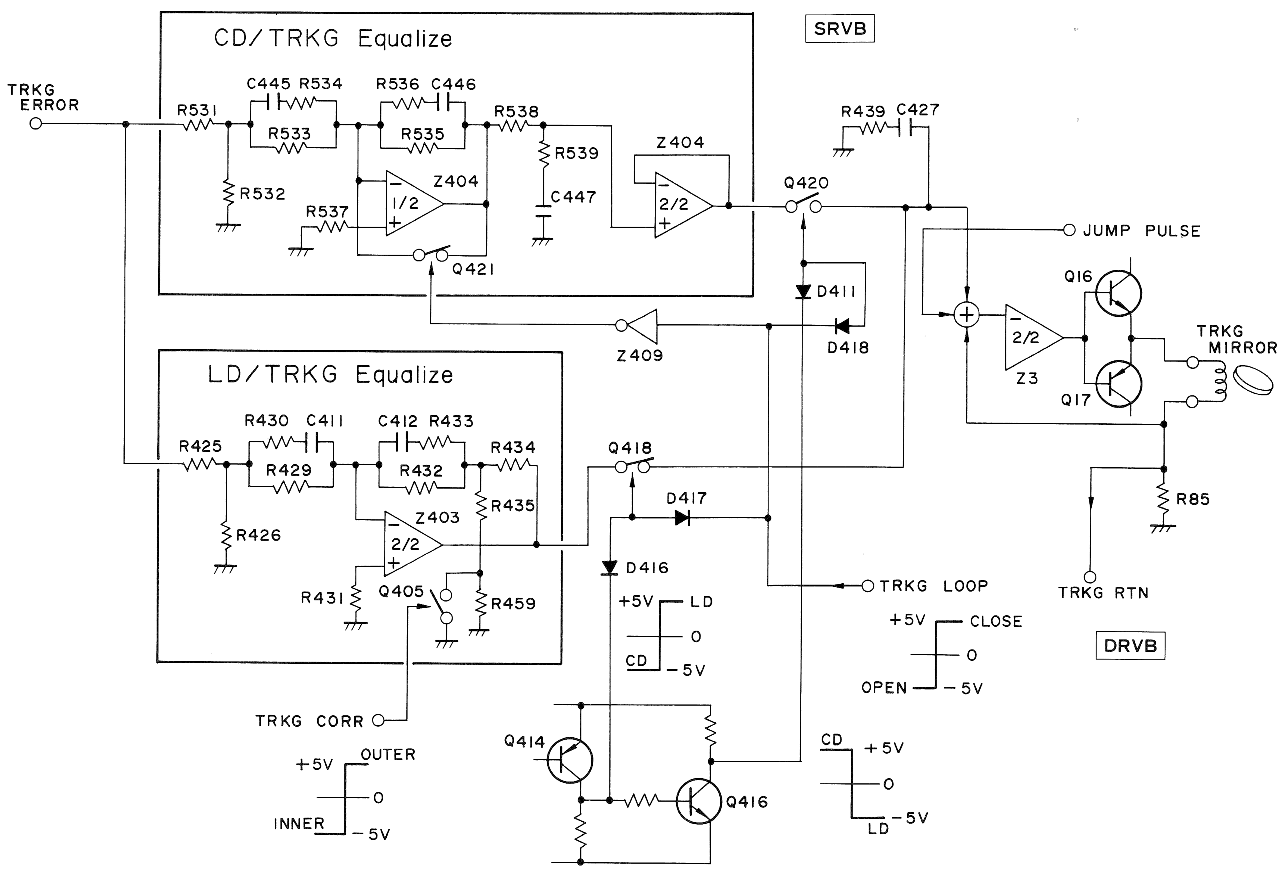


Fig. 5.1 Tracking equalizer circuit

The switch based on Q421 is provided to discharge the charge accumulated in C446 and it operates when the servo loop is open.
For detecting the tracking error an imbalance in its level is created, in principle, at the inner and outer circumferences of the disc. In other words, even if a track shift identical to the inner circumference is created at the outer circumference, the detected tracking error has a lower level than that of the inner circumference.
As a result, the gain of the equalizer circuit is increased by driving Q405 into conduction at the outer circumference.
Switching (approximately 2dB) is undertaken near the center of the disc's playback range by the RF CORR signal which is sent from the TBC section.

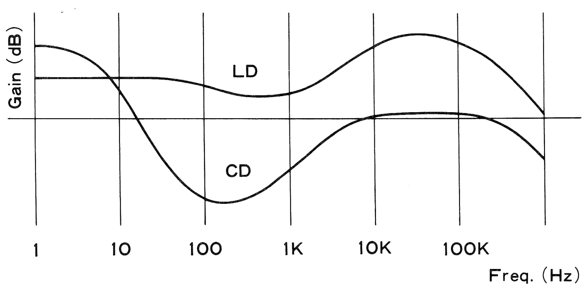


Fig. 5.2 Tracking equalizer characteristics

5.3 TRACKING LOOP CONTROL CIRCUIT

The tracking servo loop is allowed to close by the TRKG O/$\overline{C}$ signal from the CONT section being set low although, in actual fact, the closing of the loop is undertaken at a timing which meets certain conditions so that the operation itself is performed reliably.
On-track detection and tracking error low-frequency range detection are undertaken as functions which detect this timing. These operations are described below.
Fig. 5.3 shows the path traced by the beam on the tracks with the tracking servo loop open. The tracks are naturally shaped in the form of a spiral although in terms of their pitch they may be considered circular. Point P1 is the center of the beam path and P2 is the center of the tracks. The distance between P1 and P2 represents the amount of eccentricity.
When the tracking servo is not functioning, the beam does not trace the tracks and, as shown in the figure, it cuts across the tracks continuously. However, at points A and C and at points B and D a difference in the number of tracks cut across per unit time is produced. This difference appears as a difference in the frequency of the tracking error signal. It is thus clear that the loop is closed more smoothly and reliably at points A and C than at points B and D.
Fig. 5.4 is a timing chart of the circuit which detects the low frequency points.

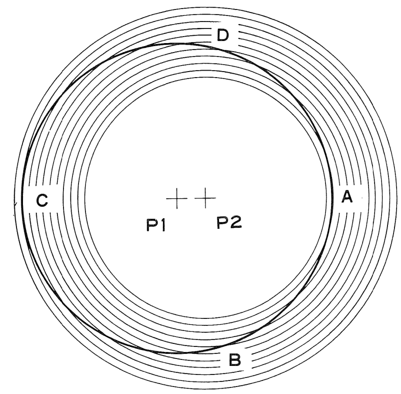


Fig. 5.3 Tracks and their tracing by the beam

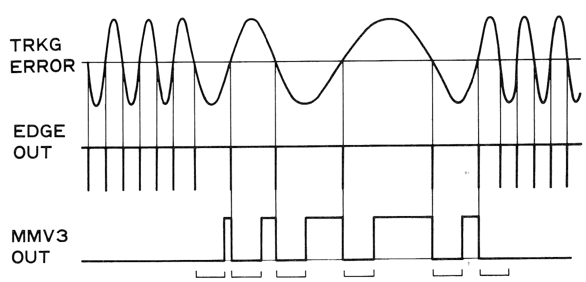


Fig. 5.4 Detection of the low-frequency range

Monostable multivibrator MMV3 is a retriggered type. Its output is kept low with higher inputs than the set frequency and with low-frequency inputs an interval is created in which it is set high. The tracking servo loop is allowed to close while it is set high.

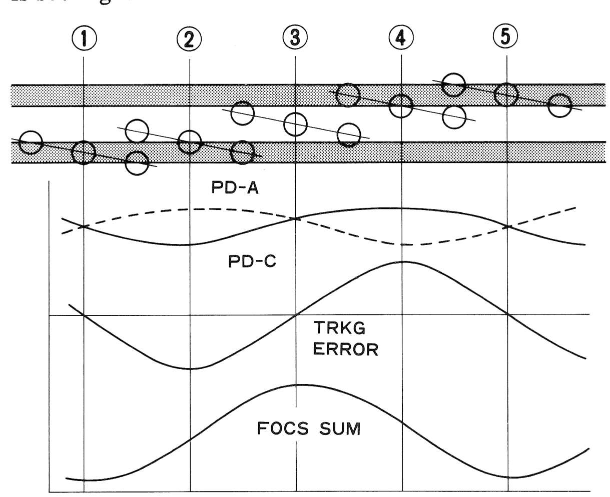


Fig. 5.5 On-track detection

Fig. 5.5 shows the states of 3 beams crossing the tracks (① → ⑤) and the TRKG ERROR and FOCS SUM signals which are thereby created. It is clear that the pick-up level is high when the beam is directed onto the surface out of the track, as was already mentioned in the description of the optical path system.

Rather than the closing of the servo loop in ②, ③ and ④ of the figure, its closing at the positions of the main beams ① and ⑤ on the tracks is more reliable. This timing is delivered by on-track detection. Fig. 5.6 is a timing chart.
In this figure, the point at which the detection signal is set high is the on-track timing.
In addition to the functions mentioned above, the tracking loop control circuit serves to open the loop in the following cases:

- When the focus servo loop is open
  The level of the Z401 pin 25 signal is converted by D403 and D404, the signal is integrated so that it does not respond to the loop opening for a very brief time and it is supplied to pin 20.
- When the tracking mirror stopper circuit has operated
- When a jump operation is performed

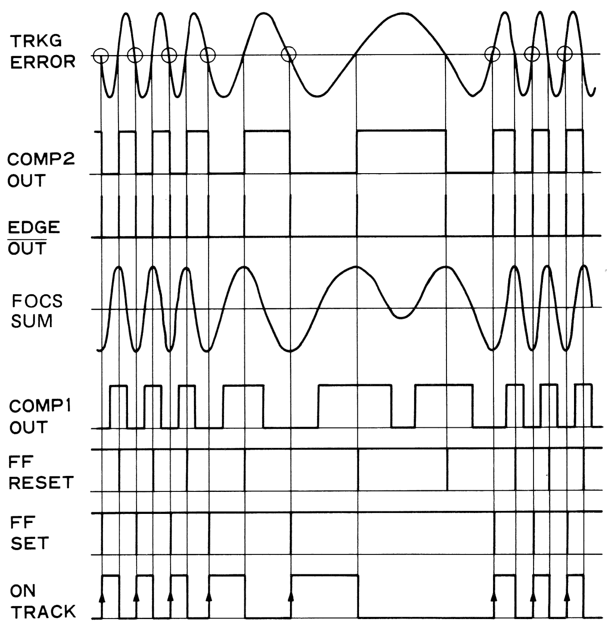


Fig. 5.6 Timing chart for on-track detection

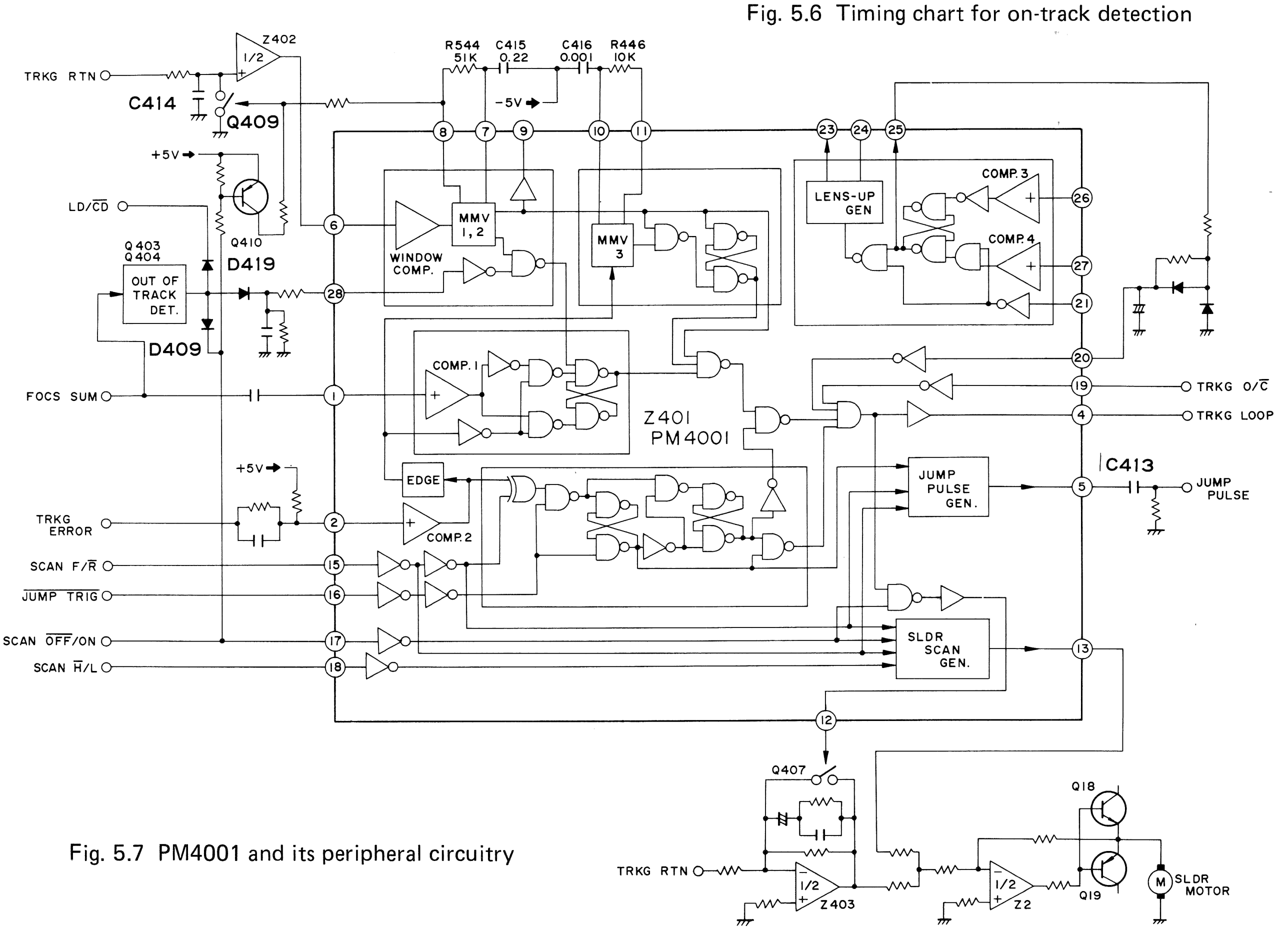


Fig. 5.7 PM4001 and its peripheral circuitry

5.4 TRACKING MIRROR STOPPER CIRCUIT

In order for the tracking servo to function so that the beam is directed onto one particular track, the SCAN ON/OFF signal is set high and when the slider moves at high speed, the mirror's angle of inclination increases in line with the movement.
However, when this angle of inclination exceeds a certain range, vignetting is produced in the objective lens. Furthermore, other problems arise such as impairment of the characteristics of the mirror's moving element.
This is why the tracking mirror's drive current is constantly monitored and excessively high current is detected by the mirror stopper circuit. When an excessively high current is detected, the mirror drive is inhibited by opening the tracking servo loop for a fixed time.
The drive current of the tracking mirror can be ascertained by the terminal voltage (TRKG RTN signal) of R85 on the DRVB circuit board which is connected in series with the mirror drive coil.
The TRKG RTN signal is sent to the SRVB circuit board, the fluctuation components in the high frequency are eliminated by the integrating circuit, the signal is then temperature-compensated by Z402 and it is amplified. Except when a scanning operation is undertaken, the signal is prevented from entering Z402 by Q409 which is driven into conduction.

The Z402 output is supplied to pin 6 of Z401 (PM4001). This pin is the comparator input pin. The comparator judges whether the absolute value of the input exceeds the reference voltage. In other words a frame of reference centering on DC 0V is established and the comparator judges whether the input comes within this range or not. Because of the nature of its operation, it is known as a window comparator.
When the window comparator detects an excessively high input during scanning (SCAN ON/OFF signal is set high → Q410 is turned off → Q409 is turned off), pin 8 is set high (positive voltage) for a fixed time by the operation of the monostable multi-vibrator.
The loop opens during this high interval, and the mirror which was set at a high angle of inclination is returned to the neutral position. The charge accumulated in C414 by the TRKG RTN signal is rapidly discharged by Q409 which is driven into conduction. When the mirror approaches the neutral position, the state in which the closed loop is set forcibly is terminated.
However, in order to disallow the closed loop for a short period of time, the loop is repeatedly opened and closed by the operation of the above-mentioned on-track detection circuit.
This operation applies a braking effect to the mirror which is about to return to the neutral position and when the closed loop is allowed in due course, a return is made to the stable servo operation.
In cases where the braking effect is insufficient because of the mirror's characteristics or ambient temperature and the servo does not attain the stable state, disturbances in the FOCS SUM signal are detected by Q403 and Q404 and the braking time is extended. In order that the circuit does not malfunction, it is disabled by D409 and D419 at all times except during scanning with an LD disc.

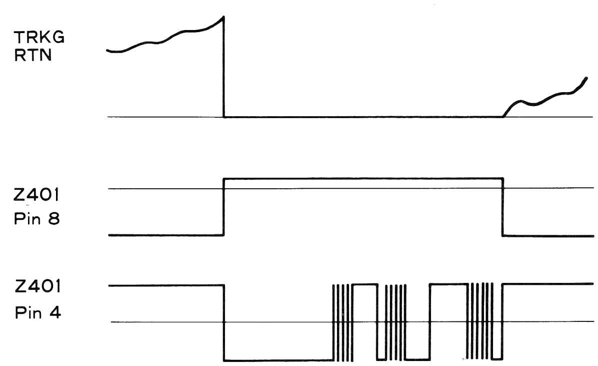


Fig. 5.8 Operation of tracking mirror stopper

5.5 JUMP CONTROL CIRCUIT

The $\overline{\text{JUMP TRIG}}$ signal, serving as the start command of the jump operation, is sent from the CONT section on the SRVB circuit board to the FTS section.
The SCAN $F/\overline{R}$ signal determines the jump direction. When it is low, the beam is made to jump to the track adjoining the inner circumference of the disc; when it is high, it is made to jump to the outer circumference.
Fig. 5.9 is a timing chart of the jump operation in the inner circumferential direction.
The servo loop is set to open with the $\overline{\text{JUMP TRIG}}$ signal set low and the jump pulse generator circuit sets pin 5 to −5V. This change is differentiated by C413 to form pulses which are sent to the DRVB circuit board to drive the mirror.
As the beam is sent to the inner circumference, the tracking error signal increases in the negative direction and when it moves as far as the interim point with the adjoining track, it returns again to zero. (Position ③ in Fig. 5.9) COMP 2 detects this point, and the servo loop closes as pin 5 returns to 0V. The change in pin 5 to 0V is differentiated to form pulses in the opposite direction to that of the jump operation, and the mirror which is still moving due to inertia is braked.

In due course, the jump operation is terminated as the beam reaches a position above the adjoining track and a return is made to the servo state.
Jumps in the outer circumferential direction are undertaken in the same way. The output of the jump pulse generator circuit changes pin 5 to +5V (the reverse of a jump in the inner circumferential direction) and differential pulses in the positive direction precede.
The TRKG ERROR signal also undergoes the reverse change and the COMP 2 output is equalized as with a jump in the inner circumferential direction by the EX OR gate.

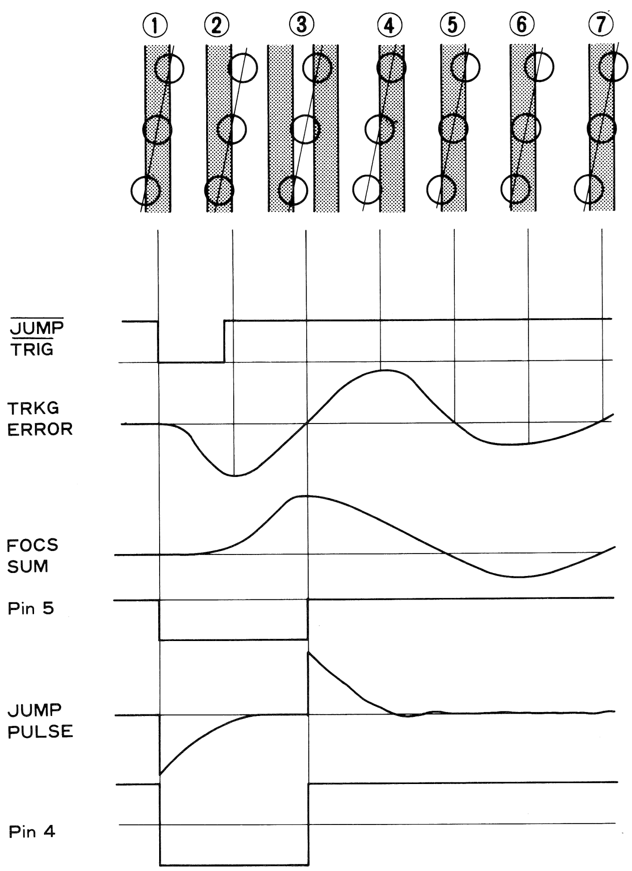


Fig. 5.9 Timing chart of jump operation

5.6 SLIDER SERVO CIRCUIT

During normal play the tracking servo operates so that the beam traces tracks toward the outer circumference but when the tracking mirror inclines too far, problems arise such as vignetting in the optical path which was mentioned in the previous section.
When the drive current of the tracking mirror starts to increase, therefore, the slider servo causes the slider motor to rotate and the mirror inclination to be reduced by feeding the slider to the outer circumference.
The TRKG RTN signal is amplified by the Z403 equalizer circuit and it is sent to the motor drive circuit on the DRVB circuit board.
A loop switch composed of Q407 is installed in Z403 and the slider loop is closed when the tracking servo loop is open and when a scanning operation which will be described later is performed.
Scanning and search operations with LD discs and search operations with CD discs are undertaken by moving the slider at high speed to the inner or outer circumference. (The above operations will hereafter be referred to as "scanning" operations and scanning as a function with LD discs will be referred to as "LD scanning.")
Scanning operations are performed by setting the SCAN $\overline{\text{OFF}}$/ON signal high, by setting the SCAN F/$\overline{\text{R}}$ signal as the scanning direction and by varying the scan $\overline{\text{H}}$/L signal, as in Fig. 5.10, in accordance with the type of scanning operation.
Search operations are performed by combining the H-SCAN and L-SCAN signals in the figure.
The scan voltage generator circuit outputs +3.5V (forward direction) or −3.5V (reverse direction) to pin 13 when the SCAN $\overline{\text{H}}$/L signal is low, this voltage (pulse) is amplified by the DRVB circuit board and the motor is rotated.

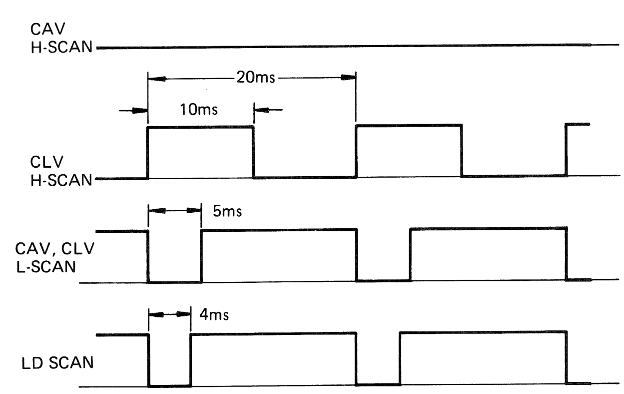


Fig. 5.10 SCAN H/L signal with a scanning operation

6. DESCRIPTION OF SPINDLE SERVO (LD)

The spindle servo functions with LD discs to detect rotational errors in the disc by comparing the horizontal sync signal (PB H) of the reproduced video signal with the reference frequency signal (REF H) and thus control the rotation of the disc. The rotational control with CD discs will be described in a separate section.

6.1 SPINDLE ERROR CIRCUIT (SRVB, TBC SECTION)

The $\overline{\text{RUN}}$ signal is sent from the CONT section of the SRVB circuit board, the focus servo of the FTS section starts operating, and when the servo loop is closed, the $\overline{\text{FOCS LOCK}}$ signal is sent to the TBC section.
The $\overline{\text{FOCS LOCK}}$ signal is supplied to pin 24 of Z201 (UM3002A) and when this is set low, SW7 is turned on by the operation of the inside logic circuit. A negative voltage is output to pin 7, it is inverted and amplified by Z205 (BA4558DX) 1/2, and a positive voltage is sent as the SPDL ERROR signal to the DRVB circuit board.
Z205 1/2 outputs a maximum voltage which is limited by the D209 Zener diode of the negative feedback circuit. Furthermore, when rapid acceleration is required such as with start-up, D209 functions to prevent any delay in the rise of the output voltage based on C228.
The spindle motor starts rotating and it accelerates rapidly due to the action of the spindle drive circuit which will be described later.
The spindle drive circuit uses a Hall device to detect the motor rotation and the motor's rotational speed is sent to the spindle error circuit as a frequency-modulated pulse train (FG signal). The FG signal is shaped by Q203 in the spindle error circuit and converted into a voltage signal by the integrating circuit. This signal, which indicates the motor's rotational speed, is supplied to pin 12 of Z201 and the voltage, or in other words the rotational speed of the motor, is determined by the three comparators, COMP 1, 2 and 6.
COMP 1 uses 440 rpm as a reference, COMP 2 uses 1400 rpm and COMP 6 uses 2300 rpm. When the motor speed is higher, the output is inverted and supplied to the logic circuit.

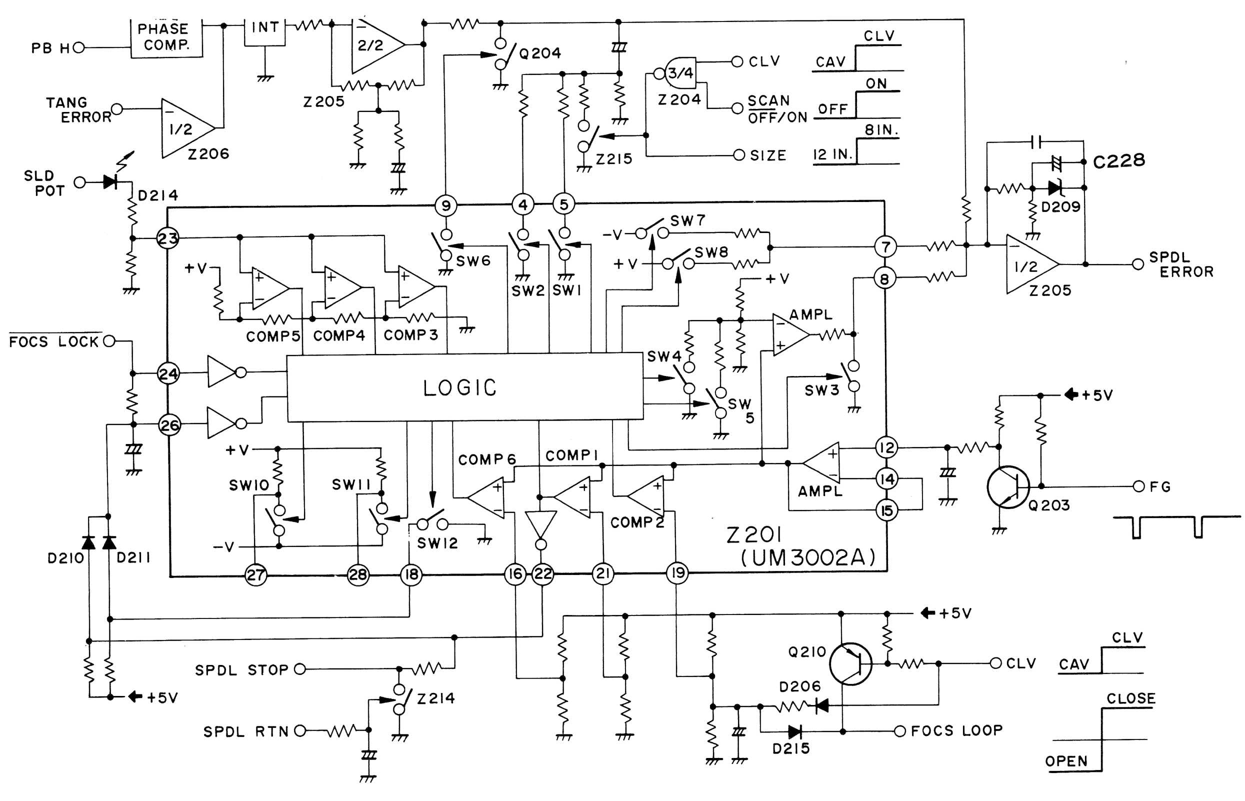


Fig. 6.1 Spindle error circuit

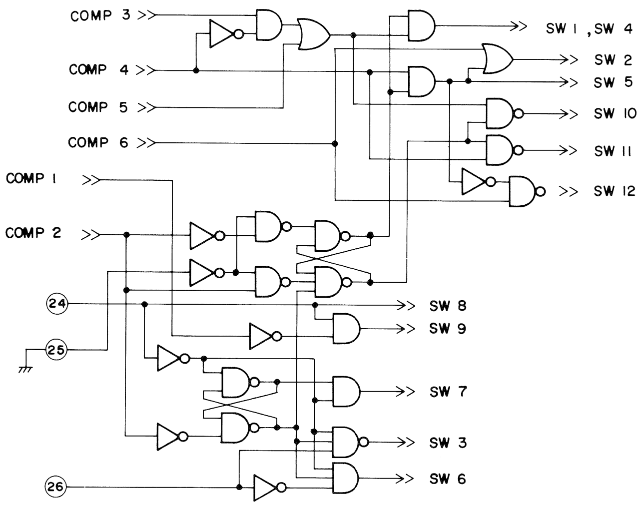


Fig. 6.2 UM3002A logic circuit

When the motor accelerates, COMP 1 is activated first and when the motor's speed reaches 1400 rpm, this is detected by COMP 2. The logic circuit stops the motor's rapid acceleration with SW7 off, it turns off the loop switch based on Q204 by turning SW6 off and it sets the servo loop to the closed state.

The motor start-up operation up to this point is the same regardless of the type of disc but control of the spindle motor's speed with playback must be selected in accordance with the size (12 or 8 inches) of the disc and the disc's recording system (CAV, CLV).

The speed is constant at 1800 rpm with CAV discs but it varies from 1800 to 600 rpm with CLV discs in accordance with the radial position of the disc. Furthermore, differences in the mass and moment of inertia for the disc size also greatly affect the servo loop. For instance, even when the same external disturbances occur in the servo loop, the rotational error which is detected will differ according to the rotational speed at that time and the size of the disc used.

For this reason the spindle servo loop gain is controlled by a combination of three switches: by SW1 and SW2 inside Z201 and by the Z215 switch.

Table 6.1 gives the correlation between the recording system and playback radial position of the discs, the size of the discs and the states of the various switches. The gain values in the table are approximations with a 12-inch CAV disc referenced as 0 dB.

When scanning with an 8-inch CLV disc, Z215 is forcibly set off and the loop gain increased so that the servo state is maintained as far as possible in respect of the movement of the radial position.

Table 6.1 Spindle servo gain control

	12 inch CAV	12 inch CLV In			Out	8 inch CAV	8 inch CLV In	Out
SW 1	OFF	OFF	ON	OFF	ON	OFF	OFF	ON
SW 2	OFF	OFF	OFF	ON	ON	OFF	OFF	
Z215	OFF	OFF				ON	ON (OFF)	
GAIN (dB)	0	0	−4	−5	−8	−13	−13 (0)	−14 (−4)

The radial position currently being played is detected with the voltage (SLD POT signal) of the potentiometer connected mechanically to the slider.

The SLD POT signal supplied from pin 23 is judged by the 3 comparators (COMP 3, 4 and 5) inside Z201, and with 12-inch discs, the playback radial range is divided into 4 and detected.

Z201 (UM3002A) was developed for players accommodating only the LD discs and the reference voltage of the above comparators is set so that the maximum playback range (approx. 90 mm) of an LD disc is divided into 4. However, the CLD-900 is characterized by the fact that the SLD POT signal varies by movement from the innermost circumference of a CD disc to the outermost circumference of an LD disc (approx. 120 mm). In order to make the voltage of the SLD POT signal during LD disc playback identical to that for the LD player, it is reduced by about 1.6V by the D214 LED and the voltage division ratio based on the resistance is made a different value from that of an LD player.

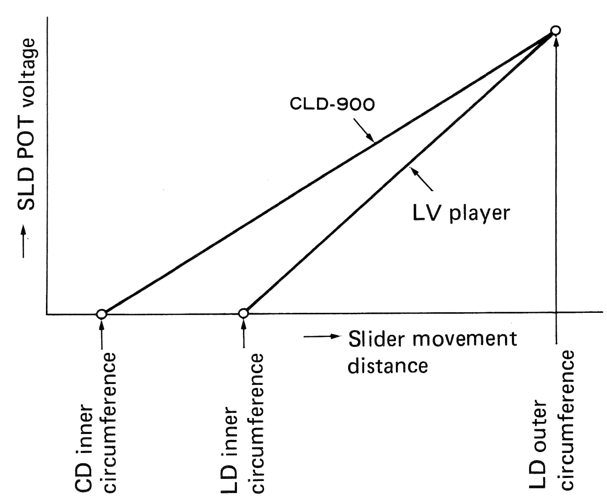


Fig. 6.3 SLD POT signal

The information pertaining to the playback position is obtained in this way. In order to enable the spindle servo gain to be controlled by this information, it is passed through D206 by the CLV signal, the pin 19 voltage is raised, and COMP 2 which has inverted the output when the rotational speed of the disc reached 1400 rpm is inverted again.
The reproduced PB H and reference REF H signals are compared by Z203 (TC5081AP). Comparison results, such as those in Fig. 6.4 (A) and (B), are output from pin 3 of Z203. This signal is made the voltage signal by the integrating circuit, and it is amplified by the Z205 1/2 and 2/2 equalizer circuit to become the spindle error signal.

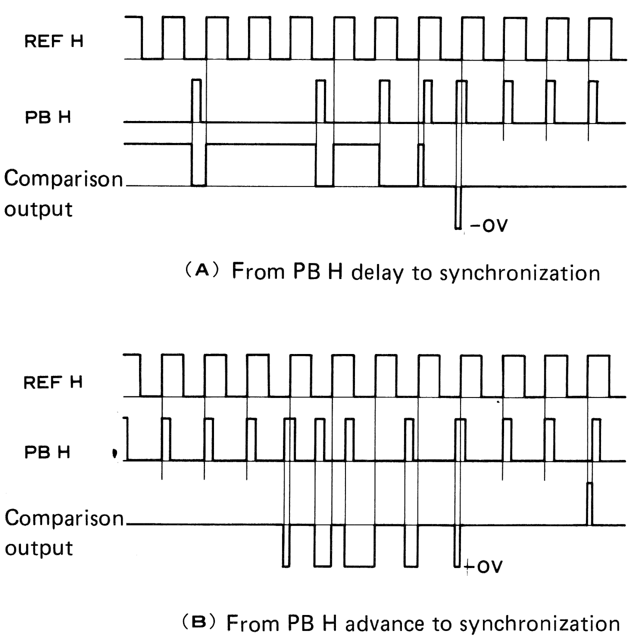


Fig. 6.4 Phase comparison of PB H and REF H signals

Pin 3 of Z203 is placed in the high-impedance state when the phase difference between the PB H and REF H signals is zero. High errors which cannot be converged by the tangential servo, which will be mentioned later, are amplified by Z206 1/2, and added to pin 3, and the spindle servo serves to support this operation. D201 and D202 are provided to reduce the gain with respect to excessively high inputs.
If the spindle motor starts to rotate recklessly and the speed exceeds 2400 rpm for some reason or other in the play mode, COMP 6 inverts the output. As a result, the logic circuit turns SW2 on, reduces the loop gain and turns SW12 off. Pin 26 level is raised high by D11 as SW12 turns off.

When pin 26 is set high, SW6 turns off and the servo loop is opened.

Furthermore, SW3 turns off and a voltage is output to pin 3.
This voltage is produced from the difference between the voltage produced from the FG signal which indicates the motor speed and the specific reference voltage. The servo operates (fixed speed servo) so that the speed is kept constant. This reference voltage is fixed when CAV discs are played but in the case of CLV discs, it is produced by combining the ON/OFF states of SW4 and SW5 so that it becomes a value corresponding to the radial position.
In this way, a return is made to the original speed, COMP 6 returns to its original state and the original PB H and REF H signal comparison servo state is established.
When the spindle motor decelerates and the speed falls below 440 rpm, COMP 1 inverts the odutput. As a result, pin 22 is high, pin 26 is raised to the high level by D210 and the same operation is undertaken as with the reckless speed of the motor.
If for some reason or other the focus servo loop opens in the play mode, pin 24 is set high, the logic circuit turns off SW6 and the servo loop is set to open. Furthermore, a positive voltage is output to pin 7 by turning SW8 on. As a result, the spindle motor rapidly decelerates.
When the focus servo loop is again set to open, pin 24 is set low.
When a CAV disc is being played, the motor first decelerates following the start-up method described above and then the servo loop is closed.
When a CLV disc is being played and the focus servo loop is open, the COMP 2 reference voltage is reduced by the FOCS LOOP signal (D215) and when the focus loop closes, the voltage is pushed up with a certain delay by the CLV signal.
Because of this delay Z201 is set to the constant speed servo mode as described above and the speed corresponds to the radial position.
The spindle servo returns to the closed state with the pin 26 being set low after pin 24.
In cases where the spindle motor decelerates and its speed falls below 440 rpm, such as when the EJECT key has been pressed or when the focus servo loop cannot be closed, a high-level signal is output to pin 22 by COMP 1. When the SPDL RTN signal from the spindle drive circuit has a sufficiently low value and Z214 is turned off, then the SPDL STOP signal is sent to the CONT section.

6.2 SPINDLE DRIVE CIRCUIT

The SPDL ERROR signal produced by the spindle error circuit on the SRVB circuit board is sent to the spindle drive circuits provided on the DRVB, LOLB and BLMB circuit boards.

The SPDL ERROR signal is first supplied to the absolute value circuit composed of Z5 (M5218L) 1/2 and Z5 2/2 on the DRVB circuit board.

In this circuit D12 is made conductive when the SPDL ERROR signal is a negative voltage. The Z5 2/2 (—) input voltage is equal to the voltage of the SPDL ERROR signal and the output is made a low voltage equivalent to the forward voltage drop (Vf) of D12. D13 and D14 are in the non-conductive state and a signal is not supplied to the Z5 1/2 (+) input. The Z5 2/2 (—) input voltage is inverted by Z5 1/2 and output. (The gain is —R95/R93 = —1.)

When the spindle error voltage is a positive voltage, D12 is made non-conductive and no current flows to the feedback circuit composed of R93 and R95 so that there is no voltage drop. As a result, by making the Z5 2/2 (—) input, Z5 1/2 (—) input and output all equivalent to the voltage of the spindle error signal, the Z5 2/2 output voltage becomes a high voltage equivalent to the sum of the D13 and D14 Vf from the SPDL ERROR signal.

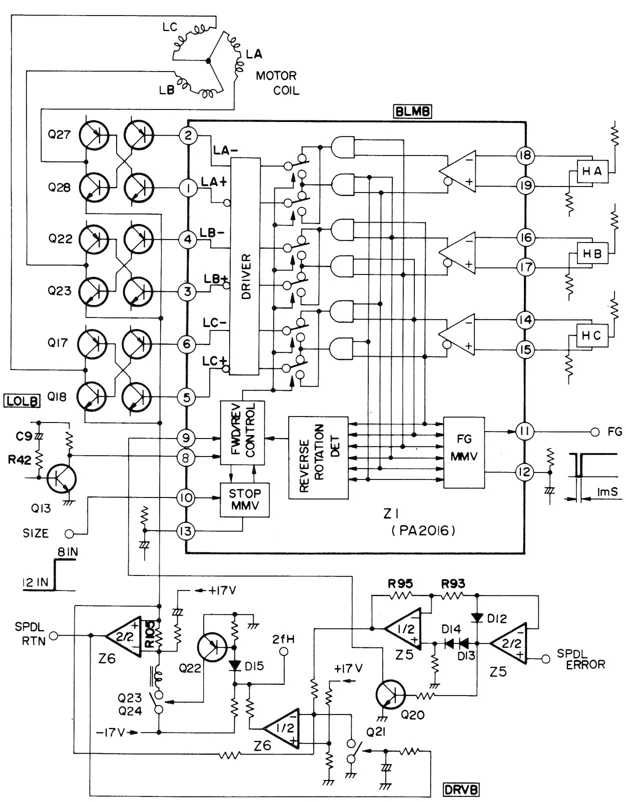


Fig. 6.5 Spindle drive circuit

Q20 determines whether the SPDL ERROR signal voltage from the Z5 1/2 output voltage is positive or negative, or in other words it determines the drive direction of the spindle motor.

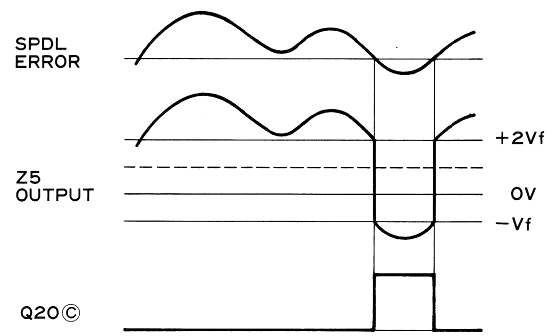


Fig. 6.6 Determining the motor drive direction

In this way, the spindle error is divided into $\overline{F}$/R signals indicating its absolute value voltage and positive/negative code and, as a result, the motor drive can use the whole voltage range from +17V to —17V (non-regulated supply voltage).

The amplitude range of the signal is converted for this purpose in Z6 1/2. In the circuit shown in Fig. 6.7, therefore, the output voltage is Eo = V — (R97/R96)·Ei and it is output from +V as the drop voltage.

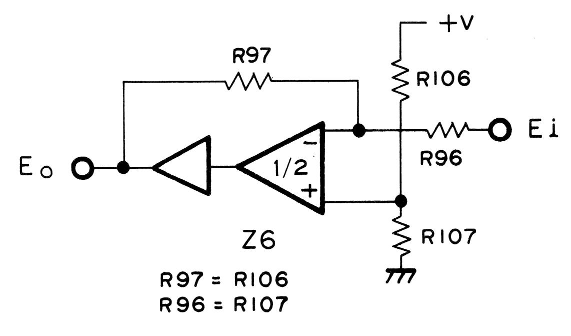


Fig. 6.7 Converting the amplitude range

The Z6 1/2 output signal is current-amplified for motor drive and current amplification is provided in the form of a chopper in order to enhance its efficiency. The 2fH signal from the SRVB circuit board is superimposed onto the error signal and its width is modulated by Q22 to become a pulse signal. As a result, the switch composed of Q23 and Q24 turns the current on and off and the square wave current produced is integrated to become the SPDL DRV signal.

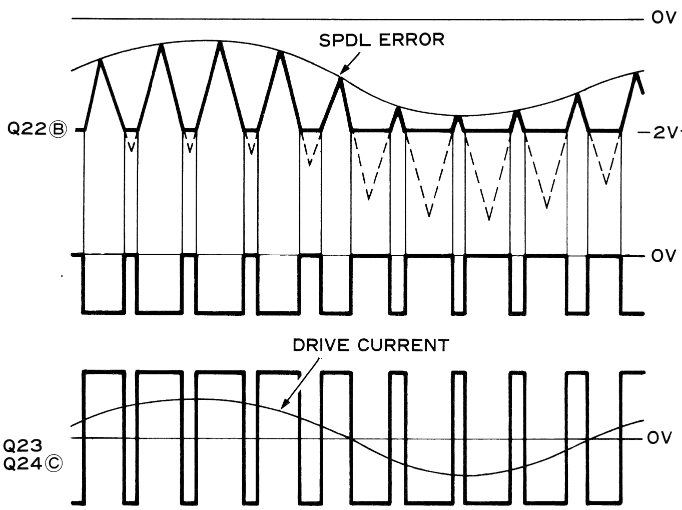


Fig. 6.8 Chopper type of amplification

The SPDL DRV signal is output to the BLMB circuit board through R105. The R105 voltage drop is amplified by Z6 2/2, this is sent to the spindle error circuit as the SPDL RTN signal and it is used to detect motor stop.
When the SPDL RTN signal increases abnormally, motor drive is prohibited by Q21 being driven into conduction. An integrator circuit is provided as its base to prevent Q21 from being driven into conduction by momentarily excessive currents such as that produced during start-up.
Used for the LD spindle motor is the same 4-pole 3-phase drive brushless motor which is employed in the LD-700. Fig. 6.9 is a timing chart showing the detection outputs of the Hall device and the phase drive with forward rotation. The currents at the timing shown by ①, ② and ③ in Fig. 6.9 are indicated by arrows in Fig. 6.10.
Current flows from the LA coil to the LB coil by Q27 and Q23 turning on at timing ①. In ②, the current flows from LA to LC and in ③ from LB to LC. The motor rotates 60 degrees at the timing of ① through ③.
Every time the Hall device outputs change from high to low or from low to high while the motor is rotating, a pulse signal with a 1ms width is output from pin 11 of Z1 (PA2016) on the BLMB circuit board and, as explained with the spindle error circuit, it serves as the FG signal which indicates the motor speed.
It is clear from Fig. 6.9 that the Hall device outputs change 6 times for each 1/2 rotation, therefore, a single pulse is output every 30 degrees rotation.

When the EJECT operation is undertaken, the $\overline{\text{SPDL RUN}}$ signal sent from the LOLB circuit board to the BLMB circuit board is set high, the motor is prevented from rotating and it is forcibly decelerated.
At this time, as has been explained in the spindle error circuit, the SPDL ERROR signal takes on a negative voltage. The $\overline{\text{F}}$/R signal is set high by Q20 on the DRVB circuit board turning off, this is supplied to pin 9 of Z1 on the BLMB circuit board and the internal switch is inverted.

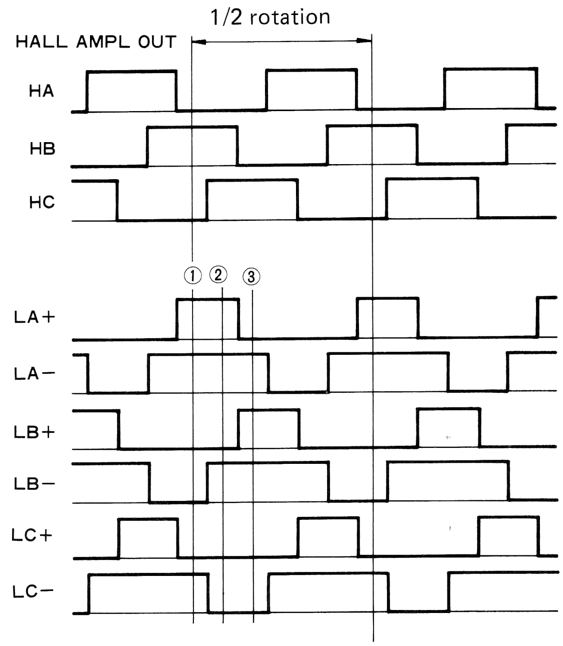


Fig. 6.9 3-phase drive timing

Due to this operation, the motor is driven in the reverse direction and its speed decelerates rapidly. In due course, however, it comes to the verge of actually reversing in accordance with the drive. At this time, the reverse rotation detector circuit inside the IC detects this from the detection output of the Hall device and for a specific period of time only the internal switch is set to forward rotation and the motor is completely stopped. The time during which the motor is driven in the forward direction is selected by the size of the disc (165 ms for 12-inch discs, 100 ms for 8-inch discs). When the motor does not stop and the power switch has been turned off in the play mode, the motor will naturally decelerate. Even if it is assumed that the power switch is set on again, operation will not be acknowledged until the motor stops by the control system operation which will be mentioned later. As a result, the $\overline{\text{SPDL RUN}}$ signal is set low for a fixed time by the turning on of the power switch. In other words, Q13 which outputs the $\overline{\text{SPDL RUN}}$ signal of the LOLB circuit board is driven into conduction by the supply voltage (+5V) rise only for the time determined by the C9 and R42 differentiation circuit, and the $\overline{\text{SPDL RUN}}$ signal is set low. As a result, the flip-flop inside PA2016 is set and becomes operational. Z201 (UM3002A) on the SRVB circuit board outputs a positive voltage to pin 7 with the initialization of power-on and so this is inverted and the SPDL ERROR signal is made a negative voltage. Due to this voltage, the motor is now decelerated rapidly by reverse drive and when it reaches reverse rotation, it is driven forward only for the time set by the disc size and in due course it stops. The PA2016 fip-flop is reset and standby is continued until the next $\overline{\text{SPDL RUN}}$ signal.

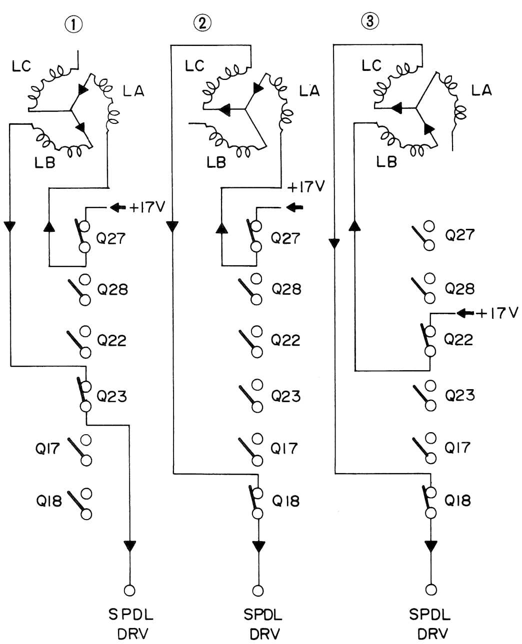


Fig. 6.10 Drive current switching

7. DESCRIPTION OF TANGENTIAL SERVO

A playback signal virtually equivalent to the frequency signal during recording is obtained by the spindle servo but about the playback of pictures, a time base error with a high precision and a high frequency must be converged.
To meet this requirement, the tangential servo serves to control the position onto which the laser beam is directed in the tangential direction of the tracks. The servo itself is composed of the circuitry which detects the high-precision time base error from the spindle servo using the phase difference between the reference H (REF H) signal and played back H (HD 2) signal, the circuitry which determines the operational state of the time base servo from the playback signal, and the circuitry for processing the phase error which has been produced.

7.1 PHASE ERROR SAMPLING CIRCUIT

In the sync processing circuit in the video playback circuit which will be described later an $\overline{\text{H SYNC}}$ signal with minimal jitter is separated from the video signal and the HD 2 signal, produced by eliminating H/2 from this signal, is sent to pin 11 of Z202. The internal monostable multivibrator is triggered by the HD 2 signal and a pulse signal with a width of 7 μs is produced. This signal now serves as the phase error sampling signal.
The REF H signal, which is output from pin 1 of X201 on the reference frequency oscillator circuit, is supplied to pin 17 of Z202 (PA9002). When the REF H signal is high, C224 connected to pin 15 is charged by a constant current and when it is low, it is discharged at a constant current.
The pin 15 voltage becomes a triangular wave signal whose slope is produced by adjusting the current flowing from pin 14 by VR202 and by varying the value of the constant current.
This triangular wave signal is made into a square wave signal by a hysteresis comparator which has two comparison reference voltages.
The comparison reference voltages of the comparator are set so that the square wave signal rise precedes by 10 μs only and its fall is delayed similarly for 10 μs, with the REF H signal rise timing used as a reference.

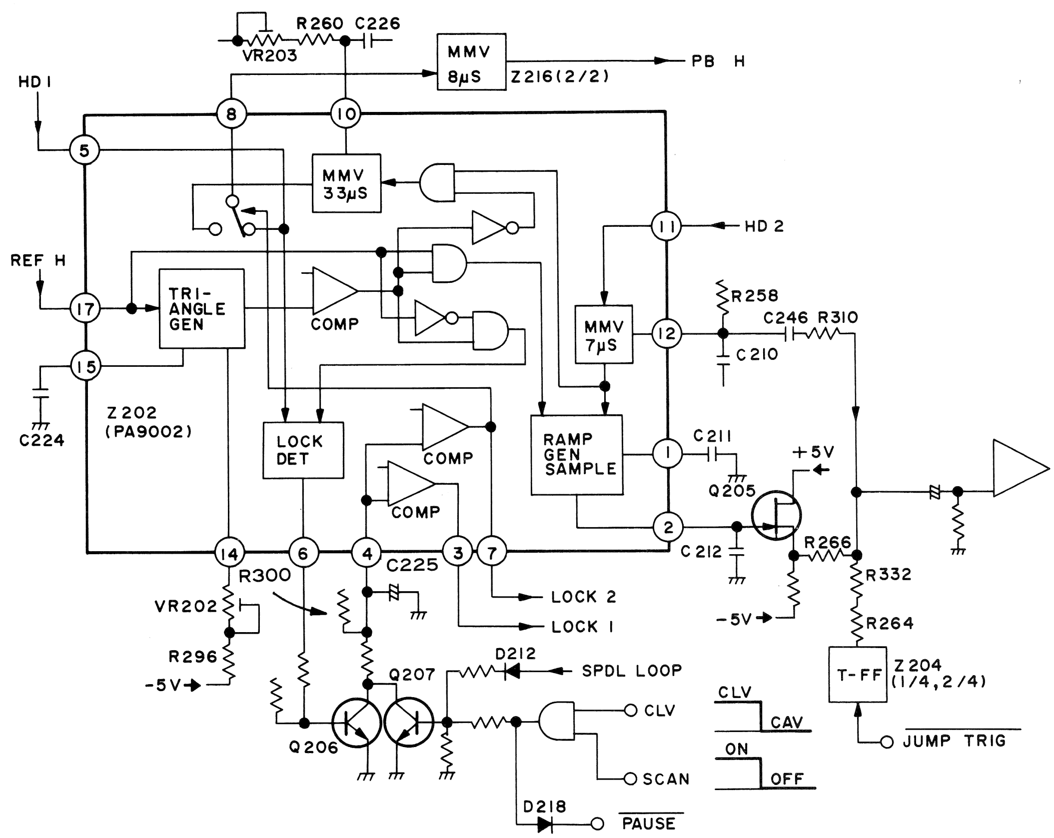


Fig. 7.1 PA9002 Peripheral Circuitry

This square wave signal is used as the gate signal by the phase error sampling circuit, and by the phase sync detector circuit and PBH signal circuit which will both be described later.
A signal which has been AND-ed by this gate signal and REF H signal is used in the phase error sampling circuit. This signal becomes a 10 μs wide signal which rises at the same timing as the REF H signal rise.

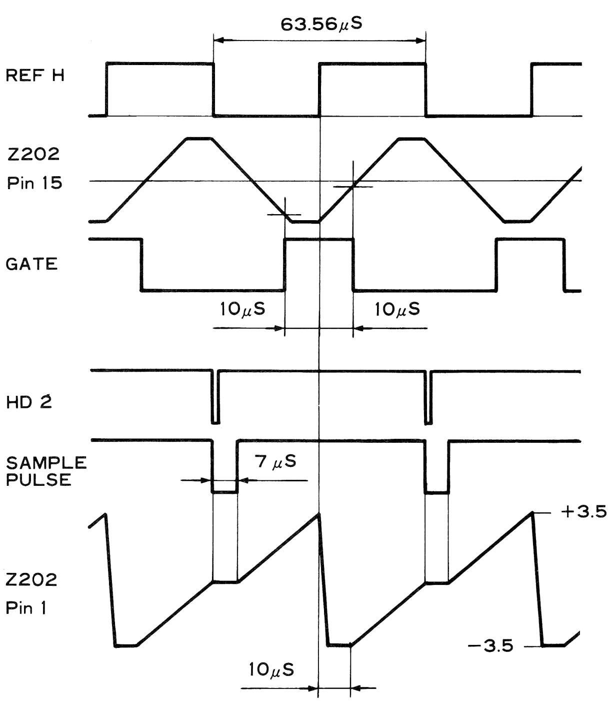


Fig. 7.2 Phase Error Sampling

C211 connected to pin 1 is charged by the constant current and the voltage increases linearly. A sawtooth wave signal is produced by resetting with the above 10 μs wide signal every 1H. During the period when the sampling signal produced from the above-mentioned HD 2 signal is low, a 7 μs flatness is produced in the sawtooth wave signal as C211 is not charged. This flat portion only is output to pin 2 and the voltage is held by C212. When the HD 2 signal phase leads, the voltage being sampled drops and when the phase is lagged, the voltage rises. In this way, the sampled phase error is output to the Q205 source. The phase difference between the REF H signal and HD 2 signal is defined as the difference in the timing of the fall of the two signals. This means that when the tangential servo is in a synchronized state, these two signals coincide at the fall timing. In other words, the sawtooth wave signal is sampled virtually near the center.

7.2 PB H SIGNAL CIRCUIT

When the spindle motor starts up and accelerates and its speed reaches 1400 rpm, the spindle servo circuit controls its rotation by comparing the phases of the REF H and PB H signals. The PB H signal for this purpose is sent from pin 8 of Z202 in the tangential servo circuit to the spindle servo.
As with the HD 2 signal, the HD 1 signal is sent from the sync processing circuit on the DEMB circuit board. The HD 1 signal is produced by eliminating H/2 from the $\overline{\text{COMP SYNC}}$ signal. Compared with the HD 2 signal, it has more jitter and yet it is detected more speedily in accordance with the start-up of the spindle motor.
The HD 1 signal, supplied from pin 5, is first output from pin 8 of Z202.
When the phases of the reference signal and playback signals virtually coincide with the operation of the spindle and tangential servos (when pin 7 is set low by the phase synchronization detector circuit which will be mentioned later), the HD 2 signal with minimal jitter is output from pin 8. However, if even one pulse of the continuous HD 2 signal is lost due to dropouts in the playback signal and other factors, the spindle servo circuit will not maintain a stable servo state.
This is why the dropouts in the HD 2 signal are compensated for as described below.
The monostable multivibrator is triggered by the trailing edge in the signal which is produced by AND-ing the signal, obtained by inverting the gate signal output from the above-mentioned

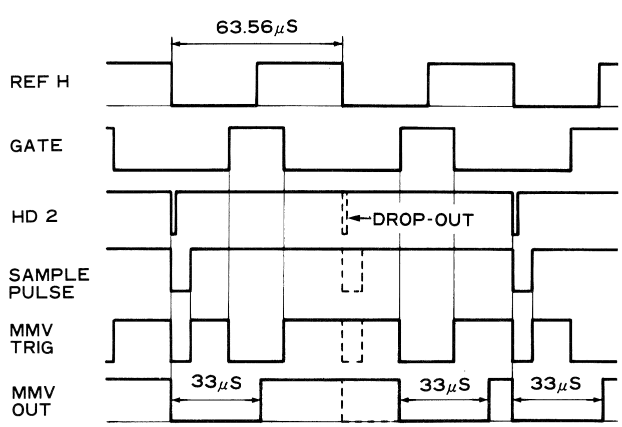


Fig. 7.3 Compensating for Dropouts in the PB H Signal

comparator, and the sampling signal, obtained from the above-mentioned HD 2 signal. A signal with a width of 33 μs adjusted by VR203 at pin 10 is output from the monostable multivibrator and this serves as the PB H signal.

Even if one pulse in the HD 2 signal, or sampling signal, is missing, the monostable multivibrator is triggered by the trailing edge of the gate signal and the 33 μs wide signal is compensated for.
The output of pin 8 has its pulse width aligned to 9 μs by Z216 (SN74LS221N) 2/2 and it is supplied to phase comparator pin 7 of Z203 on the spindle servo circuit. It is also sent to the CONT section.

7.3 PHASE SYNCHRONIZATION DETECTOR CIRCUIT

The asynchronous detection signal is produced by AND-ing the gate signal output from the comparator mentioned above and the signal obtained by inverting the REF H signal.
This detection signal serves as a signal with a 10 μs width and a fall which coincides with the timing of the REF H signal rise. This detection signal and the HD 1 signal are AND-ed and the output becomes the signal which indicates asynchronization. When the reference and playback signals are in a state of synchronization, the timing of trailing of the HD 1 signal and REF H signal coincides. Asynchronization is the state with the HD 1 signal present around the rise of the REF H signal.

The pulse signal which indicates this asynchronization is output to pin 6 and Q206 is driven into conduction. C225 connected to pin 4 is charged by R300 and as Q206 is driven into conduction, it is reset.
When the spindle motor start-up is considered, then the pulse signal is continuously output from pin 6, the pin 4 voltage rises only slightly and when the state of synchronization is approached, the pulse signal output decreases gradually and the pin 4 voltage rises is an exponential curve.

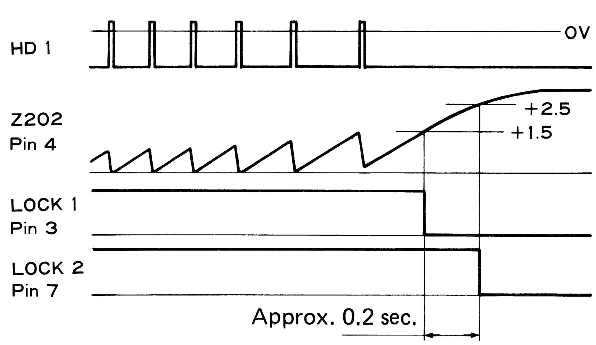


Fig. 7.4 Phase Synchronization Detection

The pin 4 voltage is determined by the internal comparator. First, when +1.5V is exceeded, a low signal is output to pin 3 and when +2.5V is exceeded, a low signal is similarly output to pin 7.
The pin 3 output controls the loop switch in the tangential error circuit which will be mentioned later, the spindle servo is considered to be stable and the tangential servo loop is closed. The pin 7 output is sent to the tangential error circuit and the mirror stopper circuit's detection value is controlled. The signal of the above-mentioned PB H signal circuit, sent to the spindle servo, is switched from the HD 1 signal to the signal produced from the HD 2 signal.
Q207 connected in parallel to Q206 is installed so as to prevent the tangential servo loop from closing when it is driven into conduction. It functions in the following cases:

- When the spindle servo loop is not closed
  The Z201 (UM3002A) pin 9 signal enters through D212.
- When conducting a scanning operation with a CLV disc
  At this time the phase error cannot be detected stably and so the tangential servo is inhibited. (CLV signal is low; SCAN $\overline{\text{OFF}}$/ON signal is high.)
- When a pause operation is being conducted.
  The pin 7 signal is sent to the CONT section on the SRVB circuit board as the $\overline{\text{SPDL LOCK}}$ signal. When the high-level state of this signal continuous for more than a particular period of time (about 3 minutes), playback is disabled and the player is stopped.
  When a pause operation is conducted with a CLV disc, the SCAN $\overline{\text{OFF}}$/ON signal is set high in order to establish a state in which the slider servo loop is opened. This drives Q207 into conduction as mentioned above, pin 7 is set high and the player is stopped once 3 minutes have elapsed with the pause operation in effect.
  In order to safeguard against this, Q207 is prevented from being driven into conduction by D218 when the $\overline{\text{PAUSE}}$ signal is low.

7.4 TANGENTIAL ERROR CIRCUIT

Two signals are added to the error signal appearing at the Q205 source.
First, in order to eliminate the transient noise caused by sampling, pulses with a phase opposite to that of the noise are added by C246 and R310 from the monostable multivibrator which produces the sampling signal.

Next, the output of Z204 (SN74LS00N) 1/4 and 2/4 of the T-FF which is inverted by the JUMP TRIG signal is added by R264 and R322.
In the video signal the color signal has its phase shifted by an amount equivalent to a half-wavelength for one frame. This is why the color signal is inverted for each jump operation performed with a CAV disc, why, depending on the performance of the color lock circuit in the TV monitor, this lock cannot be tracked and why disturbances are caused in the picture hue. Therefore, every time a jump operation is undertaken, the time base of the video signal is shifted by an amount equivalent to a half-wavelength (140 ns) of the color signal.
The frequency of the error signal is compensated for in order to stabilize the loop with the equalizer circuit composed of Z207 1/2 and of Z206 2/2 (both BA4558DX).
Z210 and Q208 form a loop switch and control is exercised by the signal of Z202 pin 3.
When the power switch is turned on, Q211 prevents the tangential mirror from swinging transiently. Since the −5V output is faster than +5V, the tangential error may be pulled by the negative voltage when the power switch is turned on and Q211 is installed and driven into conduction in order to prevent the mirror from being drawn.
The gain of Z206 2/2 is switched by the radial position of the disc during play.
It is clear that, with CAV discs, a difference is produced in the movement equivalent to time between the disc's inner and outer circumference even when the tangential mirror's angle of swing, or in other words the movement distance of the laser beam is equal. For instance, at the radial 70 mm position 10 μm is approximately 0.76 μs and at the radial 140 mm position, it is about 0.38 μs.
In order to compensate for this, Z212 and Z213 (both DTC124F) are installed, these are turned on and off by the outputs of pins 27 and 28 of Z201 and the gain of the tangential servo loop is switched.
Pins 27 and 28 of Z201 function to output signals which indicate the position which divide the LD disc's radius into four equal portions.
These signals are, for the inner circumference, −5V (Z212 and Z213 off) with both pins, approx. +2V

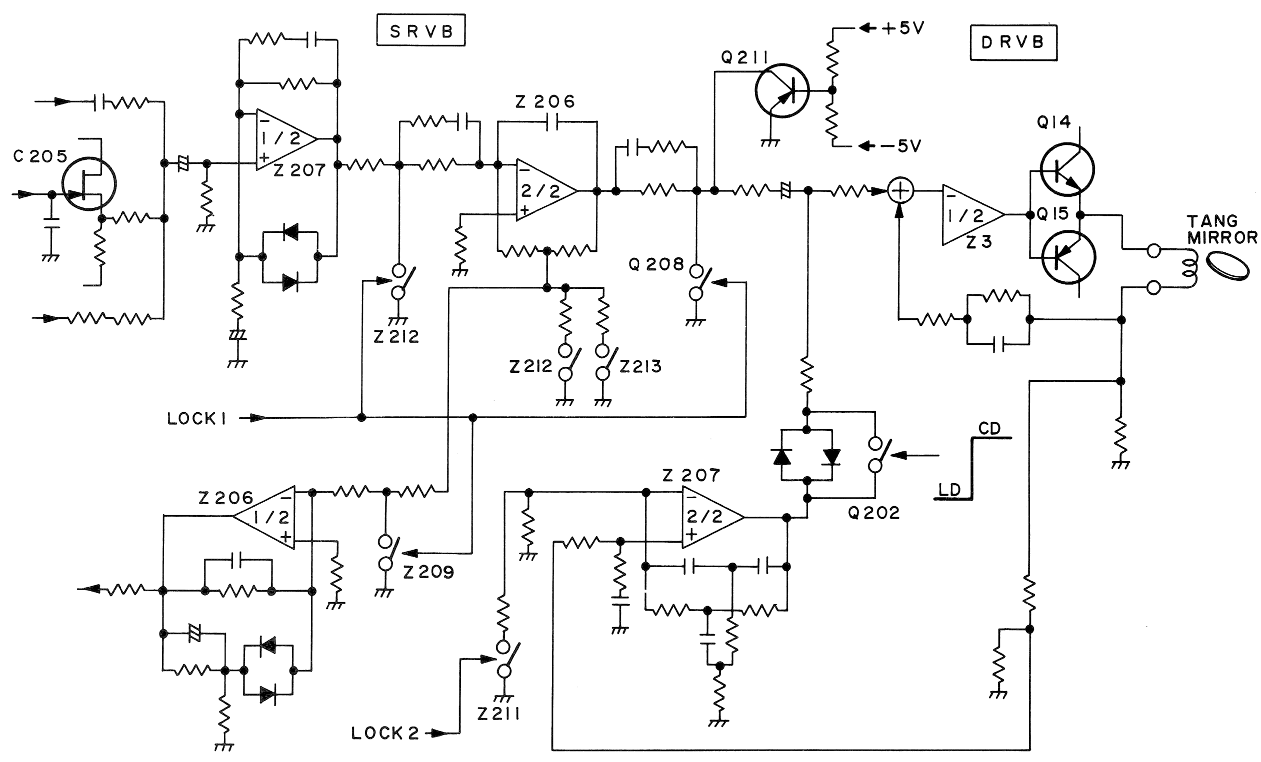


Fig. 7.5 Tangential Error Circuit

(Z212 off, Z213 on) with pin 27 only and +2V (Z212 on, Z213 off) with pin 28 only, and, for the outer circumference, +2V (Z212 and Z213 on) with both pins. This means that the loop gain increases by +3dB, +6dB and +8dB, with the inner circumference at 0dB, as the pick-up moves toward the outer circumference.
With CLV discs, the voltage remains at −5V for both pins 27 and 28.
The output error is sent as the TANG DRV signal to the mirror drive circuit on the DRVB circuit board.
The tangential error is also sent to the spindle servo circuit. When the phase difference between the PB H and REF H signal is judged by the Z203 phase comparator to be zero, the spindle servo circuit functions to converge the low-frequency components of the tangential error.
Z207 2/2 configures the mirror stopper circuit which limits the vibrating angle of the tangential mirror.
The drive current of the tangential mirror is sent to the error circuit as the TANG RTN signal. The signal amplified by Z207 2/2 is in reverse phase to that of the error signal and it is subtracted by adding it to the TANG DRV signal.
In the resonance frequency of the mirror unit control is exercised so as to minimize the vibrating angle in order to stabilize the loop.

During start-up, the Z207 2/2 output level is raised, the vibrating angle reduced and a stable state obtained and after pin 7 of Z202 ($\overline{\text{SPDL LOCK}}$ signal) has been made low, extension follows to the prescribed limit value, by turning Z211 (DTC124F) on.
This is done in order to attain a servo lock state at the position (near the neutral position) in which the inclined angle of the mirror is not great.
When a CD disc is being played, the tangential servo is not used, the mirror is placed in a free-moving state and Q202 is provided to prevent it vibrating at the resonance frequency by means of mechanical vibration. By driving Q202 into conduction with the CD signal, the mirror is brought to a state in which it is in essence shortcircuited.

8. DESCRIPTION OF VIDEO PLAYBACK CIRCUITRY

The video signal of an LD disc is played back and output by the circuitry described below.
The video playback circuitry includes the RF demodulator circuit which demodulates the video signals from the RF signals which have been picked up, the dropout compensator circuit which compensates for dropouts in the signals, the sync separator circuit which separates the sync and other signals from the video signals, the sync processing circuit which processes the sync signals, the color phase compensation circuit which suppresses the residual error of the time base which could not be suppressed by the tangential servo, the dummy sync signal generator circuit which produces the sync signals when a CD disc is played and the output processing circuit which superimposes the frame number and other indication information on the video signal and which inhibits the video signal output. Most of the circuitry is included in the VIDEO section on the DEMB circuit board.

8.1 RF DEMODULATOR CIRCUIT

The total sum of the four dividing devices (B1 to B4) of the photo-detector (PD) is arithmetically processed (Q1 to Q3) by HEAD circuit board as the RF signal and amplified (Q4 to Q6).
On the PREB circuit board the amplitude of the RF signal is adjusted to the prescribed value (RF level, VR1) and the signal is sent to the LDDB circuit board. On the LDDB circuit board the signal is sent to the DEMB circuit board without the video signal being processed in any way.
On the DEMB circuit board, the signal is first supplied to the RF correction circuit (Q201, Q202, Q204). The RF signal level drops at the inner circumference of the disc compared with its outer circumference and so correction is provided by increasing its gain for the high frequency range where the influence is particularly great.
Switching between the inner and outer circumference is undertaken by the RF CORR signal produced from the SLD POT signal by Z201 (UM3002A) on the SRVB circuit board.
The output of the RF correction circuit is sent not only to the next band-pass filter but also to the ADEM section for audio playback, to the PNJB (rear panel I/O port) for application and also to the dropout detector circuit which will be described later.

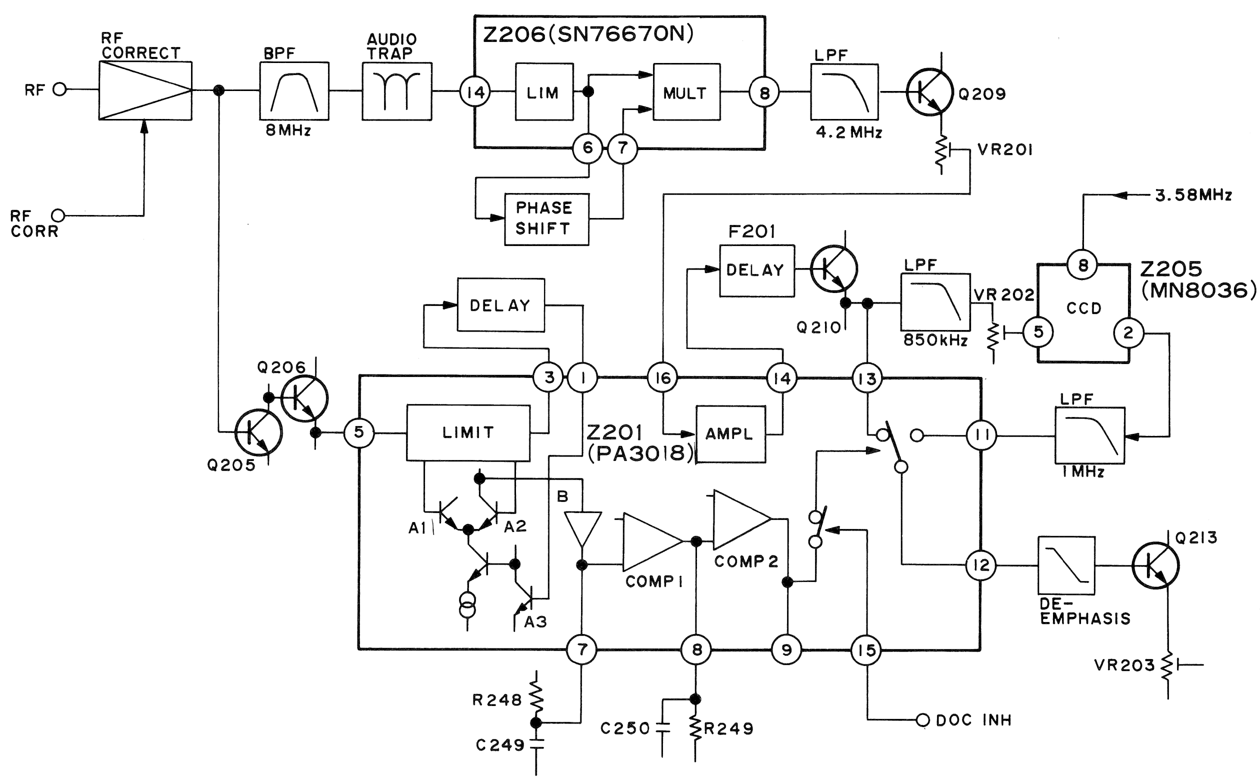


Fig. 8.1 RF Demodulator and Dropout Compensator Circuits

Fig. 8.2 shows the pass characteristics of the band-pass filter and the RF signal spectrum. In this band-pass filter it is not possible to suppress sufficiently the carrier of the audio signals so as to allow the lower-band frequency of the color signal to pass through the filter and so an audio trap is installed next to the filter. The 2/R channel (2.8 MHz) carrier is removed by C203 and L203 while the 1/L channel (2.3MHz) carrier is removed by C202 and L204.

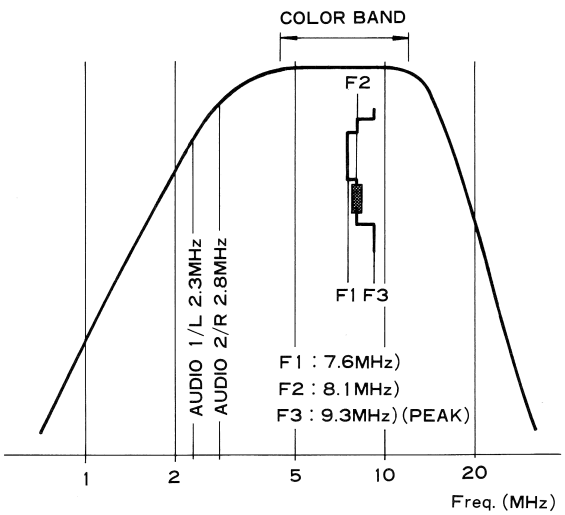


Fig. 8.2 RF Spectrum and Band-pass Filter Characteristics

Z206 (SN76670N) contains a limiting amplifier circuit and a multiplier circuit. The signal, which becomes the "product" of the limiter output signal and the signal which has passed through the phase shift circuit, is produced by the multiplier circuit, the carrier components are suppressed in the low-pass filter and the video signal is demodulated.
The demodulated video signal is amplified by the amplifier circuit inside Z201 (PA3018) and delayed by a time equivalent to 220 ns by F201. This is because a certain time delay is produced from the generation of the dropouts until their detection. Or, in other words, no problems are posed by the delay because the dropouts are detected by a time equivalent to 220 ns ahead.
The delayed video signal passes through the Q210 buffer, it is sent to the dropout compensation circuit (DOC switch and 1H delay circuit) which will be mentioned later as well as to the color burst separator circuit which will also be mentioned later, it is de-emphasized (R246, R247, C322) and then passes through the Q227 buffer and is sent to the PNJB (rear panel I/O port) for the application.

8.2 DROPOUT COMPENSATOR CIRCUIT (DOC)

RF correction circuit output signal is amplified by Q205 and Q206 and supplied to pin 5 of Z201 (PA3018).
Pin 5 is the input pin which supplies the signal to the limiter circuit composed of a 4-stage amplifier circuit, and from the second stage the A1 and A2 signals are output in reverse phase. The fourth stage limiter output becomes the A3 signal which is delayed by 30 ns by the external delay circuit. The A1, A2 and A3 signals enter the dropout detection (DOS) circuit.
The A1 signal has an average (DC) level which is lower than that of the A2 signal but if the amplitude of the RF signal is close to the prescribed value, the instantaneous voltage of the A1 and A2 signals is reversed when the momentary level of the RF signal is positive. When A1 is greater than A2 and when A3 has a negative level momently, the DOS circuit outputs a low signal.
Under normal conditions this low signal is output at every wavelength of the RF signal and the integrating circuit (R248, C249) connected to pin 7 is returned to its reset state. When dropouts arise, a low signal is not output from the DOS circuit and the pin 7 voltage continues to rise.

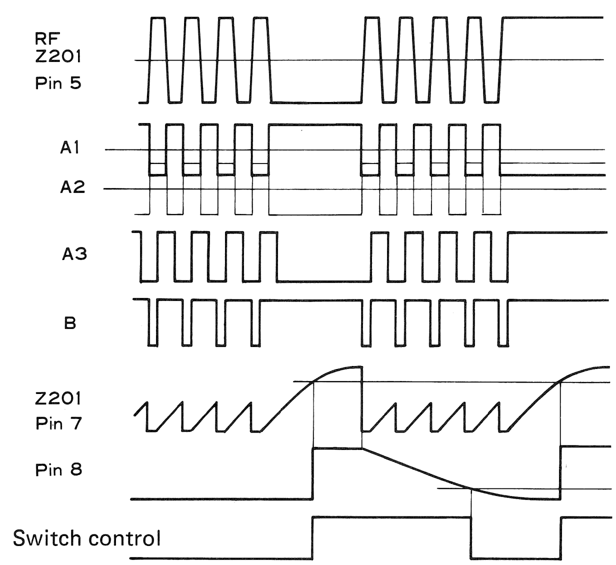


Fig. 8.3 Dropout Detection