MS-1650A

DIGITAL MEMORY OSCILLOSCOPE

INSTRUCTION MANUAL

TRIO

FEATURES

This instrument is a combination of an oscilloscope having a frequency band of DC-10 MHz and a digital memory having memory ability of 8 bits × 1024 words and write speed up to 1 μs/word. Input signal can be stored in the memory so that memory signal is displayed on the CRT at any time.
The instrument is readily connected to a pen recorder. It memorizes and displays signals proir to triggering, instantaneous signals, transient waveforms and repetitive waveforms.

1. Instantaneous signals, transient waveforms, and repetitive waveforms can be stored in the memory for displaying on the CRT.
2. Semiconductor memory circuit having memory ability of 8 bits × 1024 words and write speed up to 1 μs/word.
3. The oscilloscope covers a wide DC-10 MHz band. The controls and switches of the oscilloscope are also used to store input signals in the memory and display memory signals.
4. —DELAY function is provided to store signals prior to triggering in the memory which is not possible with conventional oscilloscopes.
5. The automatic free-run function repeats store and read input signals automatically.
6. Memory signals are readily displayed on the built-in CRT or recorded in a pen recorder.
7. Real time waveform being displayed on the CRT can be stored in the memory, thus providing simplified operation.
8. Both the real time waveform and memory signal can be displayed simultaneously, permitting you to compare one signal with the other.
9. By using alkaline battery (option), the memory data can be retained for many hours even when the power cord is disconnected. Battery charge terminal is also provided.
10. Signals synchronized with power frequency can be displayed or stored in the memory.
11. The oscilloscope can be used as a X-Y scope by simply setting the DISPLAY MODE switch to the X-Y position.
12. Large sized, square CRT displays waveforms over the entire area of the screen.
13. Rigid construction with die casing front panel and compact design.

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SPECIFICATIONS

Cathode Ray Tube

Type
E2713B31A

Acceleration voltage
Approx. 2 kV

Display area
8 div × 10 div (1 div = 9.5 mm)

Vertical Axis

Sensitivity
10 mV/div — 20 V/div, ±5%

Attenuator
10 mV/div — 20 V/div, 1-2-5 sequence
11 ranges, fully adjustable

Input impedance
1 MΩ, ±5%   22 pF, ±4 pF

Frequency response

Oscilloscope	DC:	DC-10 MHz (−3 dB) (10 mV/div — 10 V/div)
	AC:	2 Hz-10 MHz (−3 dB) (10 mV/div — 10 V/div)
Digital memory	DC:	DC-250 kHz (−3 dB)
	AC:	2 Hz-250 kHz (−3 dB)

Rise time
35 ns (Oscilloscope operation)

Overshoot
3% or less (at 100 kHz square wave)

Maximum input voltage
600 Vp-p or 300 V (DC + AC peak)

Operating mode
REAL: Oscilloscope operation or memory free-run
DUAL: Real time and memory waveforms, dual trace operation (500 kHz CHOP)
MEMORY: Memory waveform readout
X-Y: X-Y scope operation

A/D Converter

Resolution
8 bits

Convertion system
Successive comparison A/D converter

Scale-over
8 div vertical scale

Sweep Circuit

Sweep system
Trigger sweep (NORM), auto sweep (AUTO)

Sweep time
1 μs/div — 1 s/div, ±5%
1-2-5 sequence
19 ranges, fully adjustable

Magnifier
5 MAG ± 10%

Linearity
3% (5 μs/div — 1 s/div)
5% (1 μs/div — 2 μs/div)

Sync Circuit

Sync input
INT: Vertical input
LINE: Line frequency
EXT: EXT TRIG input

Polarity
Positive and negative

Sync voltage
INT: More than 1 div of amplitude on CRT
LINE: Within the specified power supply voltage
EXT: More than 1 Vp-p

Sync frequency
INT: 20 Hz — 10 MHz
EXT: DC — 10 MHz

External sync input voltage
20 V (DC + AC peak)

Horizontal Axis

Operating system
DISPLAY MODE selector switch to X-Y position

Sensitivity
150 mV/div (±20%, HOR. GAIN MAX)

Frequency response
DC: DC—1 MHz (−3 dB) (HOR. GAIN MAX)

Input impedance
100 kΩ ± 20% 35 pF or less

Maximum input voltage
50 V (DC + AC peak)

Memory Unit

Memory capacity
1024 words (100 words/div)

Write speed
0.1 ms/div — 1 s/div, 13 ranges (equivalent to 1 μs/word — 10 ms/word)

Readout speed
SCOPE: Same as write speed
PEN: 10 ms/word, 20 ms/word 50 ms/word, 3 ranges (Switchable to 100 ms/word, 200 ms/word, 500 ms/word by changing jumper wire connection)
EXT: Rising edge of EXT CLOCK input signal
Repetition rate frequency: Less than 1 MHz
Input signal:
High level: Pulse width more than 500 ns
Low level: Pulse width more than 500 ns
Rise time, Within 500 ns
Input voltage: TTL level
Maximum input voltage:
20 V (DC + AC peak)
Input impedance: Approx. 30 kΩ

Delay
— DELAY (0-9 div, DIG SW setting)

Display time

The amount of time for which memory signals are displayed can be varied from approx. 1 to approx. 20 seconds.

Signal Output

Memory out and Memory out for pen (Output of only PEN mode)

Output wave: Memory wave
Output voltage: 1.6 Vp-p, full scale (at 8 div)
Output impedance: Approx. 470 Ω

Read gate

Output wave: Positive pulse (1 word) of final address
Output voltage: TTL level
Output impedance: Approx. 220 Ω

Read gate for pen (Output of only PEN mode)

Output voltage: TTL level (LOW active)
Output impedance: 220 Ω

Sweep gate

Output wave: Positive pulse synchronized with sweep signal
Output voltage: TTL level
Output impedance: Approx. 220 Ω

CAL (Calibrating voltage)

Output wave: 1 kHz, ±10%, square wave
Output voltage: 1 Vp-p ±5%

Data out

Data output:
8 bit binary parallel output, TTL level, active high
Timing pulse:
Active high or low (MOS) (TTL level)
Read gate out:
Positive output of the last-adress one word
Output impedance: approx. 220 Ω (TTL level)
Ext. clock:
TTL level clock input of 1 MHz or below
Positive pulse width: not less than 500 ns
Negative pulse width: not less than 500 ns
Rise time: not more than 500 ns
Input impedance: approx, 30 kΩ

Intensity Modulation

Input voltage
TTL level (Positive voltage increases brightness)

Input impedance
Approx. 15 kΩ

Input frequency
DC — 1 MHz

Maximum input voltage
50 V (DC+AC peak)

Power Requirement

Voltage 100/120/220/240 V, ±10%
Power consumption Approx. 50 W

Dimensions

Width 284 mm (328 mm)
Height 138 mm (153 mm)
Depth 400 mm (463 mm)
Figures in ( ) show maximum size
Weight Approx, 9 kg

Accessory

Probe (PC—22) ....1 piece
Attenuation 1/10
Input impedance ....10 MΩ
Less than 18 pF
Replacement fuse..........................1.5 A 2 pieces
0.7 A 2 pieces
Instruction manual...................................1 copy
AC cord ....1 piece
Digital output plug...................................1 piece

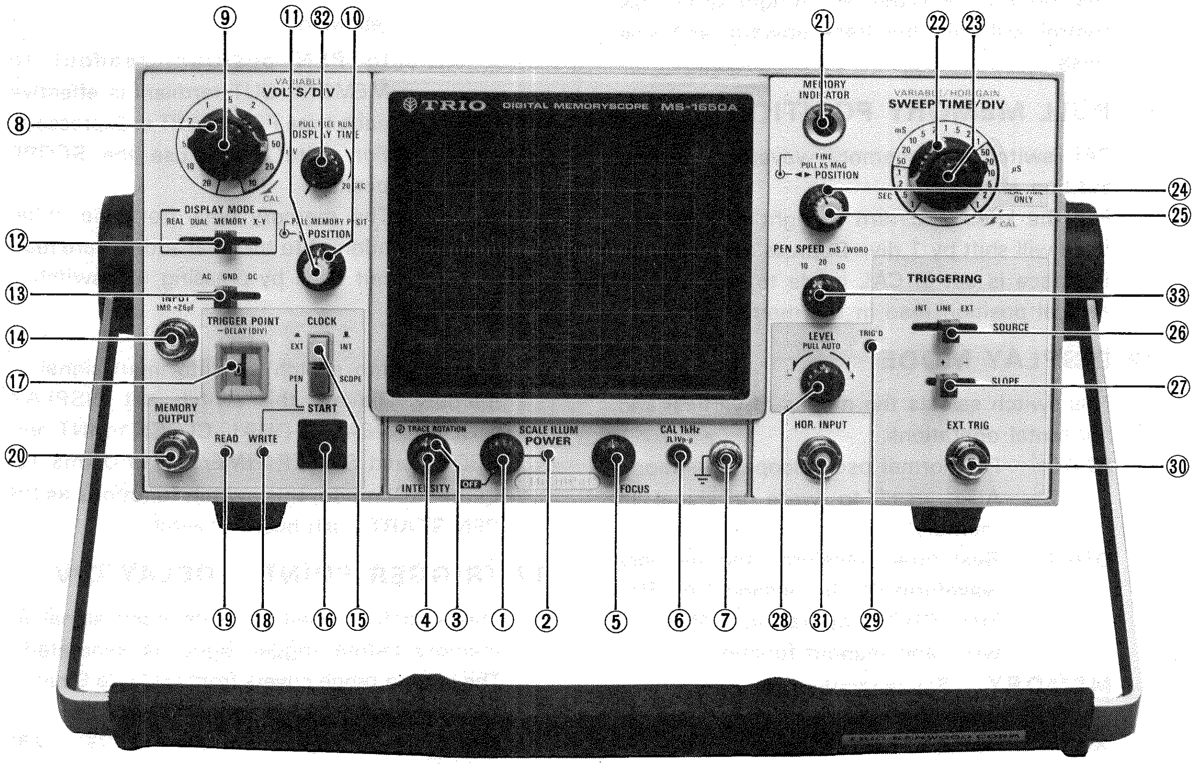
Option

Backup battery Alkaline rechargable battery (UM3×3)

PIN CONFIGURATION

14-pin cable receptacle #	Data contents	14-pin cable receptacle #	Data contents
Pin # 1	Data LSB	Pin # 8	MSB
Pin # 2	BIT 2	Pin # 9	Timing pulse MOS
Pin # 3	BIT 3	Pin # 10	Timing pulse MOS
Pin # 4	BIT 4	Pin # 11	EXT. CLOCK
Pin # 5	BIT 5	Pin # 12	GND
Pin # 6	BIT 6	Pin # 13	GND
Pin # 7	BIT 7	Pin # 14	READ GATE OUT

CONTROLS ON PANELS



CONTROLS ON FRONT PANEL

1. POWER/SCALE ILLUM

Power switch and scale illumination control. Fully counterclockwise rotation of this control turns off oscilloscope. Clockwise rotation turns on oscilloscope. Further clockwise rotation of this control increases the illumination level of the scale.

2. LED PILOT LAMP

Lights when oscilloscope is turned on.

3. INTENSITY

Intensity contol. Adjusts the brightness of spot and waveforms for easy viewing. A left turn allows the waveforms to disappear.

4. TRACE ROTATION

This is used to eliminate inclination of horizontal trace.

5. FOCUS

Spot focus control to obtain optimum waveform according to brightness.

6. CAL

Provides 1 kHz, 1 volt peak-to-peak square wave input signal. This is used for calibration of the vertical amplifier attenuators and to check the frequency compensation adjustment of the probes used with the oscilloscope.

7. GND TERMINAL

Earth terminal of the oscilloscope.

8. VOLTS/DIV

Vertical attenuator calibrated in voltage per division. In the extreme clockwise (CAL) position, the vertical attenuator is calibrated.
Select the position of the control according to the magnitude of input voltage to obtain the optimum waveform.
Vertical sensitivity is calibrated in 11 steps from 0.01 to 20 volts per div.

9. VARIABLE

Vertical attenuator adjustment. Fine control of vertical sensitivity. The sensitivity within the 11 ranges of VOLTS/DIV (8) is continuously adjustable. The exteme clockwise (CAL) position is used to calibrate the vertical attenuator.

10. ▲▼ POSITION

The rotation of this control adjusts vertical position of trace as desired. A right turn of this control will shift the trace upward, and vice versa.

11. PULL MEMORY POSITION

CAL switch and memory waveform vertical position adjuster.
Pull the knob and turn to right or left. The trace will shift by 1 div. Depress the knob and the trace is set in CAL mode to indicate the vertical position read in the memory.

12. DISPLAY MODE

This switch selects the modes of vertical and horizontal operations.

REAL: For normal oscilloscope operation. Also, used to write a signal in memory.

DUAL: Real time waveform and memory waveform can be observed by 500 kHz CHOP operation. Memory write and readout functions.

MEMORY: For readout of memory waveform.

X-Y: For X-Y oscilloscope.

13. AC-GND-DC

Vertical input selector switch. AC position blocks DC component of input signal. GND position opens signal input path and grounds amplifier input. DC position directs input of AC and DC components to amplifier.
When the DISPLAY MODE is set to REAL or DUAL, a trace appears on the scope in GND position of AC-GND-DC switch regardless of the position of the PULL AUTO (28).

14. INPUT

Vertical input terminal.

15. CLOCK

INT/EXT: Clock selector switch. EXT position is used for readout only. Clock signal is inputted to EXT CLOCK (36) terminal. In this position, the waveform on the scope cannot be synchronized. INT position is used for write and readout. There are two funcitons, SCOPE and PEN (readout only).

SCOPE/PEN: Memory readout mode selector switch. In SCOPE position, readout to the scope is effected repeatedly.
In PEN position, readout to MEMORY OUT termianl is effective each time PEN START is depressed.
For write mode, use the SCOPE position.
The memory data from the initial address to the final address are read out once by pressing this switch.

16. START

A pushbutton switch to write input signal in memory. To use this switch, set DISPLAY MODE to REAL or DUAL, CLOCK to INT and SCOPE, and SWEEP TIME/DIV to 0.1ms-1s.
In the PEN mode, this switch functions as the PEN START push button switch.

17. TRIGGER POINT −DELAY/DIV

This switch is used to write input signal in memory before trigger signal is generated.
The setting range covers from 0 div. to 9 div. 1 div. represents 100 words in memory.
For −DELAY operation, push LEVEL (28) switch.

18. WRITE (LED)

Red LED lights while input signal is being written in memory.

19. READ (LED)

Green LED lights while memory data is being read out.

20. MEMORY OUT

Memory data output terminal. Readout speed is varied according to readout modes, SCOPE, PEN and EXT CLOCK.

21. MEMORY INDICATOR

Backup power check indicator (option). If it stays in the blue zone when the MEMORY BATT switch (38) at the rear panel is set to ON (power off), it means that the data is stored in memory.
When the power is ON, the indicator glows with blue regardless of the position of the MEMORY BATT switch.

22. SWEEP TIME/DIV

Horizontal sweep time selector. It selects sweep times of 1μs to 1s in 19 steps. The 1μs-50μs range is used for real time.

23. VARIABLE/HOR. GAIN

Used for fine adjustment of sweep time. Continuous adjustment between 19 ranges of SWEEP TIME/DIV (22) is possible. Sweep time is calibrated at the extreme clockwise position (CAL). When the DISPLAY MODE is set to X-Y, the signal from the HOR INPUT is attenuated by SWEEP/TIM DIV. control.
Set the variable knob to CAL in the memory operation.

24. ◀▶ POSITION

Rotation adjusts the horizontal position of trace as desired. Clockwise rotation shifts the trace to right and counterclockwise rotation, to left.

25. FINE PULL X5MAG

Horizontal position fine adjuster and sweep magnification selector switch. Pull the knob and the trace is magnified five times as large in left and right directions. Brightness is slightly decreased.
Input signal stored in the memory is not magnified even in the X5MAG position.

26. SOURCE

Sync source voltage selector switch for three functions, INT (internal sync), LINE (50/60 Hz sync) and EXT (external sync).

INT: Sweep is triggered by vertical input signal.

LINE: Sweep is triggered by 50/60 Hz power frequency.

EXT: Sweep is triggered by voltage applied to EXT TRIG terminal.

27. SLOPE

Sync polarity selector switch. In the "+" position, sweep is triggered with rising slope of input waveform, and in the "−" position, with falling slope of input waveform.

28. LEVEL, PULL AUTO

Triggering level control adjusts sync phase to determine the starting point of sweep on the slope of trigger signal waveform. By pulling the knob toward you, auto sweep is effected; the sweep is set in free-run state and trace is displayed on CRT even when no trigger signal is present. When trigger signal is present, sweep is started so the triggering level can be adjusted.

29. TRIG'D

Sync indication lamp lights when sync signal is triggered. Check this lamp lights when writing input singal to memory.
The lamp may light in the GND position of the AC-GND-DC. This is normal and is not an indication that the unit is defective.

30. EXT TRIG

Input terminal for external trigger signal. External trigger signal (1 Vp-p or higher) should be applied with SOURCE switch set to EXT.

31. HOR INPUT

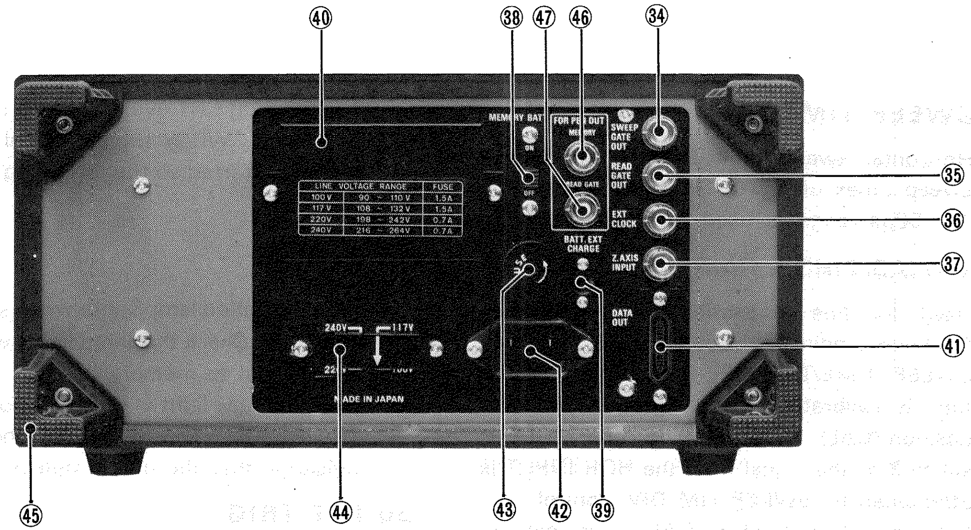
Input terminal for external horizontal signal. DISPLAY MODE switch should be set to X-Y.

32. DISPLAY TIME

Store and read signals are automatically repeated when this knob is pulled out (free run function). The display time is about 1 second when the knob is set to the left and about 20 seconds when it is set to the right. This function is effective only when the DISPLAY mode is REAL.

33. PEN SPEED

Selects the memory read speed in the PEN mode from among three speeds: 10 to 50 ms/word. This switch functions regardless of the position of SWEEP TIME/DIV ㉒.



CONTROLS ON REAR PANEL

34. SWEEP GATE OUT

Sweep gate signal (positive pulse) is available at this terminal.

35. READ GATE OUT

Positive pulse for one word of final memory address is available at this terminal.

The signal can be used as a stop signal when a pen recorder is used.

36. EXT CLOCK

Input terminal for external clock used for readout only.

CLOCK switch (15) should be set to EXT.

37. Z-AXIS INPUT

Intensity modulation terminal. Intensity is modulated at TTL level.

38. MEMORY BATT

Memory backup battery selector switch (ON-OFF). Turn ON the switch to hold the memory data at power OFF. When backup battery is not used, this switch should be set to OFF.

39. BATT. EXT

Backup battery charging terminal.

A pin in the center is minus. The battery is fully charged in about 4.5 hours at DC 7V or in about 6 hours at DC 6V. Use a power source of more than 200 mA, to charge the battery. By using battery fully charged, memory waveform is stored for 500 hours. For quick charging, set the POWER switch to OFF.

40. BATTERY CASE

Backup battery case for loading optional alkaline battery (UM3 × 3). The battery is charged at power ON.

41. DATA OUT

This is a place to mount the memory data output terminal.

Output terminal for memory data (8 bit BINARY).

42. POWER CONNECTOR

For connection of accessory power cord.

43. FUSE HOLDER

For 100/120V operation, use a 1.5A fuse. For 220/240V operation, be sure to use a 0.7A fuse.

44. POWER VOLTAGE SELECTOR

Set the selector to the position corresponding to the correct AC power voltage, 100/120/220/240V.

45. CORD REEL

Store the power cord in the reel when the oscilloscope needs to be transported or it is to be left unused.

46. MEMORY

This is valid only in the PEN mode. This terminal outputs the same data as MEMORY OUT ⑳. The terminal is grounded in the SCOPE mode.

47. READ GATE

This is valid only in PEN mode. This terminal outputs the same as READ GATE ㉟. This output signal drops to the GND level to start pen operation, and rises to the H level to stop pen operation when reading is finished. The terminal is grounded in the SCOPE mode.

OPERATION

OSCILLOSCOPE OPERATION

Refer to the previous section "Controls on Panels". Before operating the oscilloscope, set the switches and controls as follows:

Switches and Controls	Position
1. POWER/SCALE ILLUM	OFF
3. INTENSITY	Center (slightly right)
5. FOCUS	Center
8. VOLTS/DIV	20V
9. VARIABLE	Full clockwise
10. ⇕ POSITION	Center
12. DISPLAY MODE	REAL
13. AC-GND-DC	GND
22. SWEEP TIME/DIV	1ms
23. VARIABLE	Full clockwise
24. ◀▶ POSITION	Center
25. FINE PULL × 5 MAG	Center (PUSH)
26. SOURCE	INT
27. SLOPE	+
28. LEVEL	Center (PULL) AUTO

1. Connect the supplied power cord to the power connecter. The oscilloscope is factory adjusted to operate on AC 240V.
2. Turn the POWER switch (1) to ON and the POWER lamp (2) will light. When horizontal trace does not appear at the center of the screen, adjust the ⇕ POSITION (10).
3. Adjust the intensity by the INTENSITY (3). If the trace is unclear, adjust the FOCUS (5).
4. If the trace is inclined, adjust the TRACE ROTATION (4).
5. Set the AC-GND-DC (13) to AC or DC position and apply input signal to the INPUT (14). Turn the VOLTS/DIV (8) clockwise to obtain optimum waveform.
6. If the waveform is running and not triggered, turn the LEVEL (28). By pushing the LEVEL knob, the auto function is released. The waveform disappears when the knob is turned clockwise or counter-clockwise and appears again at the approximate midposition of it. Turn the knob until optimum triggering level is obtained.
7. When the signal voltage is more than 0.01V and waveform does not appear on the screen, the oscilloscope may be checked by feeding input from the CAL (6) terminal. Since the calibration voltage is 1 Vp-p, the waveform becomes 5 div at the 0.2V position of the VOLTS/DIV.
8. In measuring DC component, set the AC-GND-DC (13) to DC. If it contains positive (+) potential, the waveform moves upward. If negative (−) potential is contained, the waveform moves downward. The zero potential can be checked at the GND position.

DIGITAL MEMORY OPERATION

Set the switches and controls as follows before using the digital memory:
Other knobs and controls are the same in function as those of oscilloscope operation.

Switches and Controls	Position
11. MEMORY POSITION	CAL (PUSH)
12. DISPLAY MODE	REAL or DUAL
15. CLOCK	INT/SCOPE
17. TRIGGER POINT	0
22. SWEEP TIME/DIV	0.1ms — 1s
28. LEVEL	NORMAL (PUSH)
32. FREE RUN	PUSH
33. PEN SPEED	10 ms, 20 ms, 50 ms/word

1. Operate the oscilloscope and display a triggered signal.
2. Depress the WRITE START (16) and the WRITE (18) lamp will light.
3. When the WRITE lamp goes off, the READ (19) lamp begins to flicker.
4. Set the DISPLAY MODE (12) to DUAL or MEMORY and memory waveform will be displayed. In the DUAL mode, the real time waveform overlaps with the memory waveform. By adjusting the ⇕ POSITION (10) or MEMORY POSITION (11), both waveforms can be observed.
5. When observing memory waveform, it is not necessary to adjust the VOLTS/DIV (8) and SWEEP TIME/DIV (22). The VOLTS/DIV does not change the amplitude of the memory waveform. The SWEEP TIME/DIV changes only the readout speed; the memory waveform remains unchanged on the screen.

— DELAY Setting

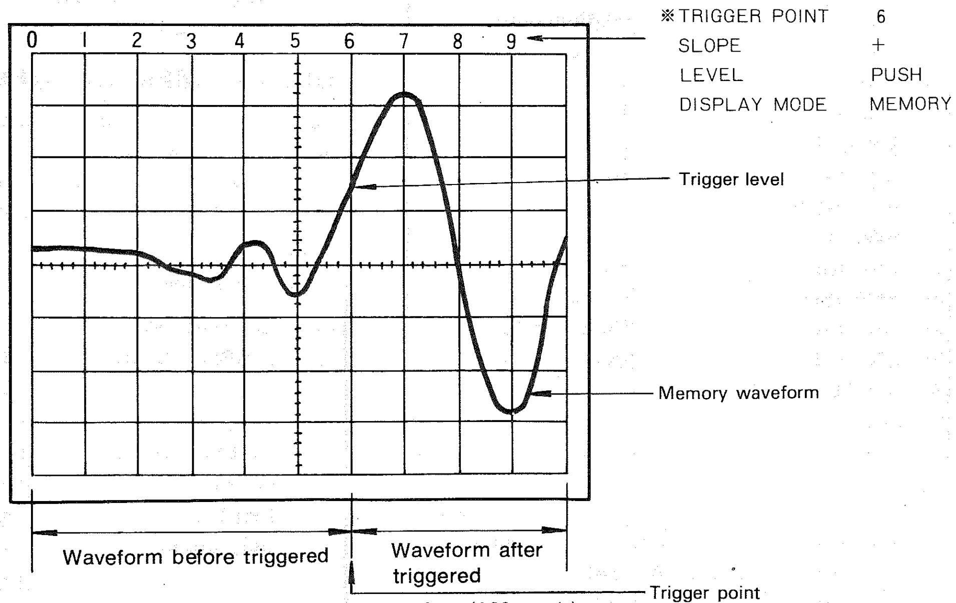
With conventional oscilloscopes, it is not possible to observe a trace before triggering signal is developed.

This oscilloscope has "— DELAY" function to store a waveform in memory before triggering signal is developed, thus permitting a wide variety of applications. The numbers indicated by the setting switch (17) correspond to the horizontal scale divisions so that trigger points can be easily checked on the scope.

The diagram below shows the — DELAY points indicated by the setting switch (17).

When a trigger point indicated by the setting switch (17) appears on the scale, the oscilloscope provides a negative delay of up to 9 div. When the — DELAY switch is "6" position, the memory waveform is as shown below.

When the — DELAY is set for one-shot signal observation, be sure to press the LEVEL (28) to NOMAL TRIGGER and then press the WRITE START (16).



The left 6 div waveform is a memory waveform (600 words) before triggered. The right 4 div waveform is a memory wave (400 words) after triggered.

The — DELAY setting switch is used in conjunction with the scale. When the — DELAY is set to 6, the trigger point is the 6th division from the left end of the scale.

Fig. 1

Readout to Pen Recorder

This oscilloscope permits any high speed traces to be stored in memory and converted into slow speed time base which a recorder is able to follow. Thus, it is possible to record a memory data in a recorder at a speed suitable to the recorder's response.

The standard readout speeds are 10ms/word, 20 ms/word, and 50 ms/word, but can be changed to 100ms/word, 200ms/word and 500ms/word by changing the connections of the jumper wire in control circuit board.

To record a memory data in a pen recorder, use the following procedures:

1. Operate the digital memory and write input signal in memory.
2. Set the DISPLAY MODE to DUAL or MEMORY. It may be set to REAL while the FREE RUN function is being used.
3. Connect the pen recorder to the MEMORY OUT FOR PEN. Set the CLOCK to INT/PEN.
4. Connect the pen recorder to the MEMORY OUT terminal.
5. Depress the START and the memory waveform is read out. The readout is completed at 1024 words and is set in the D/A conversion saturating point. To resume the readout, depress the START once again.

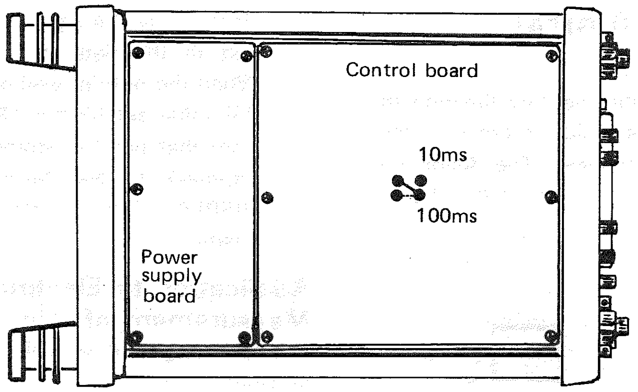


Fig. 2

Measurement of Input Signal Voltage with Pen Recorder

To obtain input signal voltage from the waveform recorded by the pen recorder, use the following equation:

$$V\,(v) = \frac{\text{Pen recorder input level (V/cm)} \times \text{Recorded amplitude (cm)}}{0.2\ \text{(V/div)}} \times \text{Write input level (v/div)}$$

Measurement of Input Signal Time with Pen Recorder

To obtain write signal time T from the waveform recorded by the pen recorder, use the following equation:

$$T\,(\text{sec/cm}) = \frac{\text{Pen recorder feed speed (sec/cm)}}{\text{Readout speed (sec/div)}} \times \text{Write speed (sec/div)}$$

FREE RUN FUNCTION

This function is used to automatically repeat store and read operations. The period for which the input waveform data is stored in the memory can be varied from about 1 to 20 seconds with the DISPLAY TIME knob; this is convenient when it is necessary to observe consecutive phenomena without observer intervention.

By pulling the DISPLAY TIME knob (REAL position), the FREE RUN functions.

Depressing the DISPLAY TIME knob resets the free run function and sets the REAL mode.

Pressing and holding the WRITE START button for one repetition of the store and read input wavefrom data cycle temporatily suspends the automatic free run function in the memory read state. Press and then pull the DISPLAY TIME knob, or set the DISPLAY MODE switch to the MEMORY (or DUAL) position, then to the REAL position to restart the automatic free run function.

Note

The FREE RUN function is sometimes started by turning on the POWER switch with the DISPLAY TIME knob in the OUT position.

APPLICATIONS

APPLICATIONS OF DIGITAL MEMORY SCOPE

This instrument has a digital memory function to analyze various waveforms which is not possible with conventional oscilloscopes. The following shows typical examples of the use of the digital memory scope.

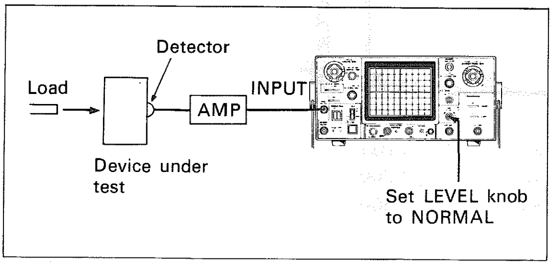


Fig. 3. Memorizing the transient phenomenon of mechanical impact waveforms

Setting of the Digital Memory Scope

1. Connect the detector to the device under test, then connect the output of the detector to the input of the scope so that the output level can be set to the input level of the scope.
2. Operation of the scope
   (1) Input Selector: Set to AC orDC position (set to either position according to the input signal being applied).
   (2) DISPLAY MODE: Set to REAL or DUAL position.

   Observe the signal from the device under test using the oscilloscope (REAL MODE) and set the input level, trigger point and sweep speed as shown below.

   LEVEL knob: NORMAL — The input singal is swept once and stops.

   Vertical attenuator (VOLTS/DIV): Any position

   SWEEP TIME/DIV: Any position between 0.1s and 0.1 ms.

   CLOCK: INT

   SCOPE PEN: SCOPE

   TRIGGER POINT (−DELAY/DIV): This digital switch is used to record a signal prior to triggering and should be set to 0 — 9 div.
3. After setting the above switches, turn the START switch to ON. The WRITE LED (red) will light to indicate that the input signal is in standby mode. The signal is now ready to be memorized.
4. Next, apply the signal from the device under test to the detector. Next, test the data. When the output level of the detector reaches the value set by the TRIG LEVEL, the signal from that point is stored in the memory.
5. To check the waveform being stored, set the DISPLAY MODE switch to DUAL or MEMORY position.

Application to Electiric Circuit Measurement of relay chattering

The operating method is the same as noted in the previous section.

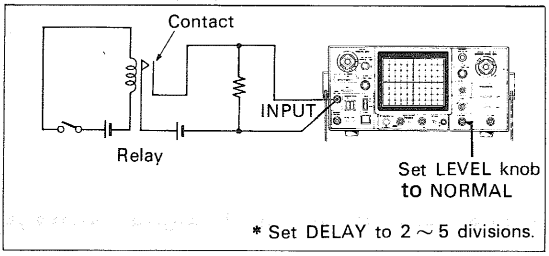


Fig. 4. Measurement of relay chattering

Data recording with pen recorder

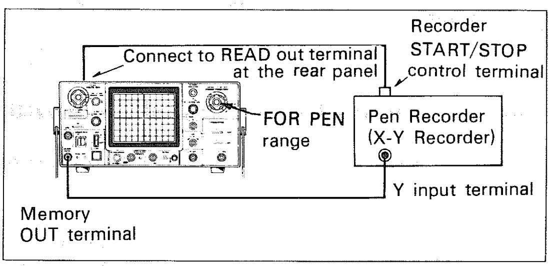


Fig. 5. Data recording with pen recorder

To record memory data with pen recorder (X-Y recorder), make the above connection and operate the scope as follows:

1. Change the position of the CLOCK MODE switch from SCOPE to PEN (Set the CLOCK to INT and the DISPLAY MODE to DUAL or MEMORY). It may be set to REAL while the FREE RUN function is being used.
2. Set the PEN SPEED knob to either the 10, 20 or 50 ms position.
3. Depress the START (memory data is outputted word by word).

Note

If the pen recorder has an external START/STOP control terminal, the timing pulse output is obtained from the READ OUT FOR PEN terminal (BNC) at the rear panel. The START signal is outputted in GND level.

To obtain the amplitude cycle of input signal from the waveform recorded by the pen recorder, refer to the section "Operation".

Readout from external CLOCK

When the scope is operated with external CLOCK, it functions only as a readout scope and does not function as a write-in scope. The readout function is useful when observing a magnified waveform (magnified to HOR×5 MAG). In this case, the SWEEP TIME is disabled so the waveform display remains the same, except that the sweep speed is varied. It is also used to read out the MEMORY OUT signal to an external device at a speed other than the scope's readout speed (INT CLOCK), or to transfer the data word by word by connecting digital outputs to the external device (see Fig. 6)

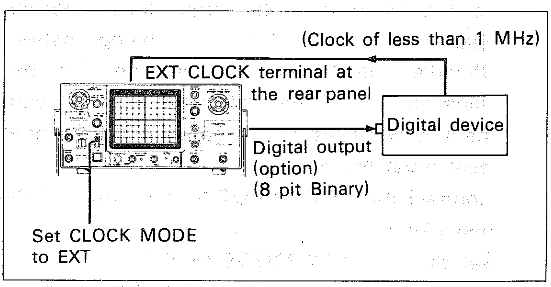


Fig. 6. Transfer of digital signal data word by word to another digital device using external clock

APPLICATIONS OF OSCILLOSCOPE OPERATION

Phase Measurement:

Phase measurements may be made with an oscilloscope. Typical applications are in circuits designed to produce a specific phase shift, and measurement of phase shift distortion in audio amplifiers or other audio networks. Distortions due to non-linear amplification is also displayed in the oscilloscope waveform.

A sine wave input is applied to the audio circuit being tested. The same sine wave input is applied to the vertical input of the oscilloscope, and the output of the tested circuit is applied to the horizontal input of the oscilloscope. The amount of phase difference between the two signals can be calculated from the resulting Lissajous' waveform. To make phase measurements, use the following procedures (refer to Fig. 7).

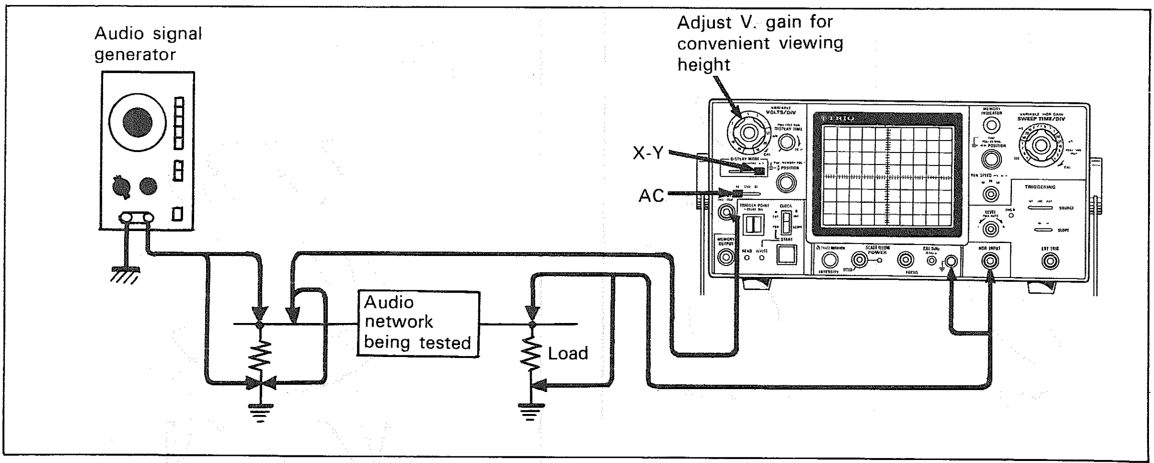


Fig. 7 Typical phase measurement

1. Using an audio signal generator with a pure sinusoidal signal, apply a sine wave test signal to the audio network being tested.
2. Set the signal generator output for the normal operating level of the circuit being tested. Observe the circuit's output on the oscilloscope and if the test circuit is overdriven, the sine wave display is clipped and the signal level must be reduced.
3. Connect the HOR. INPUT to the output of the test circuit.
4. Set the DISPLAY MODE to X-Y.
5. Connect the probe to the input of the test circuit.
6. Adjust the gain controls for a suitable viewing size.
7. Some typical results are shown in Fig. 8. If the two signals are in phase, the oscilloscope trace is a straight line. If the vertical and horizontal gain are properly adjusted, this line is at 45° angle. A 90° phase shift produces a circular oscilloscope pattern. Phase shift of less (or more) than 90° produces an elliptical Lissajous' pattern. The amount of phase shift can be calculated by the method shown in Fig. 9.

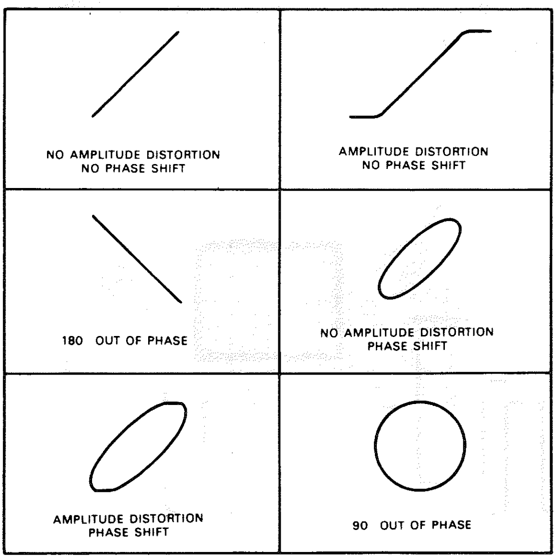


Fig. 8. Typicl phase measurement oscilloscope displays

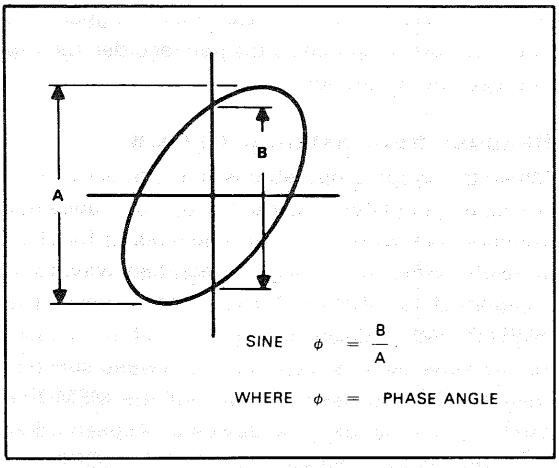


Fig. 9. Phase shift calculation

Frequency Measurement:

1. Connect the sine wave of known frequency to the vertical input of the oscilloscope and set the DISPLAY MODE switch to X-Y.
2. Connect the vertical input probe to the signal to be measured.
3. Adjust the vertical input and horizontal input for proper sizes.
4. The resulting Lissajous' pattern shows the ratio between the two frequencies (see Fig. 10).

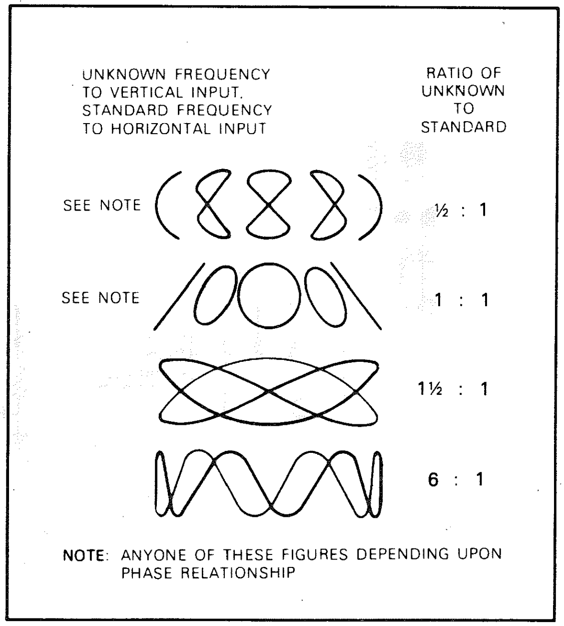


Fig. 10. Lissajous' waveforms used for frequency measurement

Amplifier Square Wave Test

Introduction

A square wave generator and the oscilloscope can be used to display various types of distortion present in electric circuits. A square wave of a given frequency contains a large number of odd harmonics of that frequency. If a 500 Hz square wave is injected into a circuit, frequency components of 1.5 kHz, 2.5 kHz and 3.5 kHz are also provided. Since vacuum tubes and transistors are non-linear, it is difficult to amplify and reproduce a square wave which is identical to the input signal. Inter electrode capacitances, junction capacitances, stray capacitances as well as narrow band devices and transformer response are the factors which prevent faithful response of a square wave signal. A welldesigned amplifier can minimize the distortion caused by these limitations. Poorly designed or defective amplifiers can introduce distortion to the point where their performance is unsatisfactory. As stated before, a square wave contains a large number of odd harmonics. By injecting a 500 Hz sine wave into an amplifier, we can evaluate amplifier response at 500 Hz only, but by injecting a square wave of the same frequency we can determine how the amplifier would response to input signals from 500 Hz up to the 15th or 21st harmonic.

The need for square wave evaluation becomes apparent if we realize that some audio amplifiers will be required during normal use to pass simultaneously a large number of different frequencies. With a square wave, we can evaluate the quality of input and output characteristics of a signal containing a large number of frequency components such as complex waveforms of musical instruments or voices.

The square wave output of the signal generator must be extremely flat. The oscilloscope vertical input should be set to DC as it will introduce the least distortion, especially at low frequencies. Because of the harmonic content of the square wave, distortion will occur before the upper end of the amplifier bandpass.

It should be noted that the actual response check of an amplifier should be made using a sine wave signal. This is especially important in an limited bandpass amplifier such as a voice amplifier.

The square wave signal provides a quick check of amplifier performance and will give an estimate of overall amplifier quality. The square wave also will reveal some deficiencies not readily apparent when using a sine wave signal. Whether a sine wave or square wave is used for testing the amplifier, it is important that the manufacturer's specifications on the amplifier be known in order to make a better judgement of its performance.

Testing Procedure (refer to Fig. 11):

1. Connect the output of the square wave generator to the input of the amplifier being tested.
2. Connect the vertical input probe of the oscilloscope to the output of the amplifier.
3. If the DC component of the amplifier output is low, set the AC-GND-DC switch to DC position to allow both the AC and DC components to be viewed. However, the AC position may be used to observe the AC component only, though this will reduce the audio frequency content of less than 5 Hz.
4. Adjust the vertical gain controls for a convenient viewing height.
5. Adjust the sweep time controls for one cycle of square wave display on the screen.
6. For a close-up view of a portion of the square wave, use the X5 magnification.

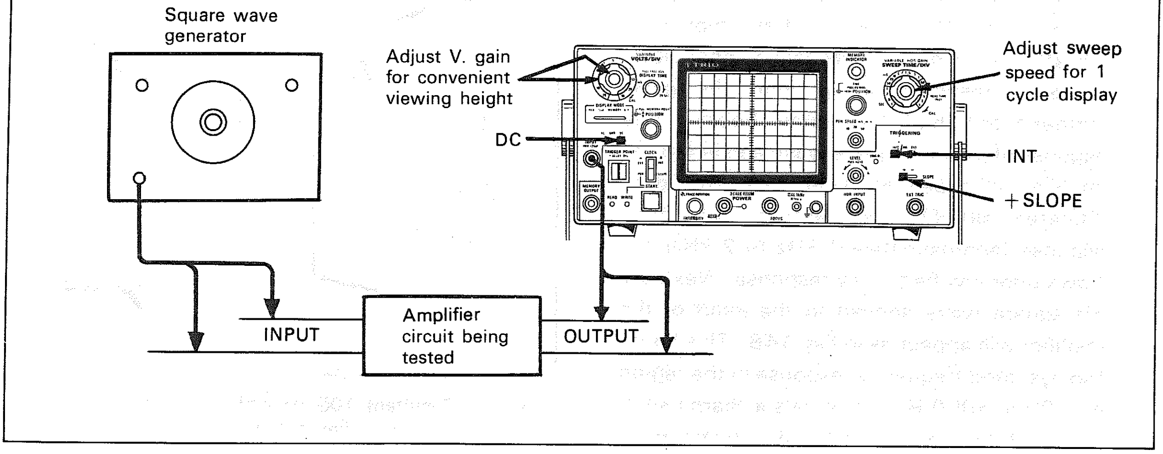


Fig. 11. Equipment set-up for square wave testing of amplifiers

Analysing the Waveforms:

The short rise time which occurs at the beginning of the half-cycle is created by the in-phase sum of the medium and high frequency sine wave components. The same holds true for the drop time. The reduction in high frequency components should produce a rounding of the square corners at all four points of one square wave cycle (see Fig. 12).

Distortion can be classified into the following three categories:

1. The first is frequency distortion and refers to the change in the amplitude of a complex waveform. In other words, the introduction in an amplifier circuit of resonant networks or selective filters created by combination of reactive components will create peaks or dips in an otherwise flat frequency response curve.
2. The second is non-linear distortion and refers to a change in waveshape produced by application of the waveshape to non-linear elements such as vacuum tubes, an iron core transformer or a clipper network.
3. The third is delay or phase distortion, which is distortion produced by a shift in phase between some components of a complex waveform.

   In actual practice, a change in amplitude of a square wave component is usually caused by a frequency selective network which includes capacity, inductance or both. The presence of the C or L introduces a difference in phase angle between components, creating phase distortion or delay distortion. Therefore, in square wave testing of practical circuitry, we will usually find that the distorted square wave includes a combination of amplitude and phase distortions.

   In a typical wide band amplifier, a square wave check reveals many distortion characteristics of the circuit. The response of an amplifier is indicated in Fig. 13, revealing poor low-frequency response along with the over-compensated high-frequency boost. The response of 100 Hz square wave applied to the amplifier will appear as in Fig. 14A. The figure indicates satisfactory medium frequency response (approximately 1 kHz to 2 kHz) but shows poor low frequency response. Next, a 1 kHz square wave applied to the input of the amplifier will appear as in Fig. 14B. This figure displays good frequency response in the region of 1000 to 4000 Hz but reveals a sharp rise at the top of the leading edge of the square wave

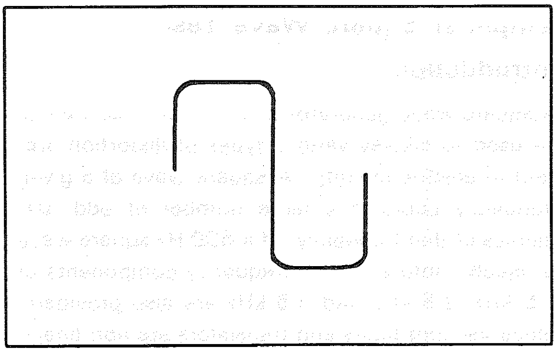


Fig. 12. Square wave response with high frequency loss

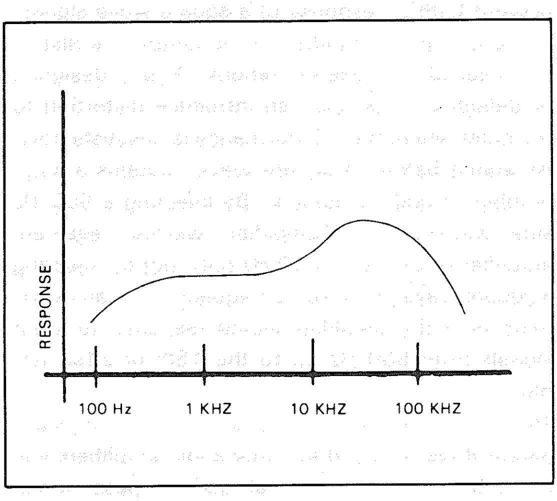


Fig. 13. Response curve of amplifier with poor low and high ends

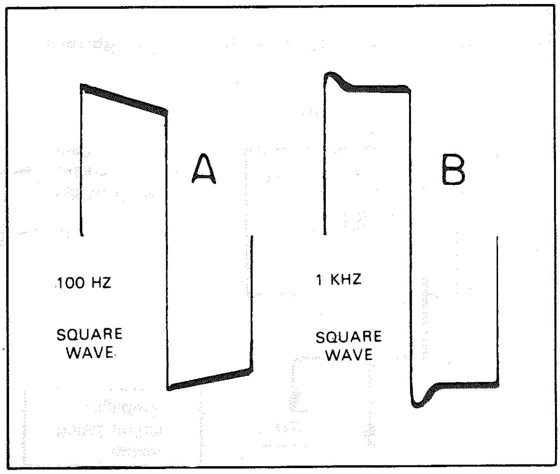


Fig. 14. Resultant 100 Hz and 1 kHz square waves from amplifier in Fig. 13.

because of overcompensation at the frequencies of more than 10 kHz.
As a rule of thumb, it can be safely said that a square wave can be used to reveal response and phase relationships up to the 15th or 20th odd harmonic or up to approximately 40 times the fundamental of the square wave. It is seen that wide-band circuitry will require at least two frequency check points to properly analyze the entire bandpass.
In the case illustrated by Fig. 13, a 100 Hz square wave will encompass components up to about 4 kHz. To analyze above 4 kHz and beyond 10,000 Hz, a 1 kHz square wave should be used.
Now, the region between 100 Hz and 4000 Hz in Fig. 13 shows a rise from poor low-frequency (1000 Hz to 1 kHz) response to a flattening out from beyond 1000 and 4000 Hz. Therefore, we can expect that the higher frequency components in the 100 Hz square wave will be relatively normal in amplitude and phase but that the low-frequency components "B" in this same square wave will be modified by the poor low-frequency response of this amplifier (see Fig. 14A).
If the amplifier were such as to only depress the low frequency components in the square wave, a curve similar to Fig. 15 would be obtained. However, reduction in amplitude of the components is usually caused by a reactive element, causing, in turn, a phase shift of the components, producting the tilt as shown in Fig. 14A.
Fig. 16 reveals a graphical development of a similarly tilted square wave. The tilt is seen to be caused by the strong influence of the phase-shifted 3rd harmonic. It also becomes evident that very slight shifts in phase are quickly shown up by tilt in the square wave.
Fig. 17 indicates the tilt in square wave produced by a 10° phase shift of a low-frequency element in a leading direction.
Fig. 18 indicates a 10° phase shift in a low frequency component in a lagging direction.
The tilts are opposite in the two cases because of the difference in polarity of the phase angle in the two cases as can be checked through algebraic addition of components.
Fig. 19 indicates low-frequency components which have been reduced in amplitude and shifted in phase. It will be noted that these examples of low-frequency distortion are characterized by change in shape of the flat portion of the square wave.

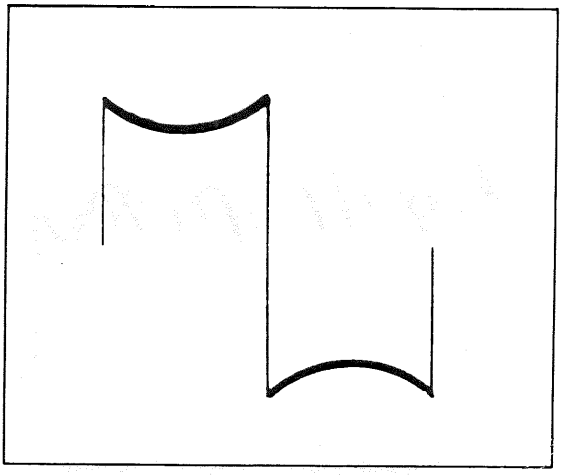


Fig. 15. Reduction of square wave fundamental frequency component in turned circuit

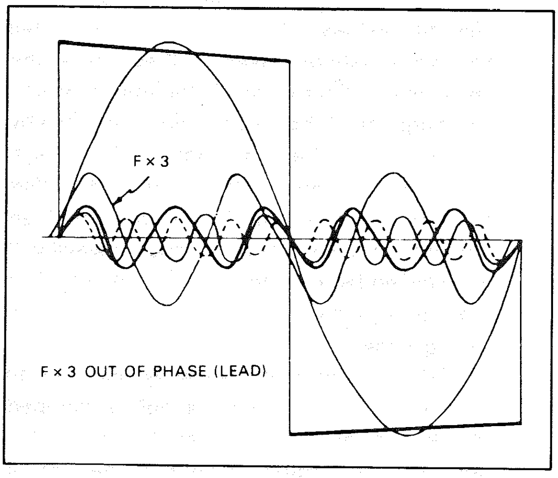


Fig. 16. Square wave tilt resulting from 3rd harmonic phase shift

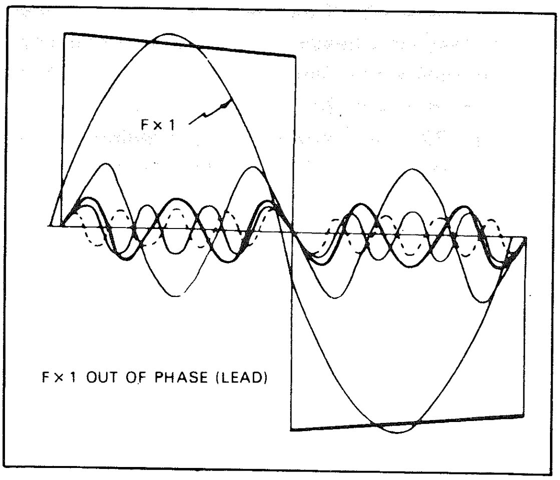


Fig. 17. Tilt resulting from phase shift of fundamental frequency in a leading direction

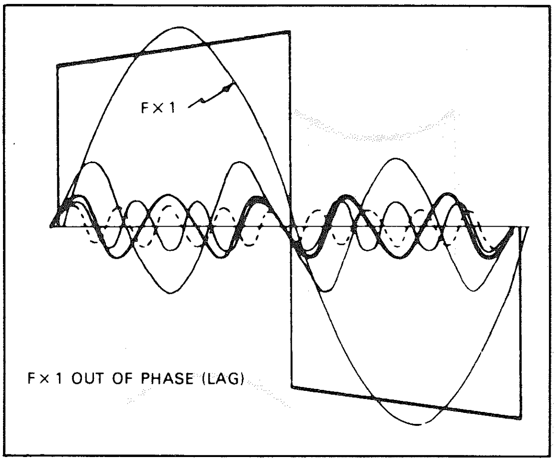


Fig. 18 Tilt resulting from a phase shift of fundamental frequency in a lagging direction

Fig. 14B shows a high-frequency overshoot produced by rising amplifier response at the high frequencies. It should again be noted that this overshoot makes itself evident at the top of the leading edge of the square wave. The sharp rise of the leading edge is created by the summation of a large number of harmonic components. If an abnormal rise in amplifier response occurs at high frequencies, the high frequency components in the square wave will be amplified larger than the other components creating a higher algebraic sum along the leading edge.

Fig. 20 indicates high-frequency boost in an amplifier accompanied by a lightly damped "shock" transient. In this case, the sudden transition in the square wave potential from a sharply rising, relatively high frequency voltage, to a level value of low frequency voltage, supplies the energy for oscillation in the resonant network. If this network in the amplifier is reasonably heavily damped, then a single cycle transient oscillation may be produced as indicated in Fig. 21.

Fig. 22 summarizes the preceding explanations and serves as handy reference.

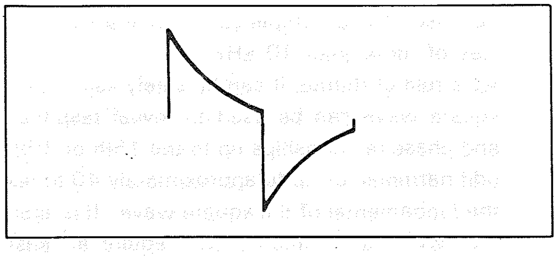


Fig. 19. Low frequency component loss and phase shift

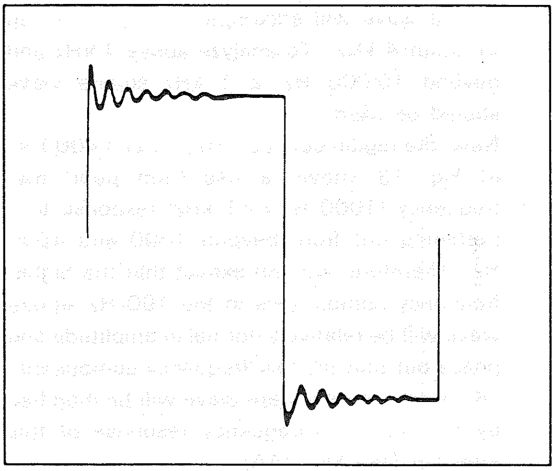


Fig. 20. Effect of high-frequency boost and poor damping

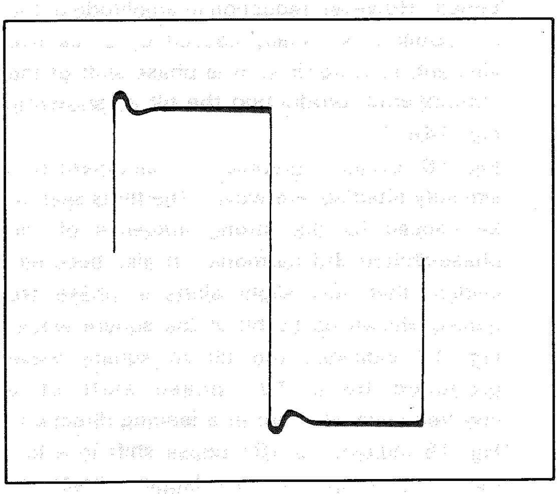


Fig. 21. Effect of high-frequency boost and good damping

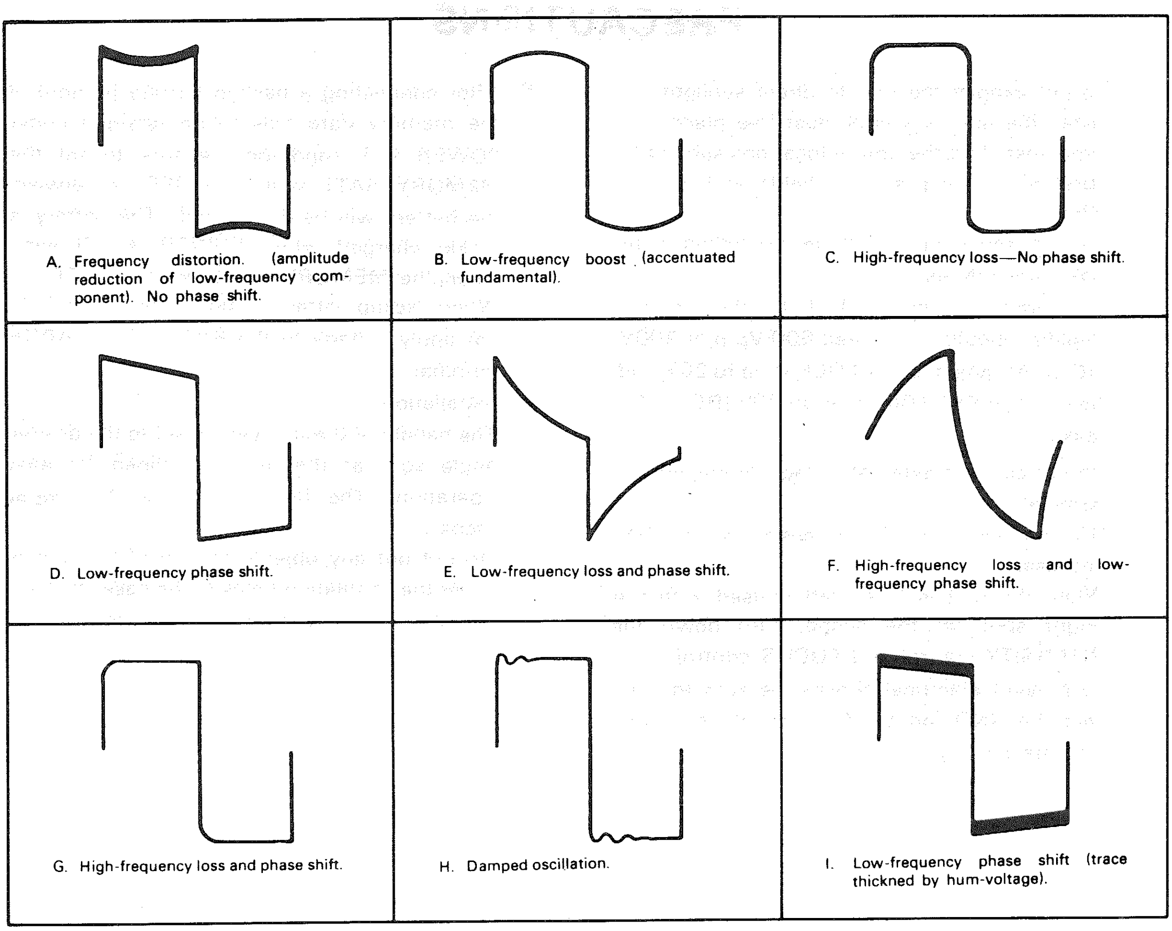


Fig. 22. Summary of waveform analysis for square wave testing amplifiers

PRECAUTIONS

1. Do not expose the unit to direct sunlight.
2. Install the unit in a cool, dust-free place.
3. Avoid installing the unit in locations subject to vibrations, strong electric fields and impact voltages.
4. Do not apply input voltage exceeding their maximum ratings.

   The input voltage applied to the vertical amplifier should not exceed 600 Vp-p or 300V (DC + AC peak), EXT CLOCK is up to 20V and the input to EXT TRIG is up to 20V (DC + AC peak).

   Do not connect external voltage to any output terminals.
5. Do not increase the intensity more than necessary.
6. When the unit is to be left unused with the bright spot on the scope, turn down the INTENSITY control and FOCUS control.
7. To prevent electrical shocks, be sure to connect the GND (on the front panel) to an appropiate earth point.
8. After connecting a backup battery (option), if the memory data fails to be retained under POWER OFF condition, be sure to set the MEMORY BATT switch to OFF; otherwise, the battery will be discharged. The battery is trickle charged when POWER is ON even when the MEMORY BATT switch is OFF.

   When backup battery (option) is not loaded, do not apply voltage to the BATT EXT CHARGE terminal.
9. Installation

   The handle of the unit can be set to the desired angle so that the unit is inclined for easy operation. The handle turns in 15 degree steps.

   Do not put any objects on top of the unit or cover the ventilation holes of the case, as it will increase the temperature in the case.

CIRCUIT DISCRIPTION

Vertical Amplifier

The vertical signal input via the BNC connector is applied to the first ATT via the AC-GND-DC switch when it is set properly. The ATT output signal is applied to the dual FETs (Q228), which has a high input impedance. (Use of dual FETs ensures stable DC balance under varying temperature conditions.) The signal is then applied to emitter followers Q204 and Q205, which have a low output impedance and are connected to the second ATT. The second ATT varies the degree of amplification by changing the emitter resistances of Q206 and Q207. DC balance of the source follower at the first stage of the second ATT is obtained with VR201, so the trace is prevented from moving when the attenuation is changed. The vertical signal is then applied to the variable amplifier consisting of Q208 and Q209, where the signal level is adjusted. VR203 adjusts the DC balance of the variable amplifier so that the trace does not move when the VR is turned. VR1a varies the DC level balance between the collectors of Q208 and Q209 to adjust vertical positioning of the input waveform. The vertical signal is then applied to both the mode selection circuit and the A/D buffer amplifier.

The mode selection circuit consists of IC202, IC204 and IC205. IC202 operates as a mode selection switch, IC204 passes the input signal and IC205 passes the memory signal. Q216 and Q217 form a cascode amplifier which amplifies the signal to a sufficient level. The signal is then amplified by the output amplifier consisting of Q220 through Q227. Finally, the vertical signal is applied to the vertical deflection electrodes of the CRT.

VR205 and VR206, connected to pins 1 and 13 of IC204 and 206, respectively, adjust their gain. The memory signal is amplified by IC203 after it is subjected to D/A conversion, and is then applied to IC205. Vertical positioning of the memory signal waveform is adjusted with VR1b, which is connected to IC203.

The A/D buffer amplifier output signal applied to the cascode amplifier consisting of Q210 through Q213, the its level is shifted by Zener diodes D204 and D205. The signal is then applied to IC201, which has single end output. The IC201 output signal is applied to the input terminal of the A/D input terminal of the control section. The signal from the emitter of Q215 is transmitted to the horizontal circuits and is used as the sync. signal.

Synchronizing Voltage

The trigger signal selected with the SOURCE switch (INT/LINE/EXT) is applied to differential amplifier IC401. The rising or falling edge of the waveform is used to determine the sweep starting point. The edge used is selected with the SLOPE switch. Variable resistor VR4 varies the DC level of the trigger signal to shift the sweep starting point. The trigger signal, after selection with the SLOPE switch, is applied to a Schmitt trigger consisting of gate circuits in IC403 through emitter follower Q402. The waveform of the trigger signal is shaped into a square wave which is used as the clock pulse signal for sweep control flip-flop IC404. The flip-flop inverts its state according to the clock pulse signal to turn Q403 OFF, then the Miller integrator starts charging.

The Miller integrator determines the sweep time according to the time constant of C and R, which is selected with the SWEEP TIME/DIV selector. It outputs a saw-tooth wave with good linearity. The state of hold-off timer IC405 is inverted when the Miller integrator output level at Q413 rises. Therefore, sweep is stopped for the time determined by the hold-off time constant. After the hold-off time has been passed, the next clock pulse is awaited.

When the TRIG AUTO switch is ON, the trigger signal output from the Schmitt trigger drives the automatic sweep circuit, which consists of Q406 through Q408. The collector level of Q408 is LOW and the flip-flop is in the free running state when no trigger signal is input. The flip-flop is synchronized with the clock signal when the trigger signal is input.

The saw-tooth wave generated with the Miller integrator is applied to the horizontal amplifier, which consists of Q416 through Q421, via the SWEEP/EXT H selector, and its signal level is amplified to the desired level. Then, the saw-tooth wave signal is applied to the horizontal deflection electrodes of the CRT.

When the DISPLAY MODE switch is set to the EXT H position, the SWEEP/EXT H selector is automatically switched to separate the Miller integrator and the horizontal amplifier so that the output of the EXT H buffer amplifier is applied to the horizontal amplifier.

Digital Memory

The vertical input signal applied to the A/D converter from the A/D buffer amplifier is converted into a digital signal. The A/D converter circuit consists of the following circuits: analog comparator IC530, which compares the A/D converter input signal with the D/A converter output signal; sequential comparison register IC529, which compares and latches MSB through LSB of the analog comparator output in that order, and D/A converter consisting of Q507 - Q514. The A/D converter output is latched by register IC578 each time one word is converted. The sampling speed is determined by the A/D start signal supplied by the time base unit.
The time base unit consists of a crystal controlled oscillator (IC541), which generates 10 MHz, and a frequency divider (IC553, IC564, IC563, IC552, IC551, IC540 and IC539). The frequency dividing ratio is determined by the SWEEP TIME/DIV switch. When the CLOCK switch is set in the INT position in the SCOPE mode, a clock signal with a period of 1/100 of the period specified by the SWEEP TIME/DIV switch is output from pin 8 of IC538. When the CLOCK switch is in the INT position in the PEN mode, a clock signal with a period of 10, 20 or 50 ms (according to the setting of the SWEEP TIME/DIV switch) is output from pin 11 of IC538. When the CLOCK switch is in the EXT position, the clock signal input to the EXT CLOCK terminal is output from pin 12 of IC549. However, when the SWEEP TIME/DIV switch is set in the range from 1 through 50 μs, the frequency divider stops operation so that the A/D converter does not operate.
The clock signal generated by the time base unit is applied to the address counter (IC526, IC519 and IC511) and the delay counter (IC533, IC532 and IC531) to write the data into memory (IC574 and IC575) in sequency when the WRITE START switch is set to ON. When a trigger pulse is generated, the delay counter starts counting by the number which is the complement of the number set by the digital switch of TRIGGER POINT to stop writing into memory. A latch circuit (IC503 and IC502) stores the initial point data.
Memory read starts in synchronization with the SWEEP GATE signal after memory write has been completed. Memory output data is latched by IC573, then applied to a D/A converter consisting of Q215 through Q522 so that it is converted into an analog signal. The analog signal is applied to a voltage follower consisting of IC501 and IC580, then is applied to the memory amplifier in the vertical amplifier for output to the MEMORY OUT terminal.

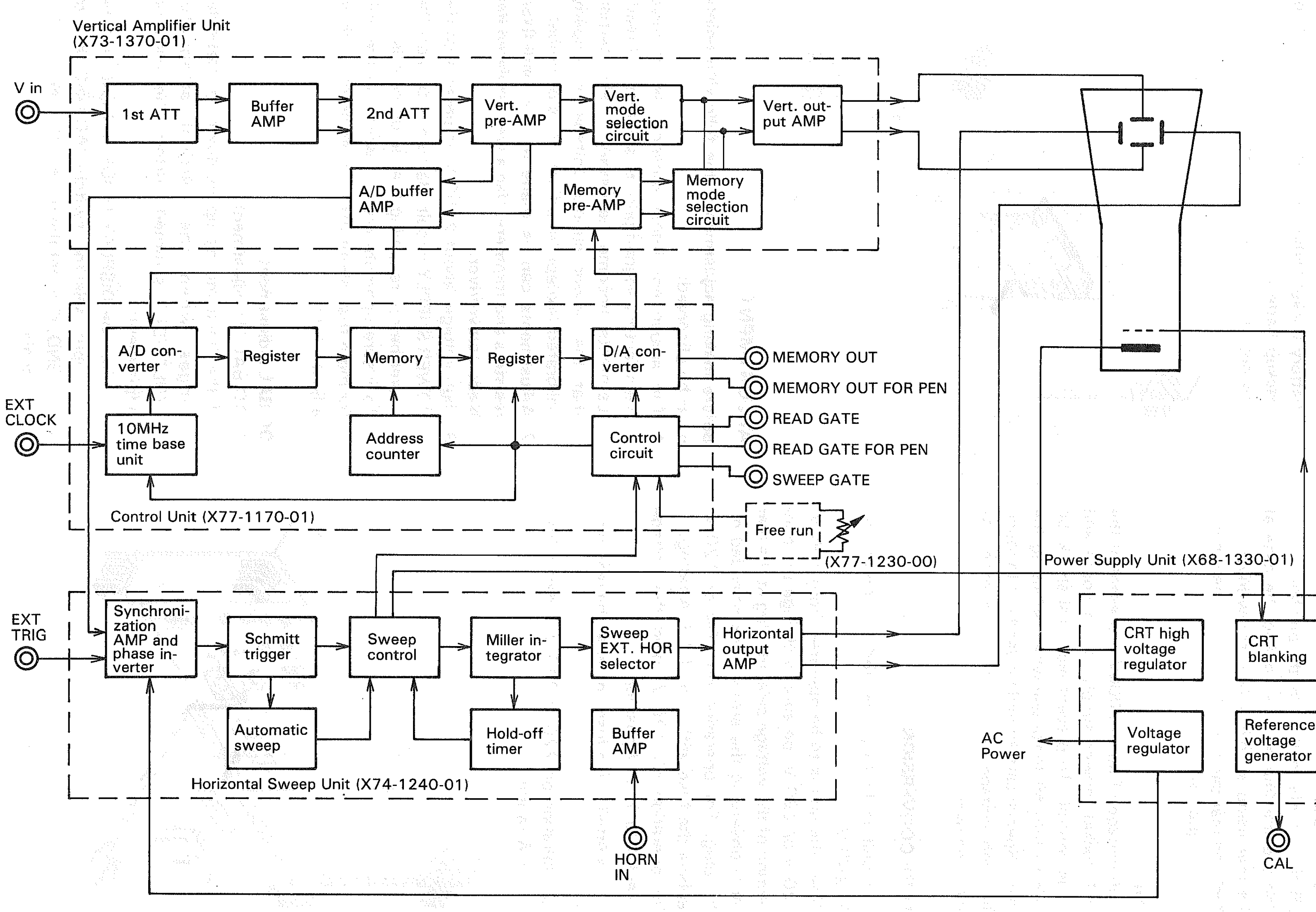
CRT Power Supply Circuit

The CRT (Cathode Ray Tube) requires a voltage of about 2 KV. This high voltage is generated using a DC-DC converter, and is regulated by a feedback-type voltage regulator. A negative feedback amplifier and a DC reproducing circuit are used to prevent the high voltage from varying when the brightness is increased and to improve the unblanking characteristics during high speed sweep.
All the power supply circuits use voltage regulators; the main power supply circuit uses a tracking generator, so it is particularly stable.

FREE RUN

S1a,b (X-77-1230-00) switches between the normal and free run modes.
The free run mode is selected by pulling the S1a,b knob out. In the free run mode, the ground level is applied to one input terminal of IC2 via diode D1 and the R/W C signal is applied to the other input terminal of IC2. When the R/W C signal becomes low during its READ period, the gate output level also becomes low; therefore, the timer (IC1) is triggered. This ground level signal from the gate circuit is applied to pin 2 (the clear terminal) of IC203 in the vertical amplifier and pin 2 (the clear terminal) of IC404 in the horizontal amplifier through diodes D2 and D3, respectively. The timer (IC1) holds pin 2 at the high level for the time determined by VR1. When pin 2 of IC1 drops to the low level, pin 6 of IC55 in the control unit is set to the low level through diode D1 so that the write state is entered (i.e., the R/W C signal level is high). After memory write has been finished, the gate of IC2 described above outputs a GND level signal again to trigger the timer. The above process is repeated automatically.

BLOCK DIAGRAM



MAINTENANCE AND ADJUSTMENT

MAINTENANCE

Removal of case

1. Lift the handle to the upright position.
2. Remove the four screws holding the case at the rear using a Philips type screwdriver.
3. Push the rear panel and the unit can be removed from the case.

Caution

High voltage of up to 2000V is present at the CRT socket, power supply circuit board and focus control. To prevent electrical shock, be sure to turn off the power when removing the case. Special care should be used not to touch the high voltage circuits after the case has been removed.

VOLTAGE CONVERSION

(1) The unit is factory adjusted to operate on AC240 V.
When the unit is to be operated from 100 V, 120 V or 220 V, be sure to change the connection of the voltage selector plug at the rear panel observing the arrow mark provided on the plug. For operation on 100 or 120 V, replace the fuse with one of 1.5 A rating.
For operation on 120 V, plug the voltage selector to 117 V position.

(2) Fuse is fitted in the fuse holder at the rear panel.
For operation on 220 or 240 V, insert a fuse of 0.7 A rating.

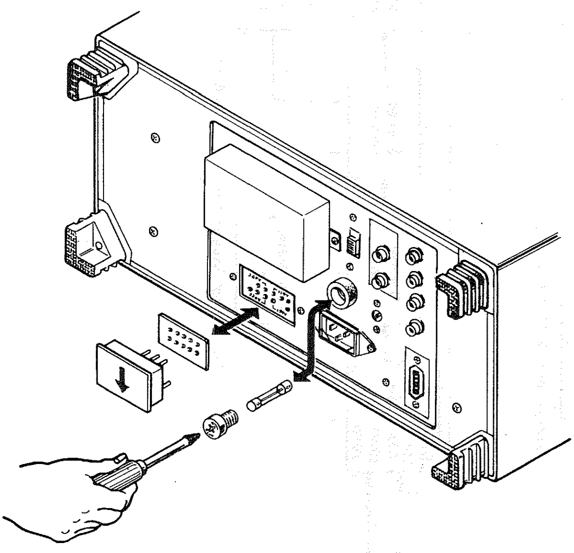


Fig. 23

BATTERY (OPTION) REPLACEMENT

This instrument should be operated on alkaline battery (nickel cadmium battery) for operating backup battery.
Do not use manganese battery.

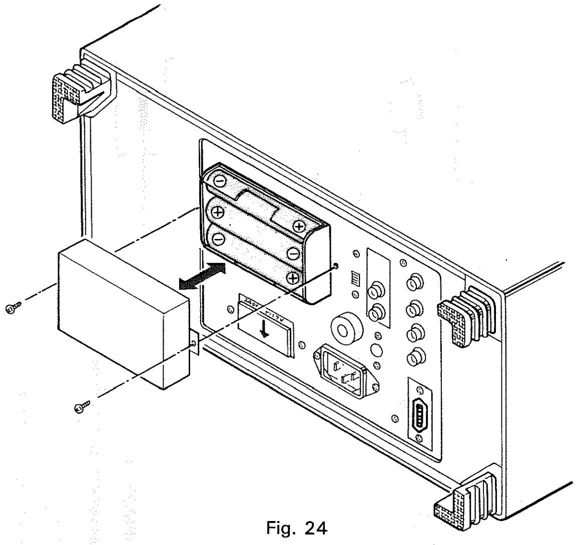


Fig. 24

ADJUSTMENT

Before making adjustments, the following points must be observed:

1. The adjustment items outlined below have been factory aligned prior to shipment. If readjustments become necessary, make certain that the power supply voltage is properly calibrated (except for adjustments of probe).
2. **Adjustments can be made by the semi-fixed resistors and trimmers. Use a well insulated flat blade screwdriver.**
3. High voltage (about 2000 V) is present on the POWER SUPPLY circuit. Be sure to turn off the power before removing the circuit boards.
4. To insure optimum results, warm up the unit for more than about 30 minutes before making adjustments.

DC BAL Adjustment

1. DC BAL (1) adjustment
If the trace moves up or down at particular ranges when the vertical attenuator (VOLTS/DIV) is turned, perform the following adjustment.
(1) Set the DISPLAY MODE to REAL and the input selector switch (AC-GND-DC) to GND, then set the trace in the center of the scale.

(2) Turn the vertical attenuator VARIABLE fully counterclockwise and adjust the STEP BAL VR so that the trace is stationary at all ranges when the VOLTS/DIV is turned.

2. DC BAL (2) adjustment
If the trace moves up or down at particular ranges when the vertical attenuator VARIABLE is turned, perform the following adjustment.
(1) With the VARIABLE turned fully counterclockwise, set the trace in the center of the scale. Next, turn the VARIABLE fully clockwise. If, at this time, the trace moves up or down, adjust the VAR BAL VR until it is centered.
(2) Repeat the above steps so that the trace stays still when the VARIABLE is turned.

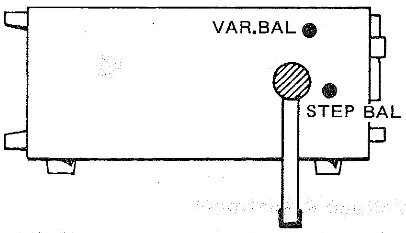


Fig. 25 DC BAL adjustment

Vertical Attenuator Adjustment (VOLTS/DIV)

(1) Using a square wave generator, apply 1kHz 0.5-100Vp-p signal to the vertical input terminal.
(2) Set the VOLTS/DIV to 0.1V and adjust the trimmer TC202 until high quality of square wave is obtained.
(3) Similarly, adjust the TC204 for the 1V range and the TC206 for the 10V range.

Probe and Input Capacity Adjustments

(1) Set the VOLTS/DIV to 0.01V.
(2) Set the probe to 10:1 and connect it to the INPUT terminal. Apply 1kHz square wave signal to the probe and adjust the trimmer of the probe until high quality of wave is obtained. During the adjustment, the input voltage is attenuated to 1/10, while the input impedance is 10MΩ and the input capacity is less than 18pF.
(3) Next, set the VOLTS/DIV to 0.1V. Adjust the TC201 until high quality of square wave is obtained.
(4) Similarly, adjust the TC203 for the 1V range and the TC205 for the 10V range.

Vertical Sensitivity Adjustment

(1) With the VOLTS/DIV set to 0.01V, turn the VARIABLE fully clockwise to the CAL position.
(2) Apply 0.05Vp-p square wave signal to the vertical input.
(3) Adjust the VR205 (GAIN ADJ) so that the vertical amplitude reaches 5 div.

CRT Center Adjustment

(1) Short the base of Q218 to the base of Q219.
(2) Adjust the V208 until the horizontal trace comes to the vertical center.

Frequency Response and Overshoot Adjustments

(1) Apply 100kHz square wave signal of good rising characteristic to the input.
(2) Adjust the trimmer TC207 for optimum mid-range waveform (after the rising portion).
(3) Adjust the VR207 for optimum high range waveform (rising portion).

Adjustments of Sweep Time (horizontal sensitivity) and Trace Length

(1) Set the SWEEP TIME/DIV to 0.1 ms range and turn the VARIABLE fully clockwise to the CAL position.
(2) Apply a calibrated 1kHz sine wave signal to the input. Adjust each POSITION control so that the waveform is in the vertical center and the start point is extreme left of the scale.
(3) Adjust the VR407 so that one wave length of the 1kHz signal is 10 div on the scale. Also, adjust the length of the horizontal trace with the VR406 (LENGTH ADJ). Since the VR406 adjusts only the end point of the waveform, the length of the waveform can be adjusted without affecting the start point and sweep time. During this adjustment, manipulate the ◀▶ POSITION and TRIG LEVEL to retain the start point in the center at the left end of the scale.
(4) Adjust 1 μs range with TC401.

X5 MAG Adjustment

(1) Set the SWEEP TIME/DIV switch to 1 ms range. Apply about 1kHz sine wave signal to the vertical input.
(2) Adjust the oscillation frequency and ◀▶ POSITION so that 11 peaks of waveform appear and each peak is on the vertical line of the scale.

(3) Adjust the VR408 (MAG ADJ) so that the peak-to-peak space is 5 div when the MAG switch is pulled.

MAG Center Adjustment

(1) Set the SWEEP TIME/DIV to 0.1 ms. Apply 1kHz square wave to the vertical input. Adjust so that one wave covers the entire scale.

(2) Set the ◄► POSITION to the mechanical center position (the waveform may deflect in horizontal direction).

(3) Pull the MAG switch and adjust the VR404 (MAG CENT) so that the rising (or falling) portion in the center of the waveform comes to the position of "X1" (MAG switch is depressed).

(4) Repeat the above adjustment until the rising (or falling) portion of the waveform remains in the same position regardless of the position of the MAG switch.

Adjustments of EXT-H, Horizontal Position and Sensitivity

(1) Set the DISPLAY MODE to EXT. H and the ◄► POSITION to the mechanical center position.

(2) Turn the VARIABLE fully clockwise to the CAL position.

(3) Adjust the VR405 until the spot comes to the center of the horizontal axis.

(4) Apply 1kHz 1.5Vp-p sine wave signal to the HOR. INPUT terminal.

(5) Adjust the VR404 so that the trace reaches 10 div on the scale.

Sync Level Adjustment

(1) Apply 1 kHz sine wave signal to the vertical input and set the SOURCE switch to INT.

(2) Adjust the VR401 so that the waveform starts at the same position on the opposite slope when the SLOPE polarity ("+" and "−") is changed.

Calibration Voltage Adjustment

(1) Connect the calibration voltage output to the vertical input. Set the VOLTS/DIV to 0.2 V and SWEEP TIME/DIV to 0.2 ms.

(2) Adjust the frequency to 1kHz with the VR102, and the duty ratio to 50:50 with the VR106.

(3) Adjust the VR101 to obtain output voltage of 1Vp-p.

ASTIG Adjustment

Adjust the ASTIG VR until the trace is even in thickness. This adjustment should be made in conjunction with the FOCUS control. Since the ASTIG is stabilized, no readjustment is required.

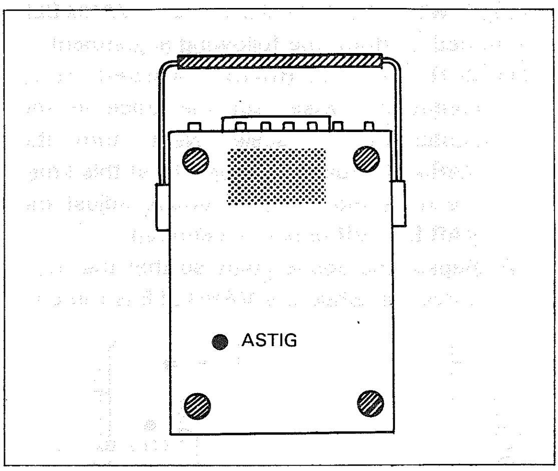


Fig. 26

High Voltage Adjustment

(1) Connect a high input impedance (more than 100MΩ) DC voltmeter for high voltage measurement to the No. 1 pin of P103.
Connect the other side to the chassis.

(2) Adjust the VR103 to obtain −18.5kV.

Blanking Voltage Adjustment

(1) Set the LEVEL to PULL AUTO to display a trace.

(2) Adjust the VR104 so that the trace disappears at 9-11 o'clock position of the INTENSITY knob.

Memory Circuit

Adjustments of Memory Position and Memory Output Voltage

(1) Set the VOLTS/DIV to 0.1V and SWEEP TIME/DIV to 1 ms. Write 200 Hz 1 Vp-p sine wave signal in the memory (both the "+" and "−" sides of memory wave on the scope are saturated).

(2) Adjust the VR2 (semi-fixed resistor on MEMORY POSITION switch) until the center level of the memory wave becomes 0V. Next, adjust the VR206 (VERTICAL circuit) so that the amplitude between the "+" and "−" saturation points becomes 8 div on the scope.

(3) Repeat the above adjustments a few times.

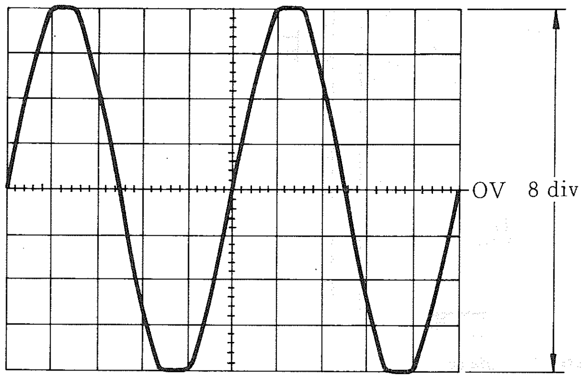


Fig. 27

(4) Adjust the VR505 so that the MEMORY output center level is 0V. Next, adjust the VR506 until the amplitude between the output voltage saturation points reaches 1.6Vp-p.

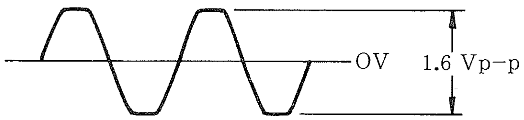
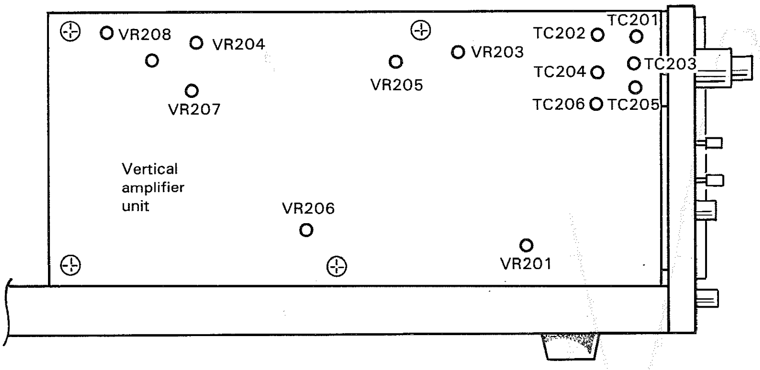


Fig. 28

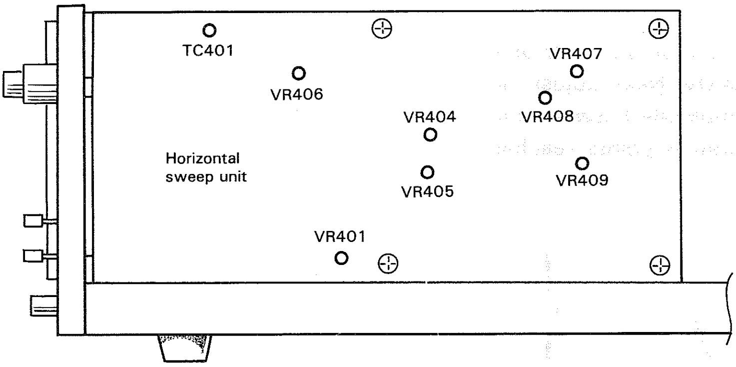
Deviations of Real Wave and Memory Wave

(1) Set the DISPLAY MODE to DUAL, the VOLTS/DIV to 0.1V, and the SWEEP TIME/DIV to 1 ms. Write 0.6 Vp-p sine wave signal in the memory (6 div amplitude).

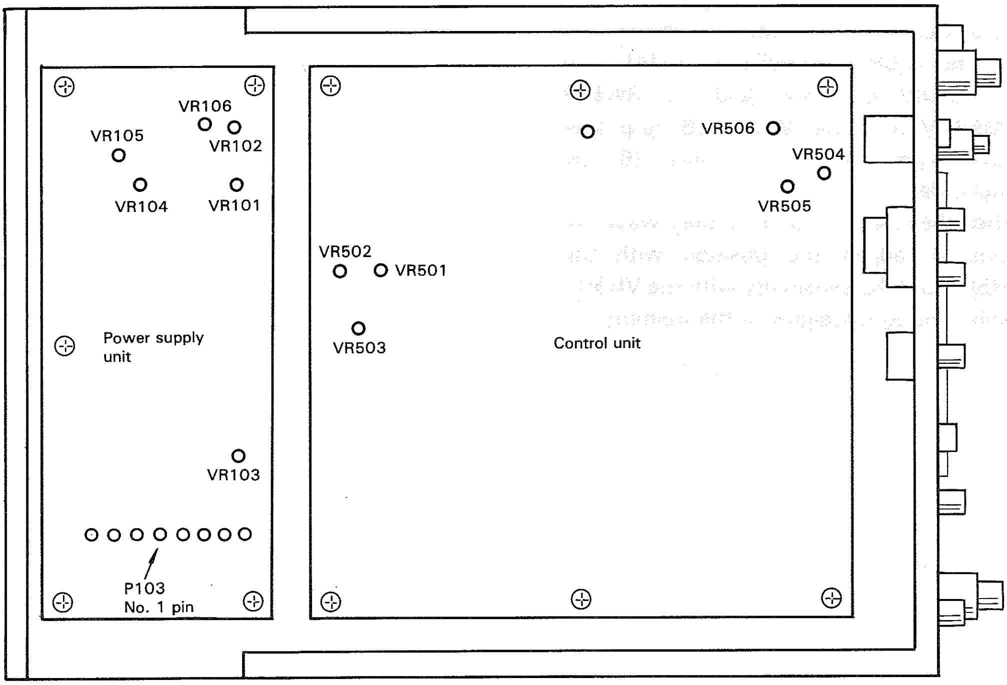
(2) When the real wave and memory wave are deviated, adjust the position with the VR502 and the sensitivity with the VR501 while writing the signal in the memory.



Location of Adjustments (Left side view)



Location of Adjustments (Right side view)



Location of Adjustment (Bottom view)

PARTS LIST

MAIN CHASSIS

Ref. No.	Parts No.	Name & Description
	A20-2753-25	Diecasting panel
	A21-0899-04	Decorative panel (1)
	A21-0871-04	Decorative panel (2)
	A21-0871-04	Decorative panel (3)
	A22-0819-03	Sub panel (1)
	A22-0820-03	Sub panel (2)
	B07-0122-04	Push escutcheon
	B07-0706-04	Push escutcheon
	B07-0710-02	Rear escutcheon
	B19-0716-03	Filter
	B19-0710-04	Acryl (for light focus)
	B20-0916-04	Graticule
	B30-0920-05	Lamp
	B09-0011-04	Hole bushing
	B40-2765-04	Name plate
	B41-0726-04	Voltage indication plate
	B50-2950-00	Instruction manual
DN1-4	B30-0920-05	Lamp ass'y
M-1	B31-0722-08	Meter (round type)
	D23-0061-04	Bearing
	D22-0402-05	Coupling
	E01-1404-05	CRT socket
	E03-0005-05	Power jack (EXT)
	E03-0201-05	Power connector
	E08-1081-05	Voltage selector (receptacle)
	E09-0681-05	Voltage selector (plug)
	E21-0654-04	CAL terminal
	E21-0657-04	Terminal (GND)
	E30-1818-05	Power cord (JIS)
	E30-1819-05	Power cord (CEE)
	E30-1821-05	Power cord (SAA)
	E22-0781-08	Lug terminal

Ref. No.	Parts No.	Name & Description
	E04-0251-05	BNC receptacle
	E29-0526-08	Plug
	E29-0527-08	Cap
	E29-0528-08	Plug
	E29-0529-08	Cap
	E40-1064-05	Pin connector
	F01-0231-14	Heat sink
	F07-0908-14	Handle cover
	F11-0950-02	CRT shield (1)
	F11-0954-04	CRT shield (2)
	F11-0960-04	CRT shield (3)
	F15-0701-04	Felt
	F15-0712-04	Reflector
	F19-0703-04	Voltage selector (plate)
	F05-1521-05	Fuse 1.5A
	F05-7011-05	Fuse 0.7A
	G02-0606-14	Handle spring
	G13-0705-04	CRT mounting rubber
	G13-0710-14	CRT mounting rubber
	G13-0712-14	CRT mounting rubber
	J02-0507-05	Cord wrap
	J21-2906-05	Gear
	J21-2907-05	Ring
	J21-2912-05	LED holder
	J13-0033-15	Fuse holder
	J19-1625-08	Battery case
	K01-0512-05	Handle
	K21-0293-14	Push knob
	K21-0819-03	Knob
	K21-0822-14	Knob
	K21-0825-04	Knob

Ref. No.	Parts No.	Name & Description	
	K21-0831-24	Knob	
	K21-0832-14	Knob	
	K21-0833-14	Knob	
	K27-0502-04	Lever knob (gray)	
	K27-0504-04	Knob (square, light gray)	
	K27-0505-04	Knob (square, blue)	
	L01-9286-08	Power transformer	
	L19-0019-05	Converter transformer	
	L77-1002-05	Crystal oscillator	
	L79-0501-08	Noise filter	
	H01-2946-04	Carton box	
	H10-2812-12	Pad, formed styrene	
	H12-0531-04	Pad, carton	
	H20-1713-14	Protective cover	
	S31-2007-05	Slide switch	
	S37-2005-05	Lever switch	
	S32-2013-05	Lever switch	
	S32-4007-05	Lever switch	
	S02-1501-05	Rotary switch	
	S42-3509-08	Key switch	
	S29-1501-08	Thumb wheel switch	
	W01-0503-04	Cord wrap	
	002-0006-05	Shield gascket	
		FET	2SK228T-2&3
		Transistor	2N5771
		IC	NE529N
		IC	AN606
		IC	AN904
		CRT	E2713B31A

Ref. No.	Parts No.	Name & Description			
	RN14BK2H9003F	Metal film resistor	900kΩ	±1%	1/2W
	RN14BK2H9903F	Metal film resistor	990kΩ	±1%	1/2W
	RN14BK2H9993F	Metal film resistor	999kΩ	±1%	1/2W
R1	RW98A3H201J	Winding resistor	200Ω	±5%	5W
R2	RC05GF3A185K	Carbon resistor	1.8MΩ	±10%	1W
VR1	R19-9504-08	Variable resistor (V.POSITION)	A=500Ω, B=10kΩ		
VR2	R06-9503-08	Variable resistor (MEMORY POS.)	A=500Ω, B=10kΩ		
VR3	R19-9505-08	Variable resistor (H.POSITION)	A=5kΩ, B=10kΩ		
VR4	R01-4507-08	Variable resistor (TRIG.)	50kΩ		
VR5,6	R23-9501-05	Variable resistor (INTEN)	A=1kΩ, B=5kΩ		
VR7	R05-8503-08	Variable resistor (FOCUS)	3MΩ		
VR8	R03-2504-08	Variable resistor (POWER)	5kΩ		
	R01-8503-05	Variable resistor (FREE RUN)	2MΩ		
	R12-1029-05	Semi-fixed resistor	1kΩB		
	R12-0502-05	Semi-fixed resistor	100ΩB		
	R12-6005-05	Semi-fixed resistor	330kΩB		
C1	CE62W2V470	Electrolytic capacitor	47μF		350WV
C2	CK45B3D102K	Ceramic capacitor	1000pF	±10%	2000WV
	CK45E3D103P	Ceramic capacitor	0.01μF	+100%, −0%	2000WV
	CK45E3D102P	Ceramic capacitor	1000pF	+100%, −0%	2000WV
	C05-0403-05	Ceramic trimmer	6pF		
	C05-0404-05	Ceramic trimmer	10pF		
	C05-0405-05	Ceramic trimmer	20pF		
		Transistor	2SD288		
		Transistor	2SB630		
		IC	ES7812M		
		IC	FS7912M		
D1,2		LED	AR4133S		
D3		LED	PG4133SX		

Ref. No.	Parts No.	Name & Description	
D4		LED	AR4133S
D5		Rectifier	S2VB20
	Y87-1330-00	Probe PC-22	
	X67-1080-00	Digital output cord	

VERTICAL AMPLIFIER UNIT (X73-1370-01)

Ref. No.	Parts No.	Name & Description			
R201,202	RD14BB2E470J	Carbon res.	47Ω	±5%	1/4W
R203	RN14BK2H9003F	Metal film res.	900kΩ	±1%	1/2W
R204	RN14BK2E1113F	Metal film res.	111kΩ	±1%	1/4W
R205	RN14BK2H9903F	Metal film res.	990kΩ	±1%	1/2W
R206	RN14BK2E1012F	Metal film res.	10.1kΩ	±1%	1/4W
R207	RN14BK2H9993F	Metal film res.	999KΩ	±1%	1/2W
R208	RN14BK2E1001F	Metal film res.	1kΩ	±1%	1/4W
R209	RN14BK2E1004F	Metal film res.	1MΩ	±1%	1/4W
R210	RD14BB2E104J	Carbon res.	100kΩ	±5%	1/4W
R211,212	RD14BB2E101J	Carbon res.	100Ω	±5%	1/4W
R213,214	RN14BK2E4991F	Metal film res.	4.99kΩ	±1%	1/4W
R215	RD14BB2E101J	Carbon res.	100Ω	±5%	1/4W
R216	RD14BB2E102J	Carbon res.	1kΩ	±5%	1/4W
R217,218	RD14BB2E153J	Carbon res.	15kΩ	±5%	1/4W
R219-221	RD14BB2E101J	Carbon res.	100Ω	±5%	1/4W
R222,223	RN14BK2E4301F	Metal film res.	4.3kΩ	±1%	1/4W
R224	RN14BK2E7410F	Metal film res.	741Ω	±1%	1/4W
R225	RN14BK2E3830F	Metal film res.	383Ω	±1%	1/4W
R226	RD14BB2E4R7J	Carbon res.	4.7Ω	±5%	1/4W
R227	RN14BK2E1050F	Metal film res.	105Ω	±1%	1/4W
R228	RD14BB2E100J	Carbon res.	10Ω	±5%	1/4W
R229	RD14BB2E181J	Carbon res.	180Ω	±5%	1/4W
R230	RN14BK2E1820F	Metal film res.	182Ω	±1%	1/4W
R231	RD14BB2E100J	Carbon res.	10Ω	±5%	1/4W
R232	RN14BK2E1820F	Metal film res.	182Ω	±1%	1/4W
R233	RD14BB2E152J	Carbon res.	1.5kΩ	±5%	1/4W
R234,235	RD14BB2E470J	Carbon res.	47Ω	±5%	1/4W
R236	RN14BK2E6800F	Metal film res.	680Ω	±1%	1/4W
R237	RD14BB2E471J	Carbon res.	470Ω	±5%	1/4W
R238	RN14BK2E6800F	Metal film res.	680Ω	±1%	1/4W
R239,240	RD14BB2E682J	Carbon res.	6.8kΩ	±5%	1/4W
R241,242	RD14BB2E470J	Carbon res.	47Ω	±5%	1/4W
R243	RD14BB2E222J	Carbon res.	2.2kΩ	±5%	1/4W
R244	RD14BB2E101J	Carbon res.	100Ω	±5%	1/4W
R245	RD14BB2E331J	Carbon res.	330Ω	±5%	1/4W
R246,247	RD14BB2E472J	Carbon res.	4.7kΩ	±5%	1/4W
R248	RD14BB2E101J	Carbon res.	100Ω	±5%	1/4W

Ref. No.	Parts No.	Name & Description			
R249	RD14BB2E222J	Carbon res.	2.2kΩ	±5%	1/4W
R250,251	RD14BB2E102J	Carbon res.	1kΩ	±5%	1/4W
R252-255	RD14BB2E472J	Carbon res.	4.7kΩ	±5%	1/4W
R256	RD14BB2E470J	Carbon res.	47Ω	±5%	1/4W
R257	RN14BK2E5101F	Metal film res.	5.1kΩ	±1%	1/4W
R258	RN14BK2E1002F	Metal film res.	10kΩ	±1%	1/4W
R259	RN14BK2E5101F	Metal film res.	5.1kΩ	±1%	1/4W
R260	RN14BK2E1002F	Metal film res.	10kΩ	±1%	1/4W
R261,262	RD14BB2E222J	Carbon res.	2.2kΩ	±5%	1/4W
R263,264	RD14BB2E472J	Carbon res.	4.7kΩ	±5%	1/4W
R265,266	RN14BK2E3001F	Metal film res.	3kΩ	±1%	1/4W
R267	RN14BK2E2202F	Metal film res.	22kΩ	±1%	1/4W
R268	RD14BB2E470J	Carbon res.	47Ω	±5%	1/4W
R269	RD14BB2E472J	Carbon res.	4.7kΩ	±5%	1/4W
R270	RD14BB2E471J	Carbon res.	470Ω	±5%	1/4W
R271	RD14BB2E470J	Carbon res.	47Ω	±5%	1/4W
R272,273	RD14BB2E682J	Carbon res.	6.8kΩ	±5%	1/4W
R274	RD14BB2E471J	Carbon res.	470Ω	±5%	1/4W
R275,276	RN14BK2E3001F	Metal film res.	3kΩ	±1%	1/4W
R277,278	RN14BK2E6800F	Metal film res.	680Ω	±1%	1/4W
R279-282	RD14BB2E470J	Carbon res.	47Ω	±5%	1/4W
R283,284	RD14BB2E102J	Carbon res.	1kΩ	±5%	1/4W
R285	RD14BB2E472J	Carbon res.	4.7kΩ	±5%	1/4W
R286	RD14BB2E103J	Carbon res.	10kΩ	±5%	1/4W
R287	RD14BB2E223J	Carbon res.	22kΩ	±5%	1/4W
R288	RD14BB2E470J	Carbon res.	47Ω	±5%	1/4W
R289-292	RD14BB2E562J	Carbon res.	5.6kΩ	±5%	1/4W
R293	RD14BB2E470J	Carbon res.	47Ω	±5%	1/4W
R294	RD14BB2E102J	Carbon res.	1kΩ	±5%	1/4W
R295	RD14BB2E472J	Carbon res.	4.7kΩ	±5%	1/4W
R296	RD14BB2E102J	Carbon res.	1kΩ	±5%	1/4W
R297-300	RD14BB2E470J	Carbon res.	47Ω	±5%	1/4W
R301	RD14BB2E332J	Carbon res.	3.3kΩ	±5%	1/4W
R302	RD14BB2E474J	Carbon res.	470kΩ	±5%	1/4W
R303	RD14BB2E332J	Carbon res.	3.3kΩ	±5%	1/4W
R304,305	RD14BB2E102J	Carbon res.	1kΩ	±5%	1/4W
R306,307	RD14BB2E222J	Carbon res.	2.2kΩ	±5%	1/4W

Ref. No.	Parts No.	Name & Description			
R308	RD14BB2E471J	Carbon res.	470Ω	±5%	1/4W
R309,310	RD14BB2E470J	Carbon res.	47Ω	±5%	1/4W
R311,312	RD14BB2E472J	Carbon res.	4.7kΩ	±5%	1/4W
R313,314	RD14BB2E333J	Carbon res.	33kΩ	±5%	1/4W
R315	RD14BB2E331J	Carbon	330Ω	±5%	1/4W
R316	RD14BB2E822J	Carbon res.	8.2kΩ	±5%	1/4W
R317	RD14BB2E331J	Carbon res.	330Ω	±5%	1/4W
R318,319	RD14BB2E101J	Carbon res.	100Ω	±5%	1/4W
R320	RD14BB2E104J	Carbon res.	100kΩ	±5%	1/4W
R321	RD14BB2H683J	Carbon res.	68kΩ	±5%	1/2W
R322	RD14BB2E104J	Carbon res.	100kΩ	±5%	1/4W
R323,324	RD14BB2E101J	Carbon res.	100Ω	±5%	1/4W
R325	RD14BB2E331J	Carbon res.	330Ω	±5%	1/4W
R326	RD14BB2E101J	Carbon res.	100Ω	±5%	1/4W
R327	RD14BB2E223J	Carbon res.	22kΩ	±5%	1/4W
R328,329	RD14BB2E103J	Carbon res.	10kΩ	±5%	1/4W
R330	RD14BB2E101J	Carbon res.	100Ω	±5%	1/4W
R331	RD14BB2E223J	Carbon res.	22kΩ	±5%	1/4W
R332	RD14BB2E681J	Carbon res.	680Ω	±5%	1/4W
R333	RD14BB2E471J	Carbon res.	470Ω	±5%	1/4W
R334	RD14BB2E333J	Carbon res.	33kΩ	±5%	1/4W
R335,336	RD14BB2E221J	Carbon res.	220Ω	±5%	1/4W
VR201	R12-1002-05	Semifixed res.	1kΩB		
VR202	R02-2508-05	Semifixed res.	5kΩB		
VR203	R12-0401-05	Semifixed res.	100ΩB		
VR204	R12-3002-05	Semifixed res.	10kΩB		
VR205,206	R12-0505-05	Semifixed res.	200ΩB		
VR207	R12-1002-05	Semifixed res.	1kΩB		
VR208	R12-4503-05	Semifixed res.	50kΩB		
VR209	R12-5401-05	Semifixed res.	100kΩB		
C201	C91-0561-08	Ceramic cap.	0.1μF		600WV
C202	CC45CH2H470J	Ceramic cap.	47pF	±5%	500WV
C203	CK45B2H471J	Ceramic cap.	470pF	±5%	500WV
C204	CC45CH1H050D	Ceramic cap.	5pF	±0.5pF	
C205	CK45B2H332K	Ceramic cap.	3300pF	±10%	500WV

Ref. No.	Parts No.	Name & Description
C206	C90-0261-05	Ceramic cap. 0.047μF
C207,208	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C209	CEO4W1A470M	Electrolytic cap. 47μF 10WV
C210	C90-0261-05	Ceramic cap. 0.047μF
C211,212	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C213	CEO4W1A470M	Electrolytic cap. 47μF 10WV
C214	CK45B2H332K	Ceramic cap. 3300pF ±10% 500WV
C215	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C216	CC45CH1H100D	Ceramic cap. 10pF ±0.5%
C217	CC45SL1H330J	Ceramic cap. 33pF ±5%
C218	CEO4W1A101M	Electrolytic cap. 100μF 10WV
C219,220	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C221	CC45SL1H560J	Ceramic cap. 56pF ±5%
C222	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C223	CEO4W1C470M	Electrolytic cap. 47μF 16WV
C224	C90-0261-05	Ceramic cap. 0.047μF
C225	CEO4W1C470M	Electrolytic cap. 47μF 16WV
C226	CC45CH1H050D	Ceramic cap. 5pF ±0.5pF
C227,228	CEO4W1C470M	Electrolytic cap. 47μF 16WV
C229	C90-0261-05	Ceramic cap. 0.047μF
C230	CC45SL1H330J	Ceramic cap. 33pF ±5%
C231	CK45B1H103K	Ceramic cap. 0.01μF ±10%
C232	CEO4W1C470M	Electrolytic cap. 47μF 16WV
C233	C90-0261-05	Ceramic cap. 0.047μF
C234	CEO4W1C470M	Electrolytic cap. 47μF 16WV
C235	C90-0261-05	Ceramic cap. 0.047μF
C236-239	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C240	CEO4W1A470M	Electrolytic cap. 47μF 10WV
C241,242	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C243	CEO4W1C470M	Electrolytic cap. 47μF 16WV
C244	C90-0262-05	Ceramic cap. 0.047μF
C245	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C246	CC45CH1H220J	Ceramic cap. 22pF ±5%
C247	CC45SL1H221J	Ceramic cap. 220pF ±5%
C248	CEO4W1C470M	Electrolytic cap. 47μF 16WV
C249	C90-0261-05	Ceramic cap. 0.047μF
C250	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV

Ref. No.	Parts No.	Name & Description
C251	CEO4W1A470M	Electrolytic cap. 47μF 10WV
C252	CEO4W1C470M	Electrolytic ceramic cap. 47μF 16WV
C253	C90-0261-05	Ceramic cap. 0.047μF
C254	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C255	CEO4W1A470M	Electrolytic cap. 47μF 10WV
C256	No use	
C257	CC45SL1H221J	Ceramic cap. 220pF ±5%
C258	CEO4W1C470M	Electrolytic cap. 47μF 16WV
C259,260	C90-0261-05	Ceramic cap. 0.047μF
C261	CC45CH1H130J	Ceramic cap. 13pF ±5%
C262	CK45F1H103Z	Ceramic cap. 0.01μF +80% −20%
C263,264	CC45CH1HO10C	Ceramic cap. 1pF ±0.25pF
C265	CK45E2H103P	Ceramic cap. 0.01μF +100% −0% 500WV
C266,267	CC45CH1HO10C	Ceramic cap. 1pF ±0.25pF
C268	CK45B2H332K	Ceramic cap. 3300pF ±10% 500WV
C269	CK45B1H471K	Ceramic cap. 470pF ±10%
C270	CK45B2H332K	Ceramic cap. 3300pF ±10% 500WV
C271	CK45B1H471K	Ceramic cap. 470pF ±10%
C272	CK45B2H103P	Ceramic cap. 0.01μF +100%, −10% 500WV
C273	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C274	CEO4W1A470M	Electrolytic cap. 47μF 10WV
C275	CEO4W2E330M	Electrolytic cap. 33μF 250WV
C276	CK45B2H103P	Ceramic cap. 0.01μF +100%, −0% 500WV
C277,278	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C279	C90-0261-05	Ceramic cap. 0.047μF
C280,281	CK45B1H102K	Ceramic cap. 1000pF ±10%
C282,283	C90-0261-05	Ceramic cap. 0.047μF
TC201	C05-0404-05	Ceramic trimmer 10pF
TC202	C05-0403-05	Ceramic trimmer 6pF
TC203	C05-0404-05	Ceramic trimmer 10pF
TC204	C05-0403-05	Ceramic trimmer 6pF
TC205	C05-0404-05	Ceramic trimmer 10pF
TC206	C05-0403-05	Ceramic trimmer 6pF

Ref. No.	Parts No.	Name & Description
TC207	C05-0404-05	Ceramic trimmer 10pF
IC201		IC μPC159A
IC202		IC SN7472
IC203		IC μPA15
IC204,205		Transistor array AN904
IC206		IC SN7400
Q201		Transistor 2SC273 or 2SC1815
Q202		Transistor 2SA495 or 2SC1015
Q203		FET 2SK30(0)
Q204,205		Transistor 2SC373 or 2SC1815
Q206,207		Transistor 2SC1215
Q208,209		Transistor 2SC373 or 2SC1815
Q210,211		Transistor 2SC495 or 2SC1015
Q212-219		Transistor 2SC373 or 2SC1815
Q220,221		Transistor 2SC1215
Q222,223		Transistor 2SC1628
Q224,225		Transistor 2SA818
Q226,227		Transistor 2SC373 or 2SC1815
Q228		Dual FET 2SK228-1-2or-1-3
D201,202		Diode RD6, 8E
D203		Diode 1S953
D204,205		Diode RD6, 8E
D206-208		Diode 1N34
D209,210		Diode 1S953
D211		Diode RD10E
D212,213		Diode 1N34
D214,215		Diode 1S953
L201-204	L40-4701-03	Ferri inductor 47μH
L205,206	L40-6801-03	Ferri inductor 68μH
S201	S32-4007-05	Lever switch
S202	S01-2509-08	Rotary switch
P210,202	E40-1064-05	Pin connector 10P
P203	E19-0861-08	Pin plug 8P

HORIZONTAL SWEEP UNIT (X74-1240-01)

Ref. No	Parts No.	Name & Description
R401	RD14BB2E101J	Carbon res. 100Ω ±5% 1/4W
R402	RD14BB2E222J	Carbon res. 2.2kΩ ±5% 1/4W
R403	RD14BB2E104J	Carbon res. 100kΩ ±5% 1/4W
R404	RD14BB2E154J	Carbon res. 150kΩ ±5% 1/4W
R405	RD14BB2E153J	Carbon res. 15kΩ ±5% 1/4W
R406	RD14BB2E511J	Carbon res. 510Ω ±5% 1/4W
R407	RD14BB2E103J	Carbon res. 10kΩ ±5% 1/4W
R408	RD14BB2E101J	Carbon res. 100Ω ±5% 1/4W
R409	RD14BB2E682J	Carbon res. 6.8kΩ ±5% 1/4W
R410	RD14BB2E333J	Carbon res. 33kΩ ±5% 1/4W
R411	RD14BB2E332J	Carbon res. 3.3kΩ ±5% 1/4W
R412	RD14BB2E152J	Carbon res. 1.5kΩ ±5% 1/4W
R413,414	RD14BB2E332J	Carbon res. 3.3kΩ ±5% 1/4W
R415	RD14BB2E822J	Carbon res. 8.2kΩ ±5% 1/4W
R416,417	RN14BK2E1003F	Metal film res. 100kΩ ±1% 1/4W
R418	RD14BB2E122J	Carbon res. 1.2kΩ ±5% 1/4W
R419	RN14BK2E1503F	Metal film res. 150kΩ ±1% 1/4W
R420	RN14BK2E2493F	Metal film res. 249kΩ ±1% 1/4W
R421	RN14BK2E4993F	Metal film res. 499kΩ ±1% 1/4W
R422	R92-1015-08	Carbon res. 1.5MΩ
R423	R92-1016-08	Carbon res. 2.5MΩ
R424	RD14BB2E391J	Carbon res. 390Ω ±5% 1/4W
R425	RD14BB2E471J	Carbon res. 470Ω ±5% 1/4W
R426	RD14BB2E682J	Carbon res. 6.8kΩ ±5% 1/4W
R427	RD14BB2E103J	Carbon res. 10kΩ ±5% 1/4W
R428	RD14BB2E152J	Carbon res. 1.5kΩ ±5% 1/4W
R429	RD14BB2E223J	Carbon res. 22kΩ ±5% 1/4W
R430	RD14BB2E152J	Carbon res. 1.5kΩ ±5% 1/4W
R431	RD14BB2E223J	Carbon res. 22kΩ ±5% 1/4W
R432-434	RD14BB2E104J	Carbon res. 100kΩ ±5% 1/4W
R435	RD14BB2E511J	Carbon res. 510Ω ±5% 1/4W
R436	RD14BB2E103J	Carbon res. 10kΩ ±5% 1/4W
R437	RD14BB2E683J	Carbon res. 68kΩ ±1% 1/4W
R438	RD14BB2E103J	Carbon res. 10kΩ ±5% 1/4W
R439	RD14BB2E222J	Carbon res. 2.2kΩ ±5% 1/4W
R440	RD14BB2E472J	Carbon res. 4.7kΩ ±5% 1/4W
R441,442	RD14BB2E182J	Carbon res. 1.8kΩ ±5% 1/4W

Ref. No	Parts No.	Name & Description			
R443	RD14BB2E221J	Carbon res.	220Ω	±5%	1/4W
R444,445	RD14BB2E152J	Carbon res.	1.5kΩ	±5%	1/4W
R446	RD14BB2E332J	Carbon res.	3.3kΩ	±5%	1/4W
R447	RD14BB2E682J	Carbon res.	6.8kΩ	±5%	1/4W
R448	RD14BB2E183J	Carbon res.	18kΩ	±5%	1/4W
R449	RD14BB2E123J	Carbon res.	12kΩ	±5%	1/4W
R450	RD14BB2E101J	Carbon res.	100Ω	±5%	1/4W
R451	RD14BB2E103J	Carbon res.	10kΩ	±5%	1/4W
R452	RD14BB2E223J	Carbon res.	22kΩ	±5%	1/4W
R453	RS14AB1A823J	Metal oxide film res.	82kΩ	±5%	1W
R454,455	RD14BB2E223J	Carbon res.	22kΩ	±5%	1/4W
R456	RD14BB2E153J	Carbon res.	15kΩ	±5%	1/4W
R457	RD14BB2E103J	Carbon res.	10kΩ	±5%	1/4W
R458	RD14BB2E222J	Carbon res.	2.2kΩ	±5%	1/4W
R459-461	RD14BB2E103J	Carbon res.	10kΩ	±5%	1/4W
R462	RD14BB2E272J	Carbon res.	2.7kΩ	±5%	1/4W
R463	RD14BB2E473J	Carbon res.	47kΩ	±5%	1/4W
R464	RD14BB2E471J	Carbon res.	470Ω	±5%	1/4W
R465	RD14BB2E472J	Carbon res.	4.7kΩ	±5%	1/4W
R466	RD14BB2E682J	Carbon res.	6.8k	±5%	1/4W
R467,468	RD14BB2E472J	Carbon res.	4.7kΩ	±5%	1/4W
R469	R92-1017-08	Carbon res.	13kΩ		7W
R470	RD14BB2E331J	Carbon res.	330Ω	±5%	1/4W
R471	R92-1017-08	Carbon res.	13kΩ	±5%	7W
R472	RD14BB2E470J	Carbon res.	47Ω	±5%	1/4W
R473	RD14BB2E822J	Carbon res.	8.2kΩ	±5%	1/4W
R474	RD14BB2E392J	Carbon res.	3.9kΩ	±5%	1/4W
R475,476	RD14BB2E821J	Carbon res.	820Ω	±5%	1/4W
R477-479	RD14BB2E472J	Carbon res.	4.7kΩ	±5%	1/4W
R480	RD14BB2E471J	Carbon res.	470Ω	±5%	1/4W
R481	RD14BB2E151J	Carbon res.	150Ω	±5%	1/4W
VR401	R12-1002-05	Semifixed res.	1kΩB		
VR402,403	R19-9506-08	Semifixed res.	A=3k,B=100kΩB		
VR404	R12-0003-05	Semifixed res.	470ΩB		
VR405	R12-1003-05	Semifixed res.	2.2kΩB		
VR406	R12-2502-05	Semifixed res.	5kΩB		

Ref. No	Parts No.	Name & Description			
VR407	R12-1002-05	Semifixed res.	1kΩB		
VR408	R12-0505-05	Semifixed res.	200ΩB		
VR409	R12-0003-05	Semifixed res.	470ΩB		
VR410	R12-1002-05	Semifixed res.	1kΩB		
C401,402	CE04W1H010M	Electrolytic cap.	1μF		
C403	CC45SL1H050C	Ceramic cap.	5pF	±0.25pF	
C404	C90-0261-05	Ceramic cap.	0.047μF		
C405	CC45SL1H100D	Ceramic cap.	10pF	±0.5pF	
C406,407	C90-0298-05	Semiconductor ceramic cap.	0.1μF		12WV
C408	CE04W1A470M	Electrolytic cap.	47μF		10WV
C409	C90-0261-05	Ceramic cap.	0.047μF		
C410	CC45CH1H101J	Ceramic cap.	100pF	±5%	
C411,412	C90-0298-05	Semiconductor ceramic cap.	0.1μF		12WV
C413,414	C90-0298-05	Semiconductor ceramic cap.	0.1μF		12WV
C415	CE04W1A470M	Electrolytic cap.	47μF		10WV
C416	C90-0298-05	Semiconductor ceramic cap.	0.1μF		12WV
C417	CE04W1C100M	Electrolytic cap.	10μF		16WV
C418-420	CE04W1H010M	Electrolytic cap.	1μF		50WV
C421	CK45B1H102K	Ceramic cap.	1000pF	±10%	
C422	CK45F1H103Z	Ceramic cap.	0.01μF	+80%−20%	
C423	CC45SL1H101J	Ceramic cap.	100pF	±5%	
C424	CK45B1H471K	Ceramic cap.	470pF	±10%	
C425	C90-0261-05	Ceramic cap.	0.047μF		
C426	CE04W1C470M	Electrolytic cap.	47μF		16WV
C427	CC45SL1H221J	Ceramic cap.	220pF	±5%	
C428	CE04W1A470M	Electrolytic cap.	47μF		10WV
C429	C90-0298-05	Semiconductor ceramic cap.	0.1μF		12WV
C430	C91-0562-08	Ceramic cap.	1μF		
C431	C91-0556-08	Ceramic cap.	0.01μF	±2%	
C432	CC45CH1H910J	Ceramic cap.	91pF	±5%	
C433	CC45CH1H390J	Ceramic cap.	39pF	±5%	
C434,435	CS15E1A4R7K	Tantalum cap.	0.47μF		10WV
C436	C90-0298-05	Semiconductor ceramic cap.	0.1μF		12WV
C437	CC45CH1H100D	Ceramic cap.	10pF	±0.5pF	
C438	CE04W1C470M	Electrolytic cap.	47μF		16WV
C439,440	C90-0261-05	Ceramic cap.	0.047μF		

Ref. No	Parts No.	Name & Description
C441,442	CE04W1C470M	Electrolytic cap. 47μF 16WV
C443	C90-0261-05	Ceramic cap. 0.047μF
C444	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C445	CK45B1H102K	Ceramic cap. 1000pF ±10%
C446	CC45SL1H331J	Ceramic cap. 330pF ±5%
C447	CK45B1H472K	Ceramic cap. 4700pF ±10%
C448	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C449,450	CE04W1A470M	Electrolytic cap. 47μF 10WV
C451,452	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C453	C90-0261-05	Ceramic cap. 0.047μF
C454	CE04W1C101M	Electrolytic cap. 100μF 16WV
C455	C90-0261-05	Ceramic cap. 0.047μF
C456	CE04W1C101M	Electrolytic cap. 100μF 16WV
C457	CE04W2E470M	Electrolytic cap. 47μF 250WV
C458	CK45B1H472K	Ceramic cap. 4700pF ±10%
C459,460	CE04W1A470M	Electrolytic cap. 47μF 10WV
C461	CK45B1H471K	Ceramic cap. 470pF ±10%
C462	CC45SL1H020C	Ceramic cap. 2pF ±0.25%
C463	CE04W1C101M	Electrolytic cap. 100μF 16WV
C464	C90-0298-05	Semiconductor ceramic cap. 0.1μ 12WV
C465	CK45F1H103Z	Ceramic cap. 0.01pF +80% −20%
C466	CC45SL1H331J	Ceramic cap. 330pF ±5%
TC401,402	C05-0405-05	Ceramic trimmer 20pF
IC401		IC AN606
IC402		IC SN74123
IC403		IC SN74S00
IC404		IC SN7472N
IC405		IC LM555CN or MC1455
IC406		IC SN75453BP
IC407		IC CD4016AE
Q401,402		Transistor 2SC373 or 2SC1815
Q403		Transistor 2SA495 or 2AS1015
Q404-408		Transistor 2SC373 or 2SC1815

Ref. No.	Parts No.	Name & Description
Q409		FET 2SK30(0)
Q410,411		Tansistor 2SC373 or 2SC1815
Q412		FET 2SK30(0)
Q413-417		Transistor 2SC373 or 2SC1815
Q418-420		Transistor 2SC373 or 2SC1505
D401		Diode RD3, 9E
D402		Diode 1S953
D403,404		Diode 1N34
D405		Diode 1S953
D406-408		Diode 1N34
D409,410		Diode 1S953
L401-405	L40-4701-03	Ferri inductor 47μH
S401	S32-4007-05	Lever switch
S402	S32-2013-05	Lever switch
S403	S01-3503-08	Rotary switch
P401	E19-1261-08	Pin plug 12P
P402	E40-1064-05	Pin connector 10P
P403	E40-1264-05	Pin connector 12P

CONTROL UNIT (X77-1170-01)

Ref. No.	Parts No.	Name & Description			
R501	No use				
R502	No use				
R503-515	RD14BB2B472J	Carbon res.	4.7kΩ	±5%	1/8W
R516-522	RD14BB2B221J	Carbon res.	220Ω	±5%	1/8W
R523-525	RD14BB2B102J	Carbon res.	1kΩ	±5%	1/8W
R526	RD14BB2B103J	Carbon res.	10kΩ	±5%	1/8W
R527	RD14BB2B102J	Carbon res.	1kΩ	±5%	1/8W
R530,531	RD14BB2B222J	Carbon res.	2.2kΩ	±5%	1/8W
R532	RD14BB2B331J	Carbon res.	330Ω	±5%	1/8W
R533	RD14BB2B472J	Carbon res.	4.7kΩ	±5%	1/8W
R534,535	RD14BB2B222J	Carbon res.	2.2kΩ	±5%	1/8W
R536	RD14BB2B391J	Carbon res.	390Ω	±5%	1/8W
R537	RD14BB2B333J	Carbon res.	33kΩ	±5%	1/8W
R538	RD14BB2B103J	Carbon res.	10kΩ	±5%	1/8W
R539	RD14BB2B222J	Carbon res.	2.2kΩ	±5%	1/8W
R540	RD14BB2B102J	Carbon res.	1kΩ	±5%	1/8W
R541	RD14BB2B471J	Carbon res.	470Ω	±5%	1/8W
R542	RD14BB2B104J	Carbon res.	100kΩ	±5%	1/8W
R543	RD14BB2B472J	Carbon res.	4.7kΩ	±5%	1/8W
R544	RD14BB2B103J	Carbon res.	10kΩ	±5%	1/8W
R545	RD14BB2B472J	Carbon res.	4.7kΩ	±5%	1/8W
R546	No use				
R547,548	RD14BB2B222J	Carbon res.	2.2kΩ	±5%	1/8W
R549	RD14BB2B101J	Carbon res.	100Ω	±5%	1/8W
R550	RD14BB2B561J	Carbon res.	560Ω	±5%	1/8W
R551	RD14BB2B102J	Carbon res.	1kΩ	±5%	1/8W
R552	RD14BB2B104J	Carbon res.	100kΩ	±5%	1/8W
R553,554	RD14BB2B152J	Carbon res.	1.5kΩ	±5%	1/8W
R555	RD14BB2B221J	Carbon res.	220Ω	±5%	1/8W
R556	RD14BB2B103J	Carbon res.	10kΩ	±5%	1/8W
R557	RD14BB2B680J	Carbon res.	68Ω	±5%	1/8W
R558	RS14AB3A220J	Metal oxide film res.	22Ω	±5%	1W
R559	RD14BB2B222J	Carbon res.	2.2kΩ	±5%	1/8W
R560	RD14BB2B821J	Carbon res.	820Ω	±5%	1/8W
R561-567	RN14BK2E9100F	Metal film res.	910Ω	±1%	1/4W
R568-575	RN14BK2E1800F	Metal film res.	180Ω	±1%	1/4W

Ref. No.	Parts No.	Name & Description			
R576-582	RN14BK2E3600F	Metal film res.	360Ω	±1%	1/4W
R583-585	RD14BB2B222J	Carbon res.	2.2kΩ	±5%	1/8W
R586	RD14BB2B682J	Carbon res.	6.8kΩ	±5%	1/8W
R587	RD14BB2B472J	Carbon res.	4.7kΩ	±5%	1/8W
R588	RD14BB2B102J	Carbon res.	1kΩ	±5%	1/8W
R589	RD14BB2B821J	Carbon res.	820Ω	±5%	1/8W
R590-596	RN14BK2E9100F	Metal film res.	910Ω	±1%	1/4W
R597-603	RN14BK2E1800F	Metal film res.	180Ω	±1%	1/4W
R604-611	RN14BK2E3600F	Metal film res.	360Ω	±1%	1/4W
R612	RD14BB2B472J	Carbon res.	4.7kΩ	±5%	1/8W
R613	RD14BB2B221J	Carbon res.	220Ω	±5%	1/8W
R614	RD14BB2B331J	Carbon res.	330Ω	±5%	1/8W
R615	RD14BB2B391J	Carbon res.	390Ω	±5%	1/8W
R616,617	RD14BB2B221J	Carbon res.	220Ω	±5%	1/8W
R618	RD14BB2B103J	Carbon res.	10kΩ	±5%	1/8W
R619	RD14BB2B471J	Carbon res.	470Ω	±5%	1/8W
R620-629	RD14BB2B472J	Carbon res.	4.7kΩ	±5%	1/8W
R630	No use				
R631	RD14BB2B332J	Carbon res.	3.3kΩ	±5%	1/8W
R632	RD14BB2B223J	Carbon res.	22kΩ	±5%	1/8W
R633	RD14BB2B472J	Carbon res.	4.7kΩ	±5%	1/8W
R634	RD14BB2B221J	Carbon res.	220Ω	±5%	1/8W
R635	RD14BB2B472J	Carbon res.	4.7kΩ	±5%	1/8W
R636	No use				
R637,638	RD14BB2B472J	Carbon res.	4.7kΩ	±5%	1/8W
R639	RD14BB2B103J	Carbon res.	10kΩ	±5%	1/8W
R640	RD14BB2B473J	Carbon res.	47kΩ	±5%	1/8W
R641	RD14BB2B471J	Carbon res.	470Ω	±5%	1/8W
R642	RD14BB2B223J	Carbon res.	22kΩ	±5%	1/8W
R643	RD14BB2B363J	Carbon res.	36kΩ	±5%	1/8W
R644	RD14BB2B472J	Carbon res.	4.7kΩ	±5%	1/8W
R646	RD14BB2B333J	Carbon res.	33kΩ	±5%	1/8W
R647,648	RD14BB2B471J	Carbon res.	470Ω	±5%	1/8W
R649-651	RD14BB2B472J	Carbon res.	4.7kΩ	±5%	1/8W
VR501	R12-0505-05	Semifixed res.	200Ω		
VR502	R12-1026-05	Semifixed res.	3.3kΩ		

Ref. No.	Parts No.	Name & Description
VR503,504	R12-0505-05	Semifixed res. 200Ω
VR505	R12-1026-05	Semifixed res. 3.3kΩ
VR506,507	R12-3002-05	Semifixed res. 10kΩ
C501-504	No use	
C505	CK45B1H221K	Ceramic cap. 220pF ±10%
C506	CK45B1H101K	Ceramic cap. 100pF ±10%
C508,509	CK45B1H101K	Ceramic cap. 100pF ±10%
C510	CK45B1H102K	Ceramic cap. 1000pF ±10%
C511	CK45B1H331K	Ceramic cap. 330pF ±10%
C512	No use	
C513	CK45B1H101K	Ceramic cap. 100pF ±10%
C514	CC45CH1H220J	Ceramic cap. 22pF ±5%
C515	CK45B1E103K	Ceramic cap. 0.01μF ±10% 25WV
C516	CE04W1A470M	Electrolytic cap. 47μF 10WV
C517	CE04W1A150M	Electrolytic cap. 15μF 10WV
C518	CK45B1H221K	Ceramic cap. 220pF ±10%
C519	CK45CH1H100D	Ceramic cap. 10pF ±0.5pF
C520	CE04W1C470M	Electrolytic cap. 47μF 16WV
C521	CK45B1H473K	Ceramic cap. 0.047μF ±10%
C522	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C523	CE04W1A470M	Electrolytic cap. 47μF 10WV
C524,525	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C526,527	CK45B1H221K	Ceramic cap. 220pF ±10%
C528	CK45B1H473K	Ceramic cap. 0.047μF ±10%
C529	CE04W1C101M	Electrolytic cap. 100μF 16WV
C530	CE04W1A101M	Electrolytic cap. 100μF 10WV
C531,532	CK45B1H473K	Ceramic cap. 0.047μF ±10%
C533	CE04W1C101M	Electrolytic cap. 100μF 16WV
C534	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C535	CK45B1H473K	Ceramic cap. 0.047μF ±10%
C536	CE04W1A101M	Electrolytic cap. 100μF 10WV
C537	CK45B1H473K	Ceramic cap. 0.047μF ±10%
C538	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C539	CK45B1H473K	Ceramic cap. 0.047μF ±10%
C540	CE04W1C101M	Electrolytic cap. 100μF 16WV
C541	CE04W1A101M	Electrolytic cap. 100μF 10WV

Ref. No.	Parts No.	Name & Description
C542	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C543	CE04W1A101M	Electrolytic cap. 100μF 10WV
C544	CK45B1H473K	Ceramic cap. 0.047μF ±10%
C545	CE04W1C101M	Electrolytic cap. 100μF 16WV
C546	CK45B1H473K	Ceramic cap. 0.047μF ±10%
C547	CE04W1C470M	Electrolytic cap. 47μF 16WV
C548	CK45B1H473K	Ceramic cap. 0.047μF ±10%
C549	CK45B1H102K	Ceramic cap. 1000pF ±10%
C550	CK45B1H473K	Ceramic cap. 0.047μF ±10%
C551	CE04W1C101M	Electrolytic cap. 100μF 16WV
C552	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C553	CE04W1A101M	Electrolytic cap. 100μF 10WV
C554-588	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C589	CE04W1A101M	Electrolytic cap. 100μF 10WV
C590-595	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C596	CK45B1H221K	Ceramic cap. 220pF ±10%
C597	CC45CH1H330J	Ceramic cap. 33pF ±5%
C598	CK45B1H221K	Ceramic cap. 220pF ±10%
C599,600	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C601	C91-0558-08	Ceramic cap. 0.2μF 12WV
C602-605	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C606	CK45B1H102K	Ceramic cap. 1000pF ±10%
C607	CK45B1H101K	Ceramic cap. 100pF ±10%
C608	CK45B1H102K	Ceramic cap. 1000pF ±10%
C609,610	CK45B1H473K	Ceramic cap. 0.047μF ±10%
C611,612	C91-0559-08	Ceramic cap. 0.2μF 12WV
C613	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C614	CC45SL1H220J	Ceramic cap. 22pF ±5%
C615	CK45B1H472K	Ceramic cap. 4700pF ±10%
C616	C90-0298-05	Semiconductor ceramic cap. 0.1μF 12WV
C617,618	C91-0559-08	Ceramic cap. 0.2μF 12WV
C619	CC45SL1H470J	Ceramic cap. 47pF ±5%
IC501		IC LM310
IC502		IC MC14174
IC503		IC MC14175
IC504,505		No use

Ref. No.	Parts No.	Name & Description	
IC506		IC	MC1741
IC507-509		IC	SN7406
IC510		IC	SN74LS85
IC511		IC	SN74LS193
IC512-514		No use	
IC515,516		IC	SN7406
IC517		No use	
IC518		IC	SN74LS85
IC519		IC	SN74LS193
IC520-522		No use	
IC523		IC	SN7406
IC524		No use	
IC525		IC	SN74LS85
IC526		IC	SN74LS193
IC527,528		No use	
IC529		IC	AM2503
IC530		IC	NE529
IC531-533		IC	SN74LS192
IC534		IC	SN7400
IC535		IC	SN74123
IC536		IC	SN74LS107
IC537		IC	SN7400
IC538		IC	SN7403
IC539,540		IC	SN74LS90
IC541,542		IC	SN7404
IC543		IC	SN7410
IC544		IC	SN7404
IC545		IC	SN7410
IC546		IC	SN7404
IC547		IC	SN74LS107
IC548,549		IC	SN7410
IC550		IC	SN7403
IC551-553		IC	SN74LS90
IC554		IC	SN74LS107
IC555		IC	SN74279
IC556		IC	SN7400
IC557		IC	SN7404

Ref. No.	Parts No.	Name & Description	
IC558		IC	SN74LS107
IC559		IC	SN7400
IC560		IC	SN7404
IC561		IC	SN7402
IC562		IC	SN7403
IC563,564		IC	SN74LS90
IC565		IC	SN74123
IC566		IC	SN74121
IC567,568		IC	SN74LS174
IC569		IC	SN7408
IC570		IC	SN74S00
IC571		IC	CD4011BE
IC572		IC	CD4013BE
IC573		IC	SN74LS273
IC574,575		IC	μPD444C
IC576,577		IC	SN74367
IC578		IC	SN74LS273
IC579		IC	SN7474
IC580		IC	LM310
IC581		IC	SN74158
Q501		Transistor	2SA495 or 2SA1015
Q502-506		Transistor	2SC373 or 2SC1815
Q507-522		Transistor	2N5771
Q523		Transistor	E175
D501-515		Diode	1N34
D516-523		Diode	1S953
D524,525		Diode	1N34
D526-528		Diode	1S953
D529		Diode	RD6.2E
L501-508	L40-4701-03	Ferri inductor	47μH
X501	L77-1002-05	Crystal	10MHz

Ref. No.	Parts No.	Name & Description	
P501	E40-1266-05	Pin connector	12P
P502	E19-0461-08	Pin connector	4P
P503,504	E40-1266-05	Pin connector	12P
P505	E40-0461-08	Pin connector	4P
P506,507	E40-1066-05	Pin connector	10P
P508	E19-0362-08	Pin connector	3P
P509	E19-0461-08	Pin connector	4P

FREE RUN UNIT (X77-1230-00)

Ref. No	Parts No.	Name & Description				
R1	RD14BB2B472J	Carbon res.		4.7 kΩ		
R2,3	RD14BB2B222J	Carbon res.		2.2kΩ		
R4	RD14BB2B183J	Carbon res.		18kΩ		
VR1	R01-8503-05	Variable res.		2MΩB		
C1	C90—0298-05	Semiconductor ceramic cap.		0.1μF		12WV
C2	CK45B1H471K	Ceramic cap.		470pF	±10%	
C3	CS15E1A100M	Tantalum cap.		10μF		10WV
C4	CK45B1H103K	Ceramic cap.		0.01μF	±10%	
IC1		IC	NE555			
IC2		IC	SN7432			
D1-4		Diode	1N34			
P601	E19-1061-08	Pin connector	10P			

POWER SUPPLY UNIT (X68-1330-01)

Ref. No.	Parts No.	Name & Description			
R101	R92-1010-08	Winding res.	0.39Ω	±5%	2W
R102	RD14BB2E332J	Carbon res.	3.3kΩ	±5%	1/4W
R103	RN14BK2E4991F	Metal film res.	4.99kΩ	±1%	1/4W
R104	RN14BK2E1182F	Metal film res.	11.8kΩ	±1%	1/4W
R105	RD14BB2E391J	Carbon res.	390Ω	±5%	1/4W
R106	RS14AB3A220J	Metal oxide film res.	22Ω	±5%	1W
R107	RD14BB2E152J	Carbon res.	1.5kΩ	±5%	1/4W
R108	RD14BB2E220J	Carbon res.	22Ω	±5%	1/4W
R109	RD14BB2E152J	Carbon res.	1.5kΩ	±5%	1/4W
R110	RD14BB2E104J	Carbon res.	100kΩ	±5%	1/4W
R111	RD14BB2B220J	Carbon res.	22Ω	±5%	1/4W
R112	RN14BK2E1502F	Metal film res.	15kΩ	±1%	1/4W
R113	RN14BK2E3013F	Metal film res.	301kΩ	±1%	1/4W
R114	RD14BB2E473J	Carbon res.	47kΩ	±5%	1/4W
R115	RD14BB2E683J	Carbon res.	68kΩ	±5%	1/4W
R116,117	RD14BB2E222J	Carbon res.	2.2kΩ	±5%	1/4W
R118	RD14BB2E102J	Carbon res.	1kΩ	±5%	1/4W
R119,120	RS14AB3A101J	Metal oxide film res.	100Ω	±5%	1W
R121	RD14BB2E164J	Carbon res.	160kΩ	±5%	1/4W
R122	RD14BB2E473J	Carbon res.	47kΩ	±5%	1/4W
R123	RD14BB2E472J	Carbon res.	4.7kΩ	±5%	1/4W
R124	RD14BB2E471J	Carbon res.	470Ω	±5%	1/4W
R125	RD14BB2E104J	Carbon res.	100kΩ	±5%	1/4W
R126	RD14BB2E470J	Carbon res.	47Ω	±5%	1/4W
R127	R92-1011-08	Winding res.	3.6MΩ	±5%	
R128	R92-0146-25	Winding res.	2.2MΩ	±5%	
R129	R92-1012-08	Carbon res.	2MΩ	±5%	
R130	R92-0146-25	Winding res.	2.2MΩ	±5%	
R131	R92-1013-08	Carbon res.	1.8MΩ	±5%	
R132	RD14BK2H473J	Carbon res.	47kΩ	±5%	1/2W
R133,134	R92-1014-08	Carbon res.	22MΩ	±5%	
R135	RD14BB2E473J	Carbon res.	47kΩ	±5%	1/4W
R136	RD14BB2E153J	Carbon res.	15kΩ	±5%	1/4W
R137	RD14BB2E224J	Carbon res.	220kΩ	±5%	1/4W
R138	RD14BB2E223J	Carbon res.	22kΩ	±5%	1/4W
R139	RD14BB2E102J	Carbon res.	1kΩ	±5%	1/4W
R140	RD14BB2E101J	Carbon res.	100Ω	±5%	1/4W

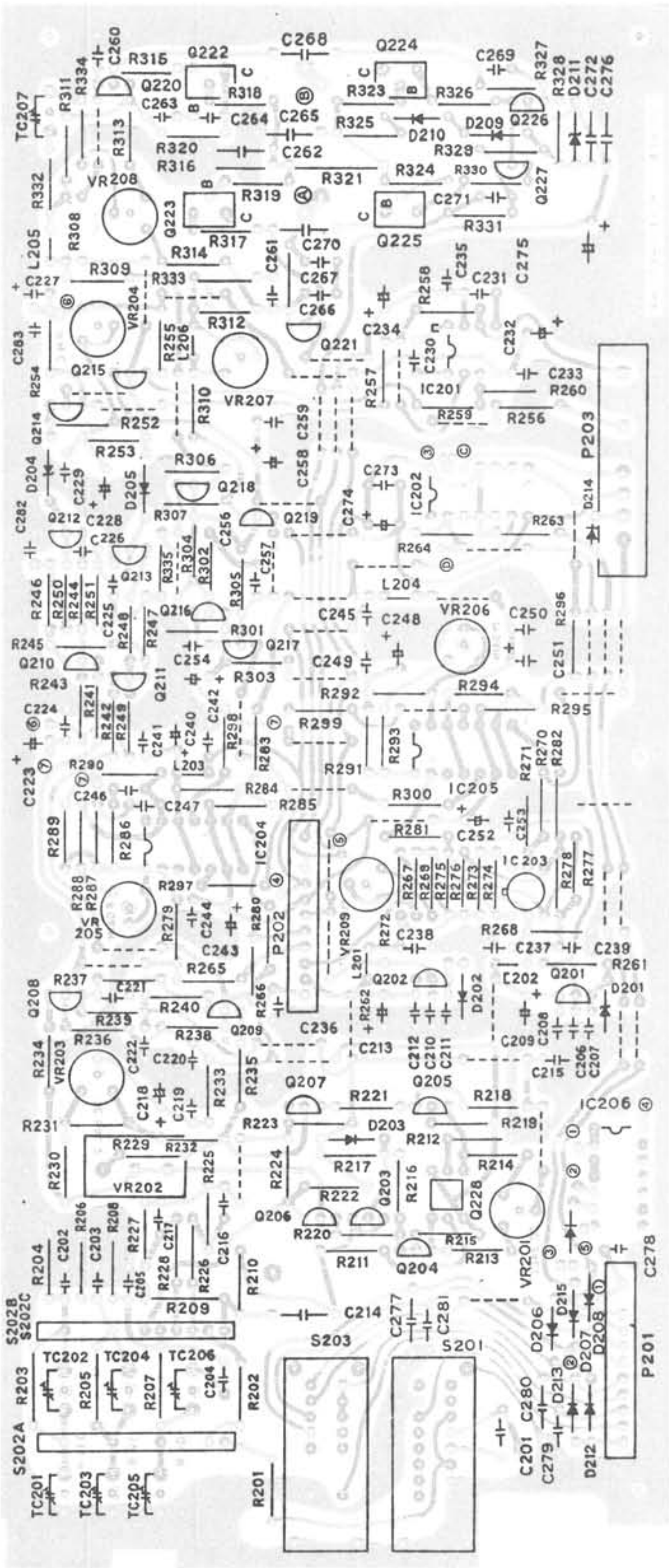
Ref. No.	Parts No.	Name & Description			
R141	RD14BB2E154J	Carbon res.	150kΩ	±5%	1/4W
R142,143	RD14BB2E101J	Carbon res.	100Ω	±5%	1/4W
R144	RD14BB2E683J	Carbon res.	68kΩ	±5%	1/4W
R145	RD14BB2E123J	Carbon res.	12kΩ	±5%	1/4W
R146	RD14BB2E332J	Carbon res.	3.3kΩ	±5%	1/4W
R147,148	RD14BB2E102J	Carbon res.	1kΩ	±5%	1/4W
R149	RD14BB2E822J	Carbon res.	8.2kΩ	±5%	1/4W
R150	RD14BB2E682J	Carbon res.	6.8kΩ	±5%	1/4W
R151	RD14BB2E101J	Carbon res.	100Ω	±5%	1/4W
R152	RD14BB2E472J	Carbon res.	4.7kΩ	±5%	1/4W
R153	RD14BB2E221J	Carbon res.	220Ω	±5%	1/4W
R154	RD14BB2E103J	Carbon res.	10kΩ	±5%	1/4W
R155	RD14BB2E224J	Carbon res.	220kΩ	±5%	1/4W
R156	RD14BB2E104J	Carbon res.	100kΩ	±5%	1/4W
R157	RD14BB2E152J	Carbon res.	1.5kΩ	±5%	1/4W
R158	RD14BB2B152J	Carbon res.	1.5kΩ	±5%	1/8W
R159	RD14BB2B102J	Carbon res.	1kΩ	±5%	1/8W
R160	RD14BB2E102J	Carbon res.	1kΩ	±5%	1/4W
VR101	R12-1002-05	Semifixed	1kΩB		
VR102-104	R12-4503-05	Semifixed	50kΩB		
VR105	R12-6005-05	Semifixed	330kΩB		
VR106	R12-4503-05	Semifixed	50kΩB		
C101	CE04W1C222M	Electrolytic cap.	2200μF		16WV
C102	CE04W1A101M	Electrolytic cap.	100μF		10WV
C103	C90-0298-05	Semiconductor ceramic cap.	0.1μF		12WV
C104,105	CE04W1E102M	Electrolytic cap.	1000μF		25WV
C106	CE04W1C101M	Electrolytic cap.	100μF		16WV
C107	C90-0261-05	Ceramic cap.	0.047μF		25WV
C108	CE04W1C101M	Electrolytic cap.	100μF		16WV
C109	C90-0261-05	Ceramic cap.	0.047μF		25WV
C110	CK45E2H103P	Ceramic cap.	0.01μF	+100% −0%	500WV
C111	C91-0556-08	Ceramic cap.	0.01μF	±2%	
C112	C90-0298-05	Semiconductor ceramic cap.	0.1μF		12WV
C113	No use				
C114	CK45F1H223Z	Ceramic cap.	0.022μF	+80% −20%	
C115	CE04W1H471M	Electrolytic cap.	470μF		50WV

Ref. No.	Parts No.	Name & Description			
C116	CK45F1H103Z	Ceramic cap.	0.01μF	+80% −20%	
C117-122	CK45E3D103P	Ceramic cap.	0.01μF	+100% −0%	2000WV
C123	CE04W2E330M	Electrolytic cap.	33μF		250WV
C124	CE04W2E010M	Electrolytic cap.	1μF		250WV
C125	C90-0298-05	Semiconductor ceramic cap.	0.1μF		12WV
C126,127	CC45CH1H010C	Ceramic cap.	1pF	±0.25pF	
C128	CC45SL1H050C	Ceramic cap.	5pF	±0.25pF	
C129	CK45E1H222P	Ceramic cap.	2200pF	+100% −0%	
C130	CC45SL1H050C	Ceramic cap.	5pF	±0.25pF	
C131-134	C90-0261-05	Ceramic cap.	0.047μF		25WV
C135,136	C90-0298-05	Semiconductor ceramic cap.	0.1μF		12WV
C137	C91-0560-08	Film cap.	0.47μF		50WV
C138	C91-0557-08	Ceramic cap.	0.1μF		50WV
IC101,102		IC	μA741CN		
IC103		IC	LM555CN		
Q101		Transistor	2SC1509		
Q102		Transistor	2SC373 or 2SC1815		
Q103		Transistor	2SA777		
Q104		Transistor	2SC1509		
Q105		Transistor	2SA777		
Q106		Transistor	2SC373 or 2SC1815		
Q107		Transistor	2SA495 or 2SA1015		
Q108		Transistor	2SD401		
Q109		Transistor	2SC983		
Q110		Transistor	2SC1566		
Q111,112		Transistor	2SC983		
Q113		Transistor	2SC1215		
Q114		Transistor	2SC373 or 2SC1815		
D101		Rectifier	S1QB10		
D102		Rectifier	S1QB60		
D103,104		Diode	1S953		
D105		Diode	LA80		
D106,107		Diode	W06C		

Ref. No.	Parts No.	Name & Description		
D108		Rectifier	RD30ER	
D109		Diode	W06C	
D110		Diode	1S953	
D111		Diode	1S955	
D112		Diode	RD5.1E-C	
L101,102	L40-4701-03	Ferri inductor		47μH
T1	L19-0019-05	Converter transformer		
N101-103		Neon lamp	NE-2	
P101	E19-0361-08	Pin connector	3P	
P102	E40-1064-05	Pin connector	10P	
P103	E19-0861-08	Pin connector	8P	
P104	E19-0561-08	Pin connector	5P	
P105,106	E40-1064-05	Pin connector	10P	

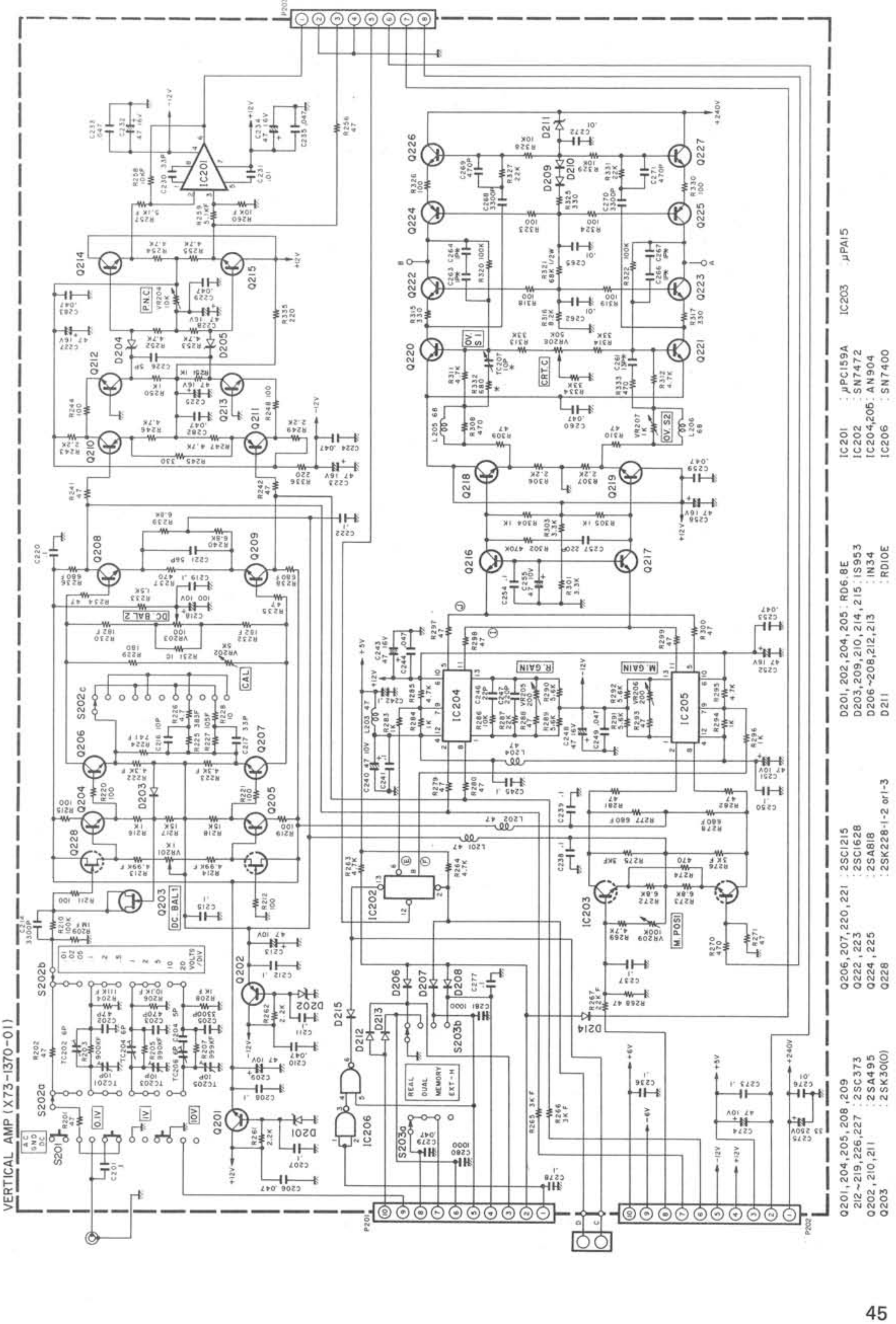
MEMO

PC BOARD



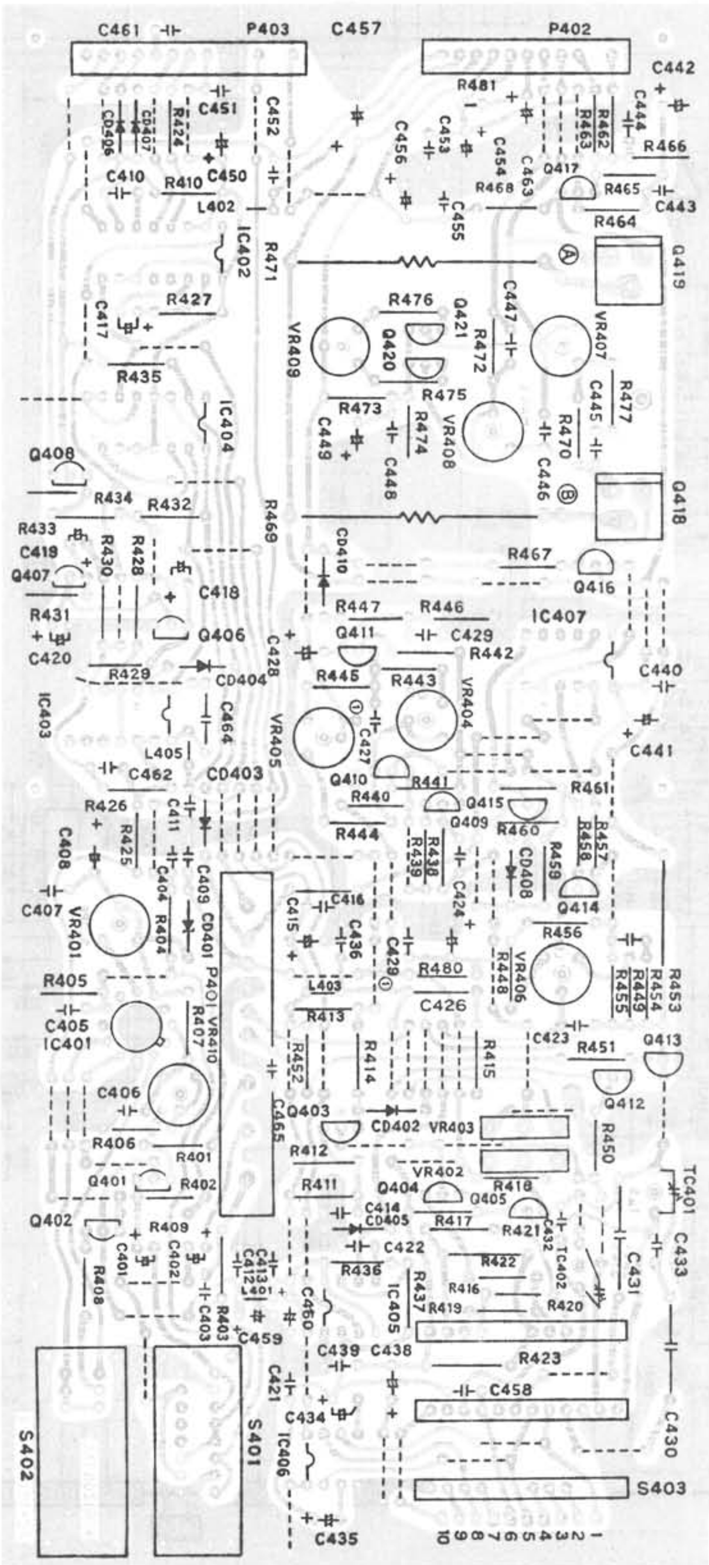
VERTICAL AMPLIFIER UNIT (X73-1370-01)

CIRCUIT DIAGRAM

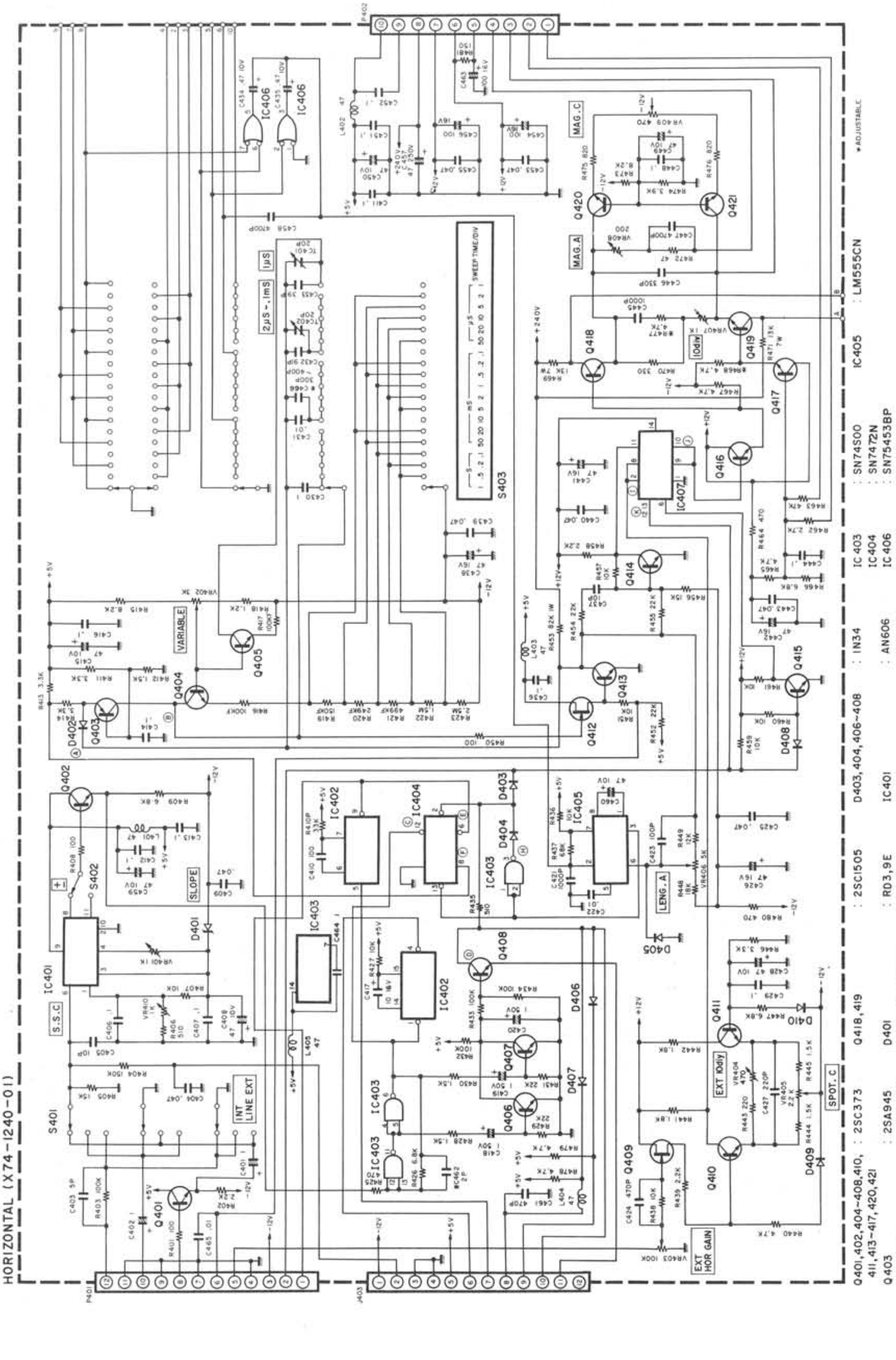


PC BOARD

HORIZONTAL SWEEP UNIT (X74-1240-01)

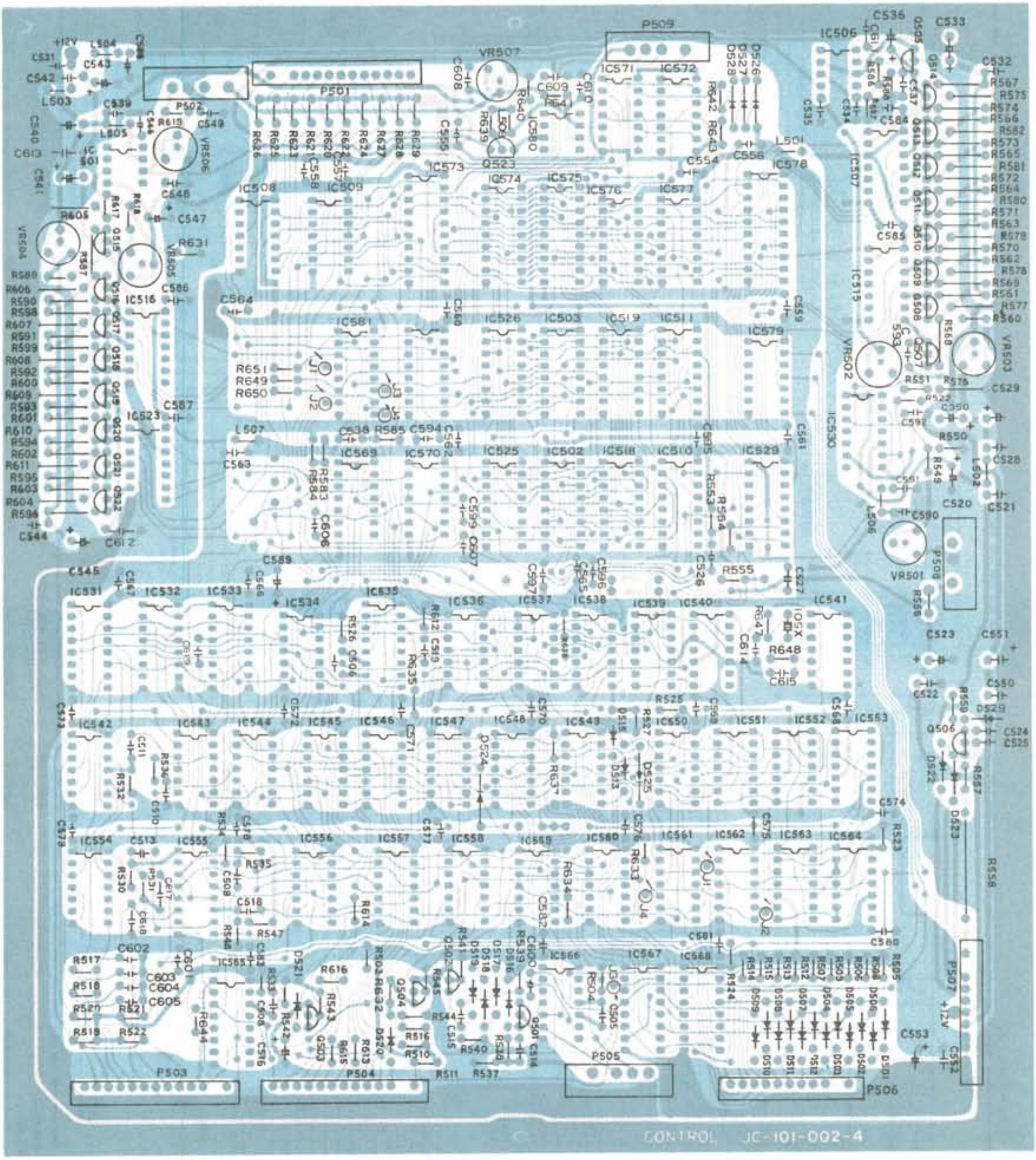


CIRCUIT DIAGRAM

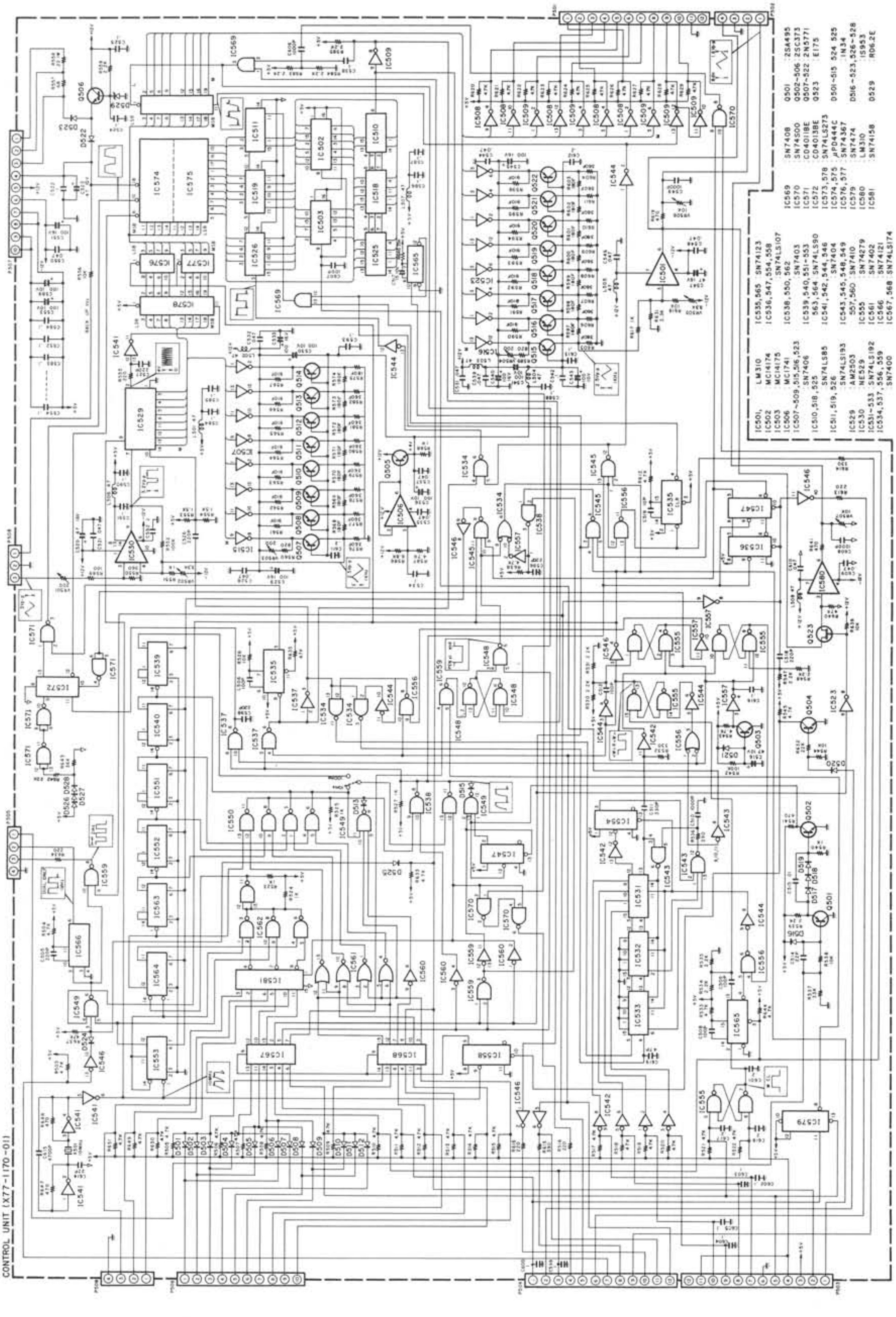


PC BOARD

CONTROL UNIT (X77-1170-01)

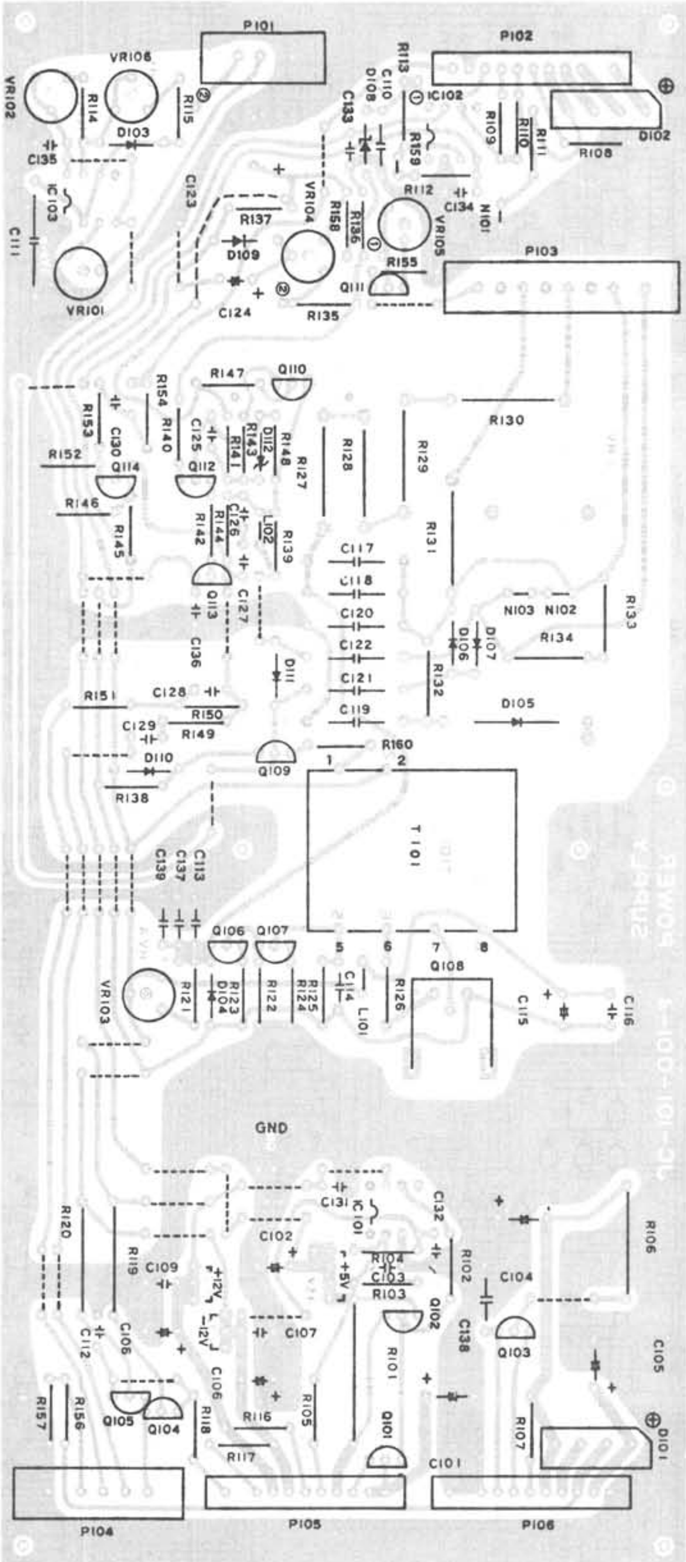


CIRCUIT DIAGRAM

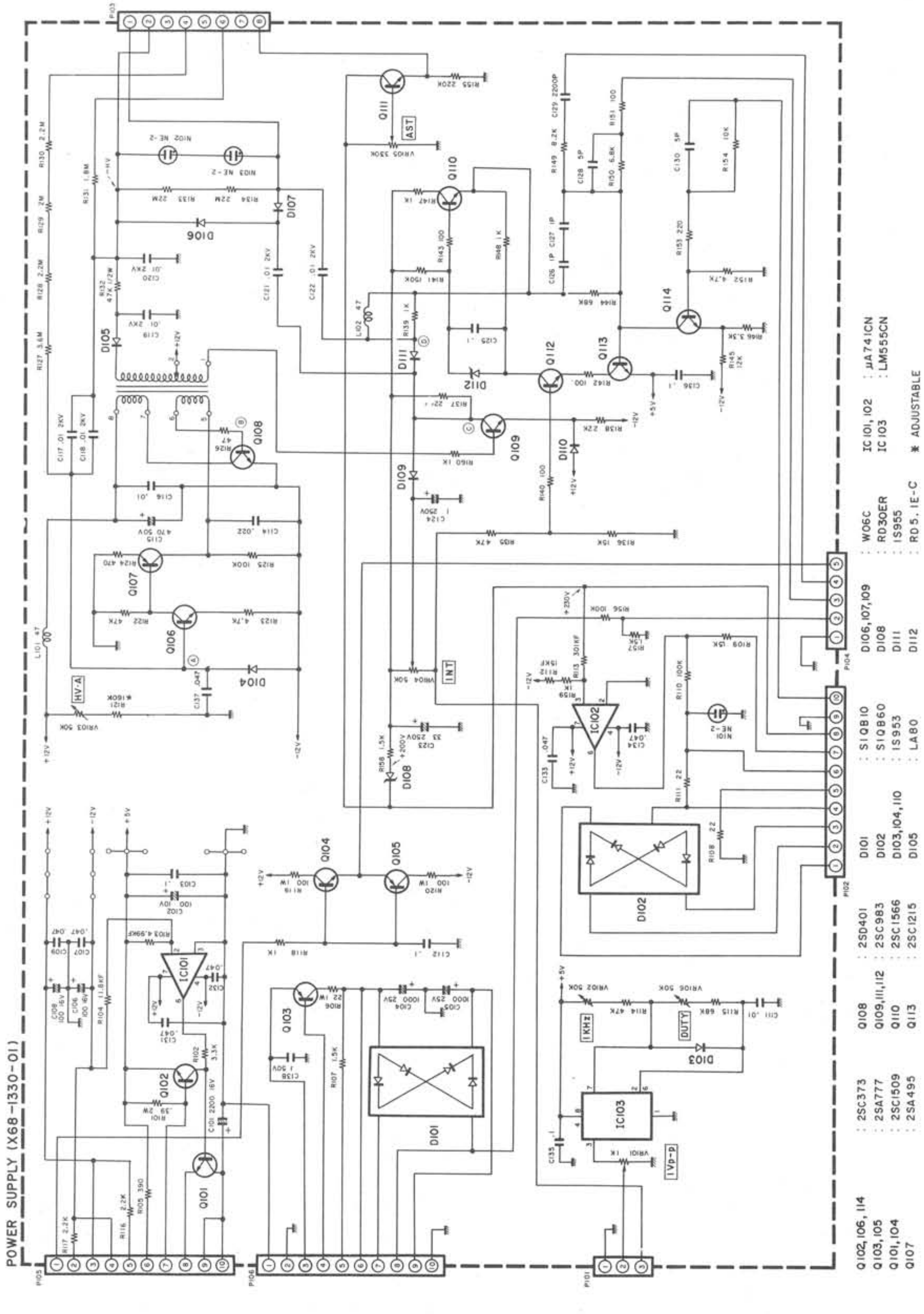


PC BOARD

POWER SUPPLY UNIT (X68-1330-01)

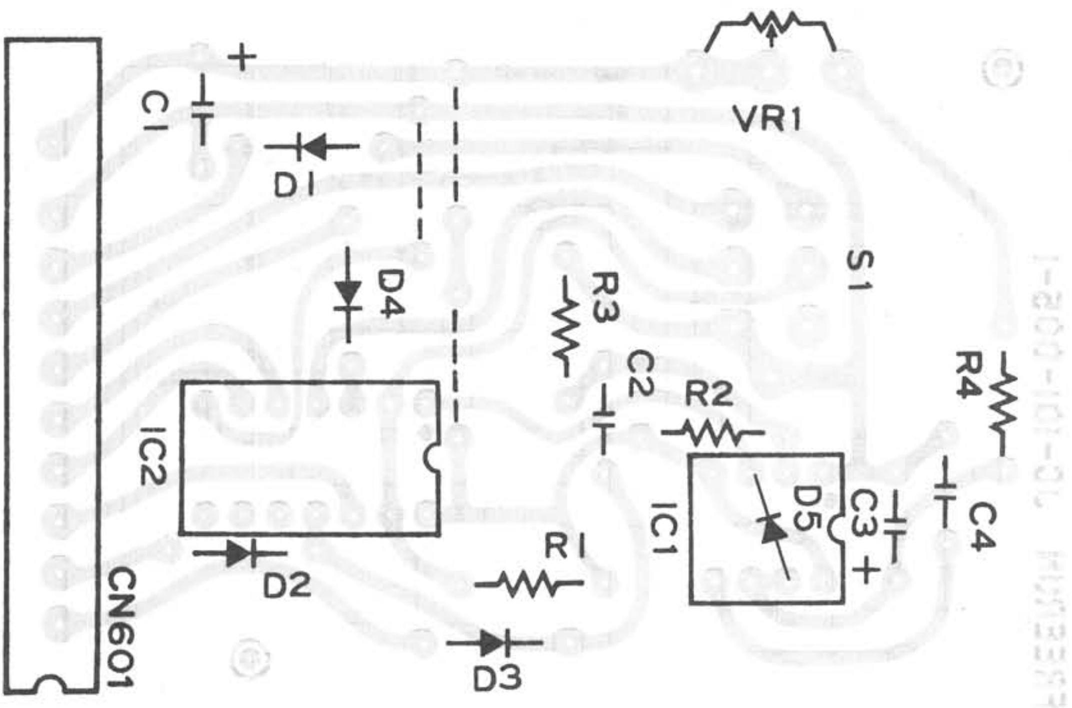


CIRCUIT DIAGRAM

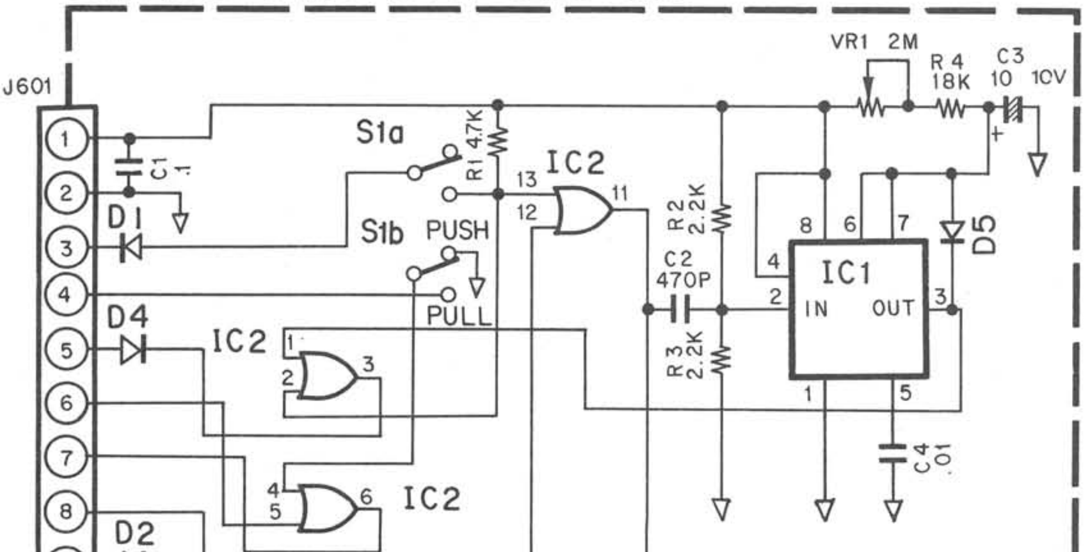


PC BOARD/CIRCUIT DIAGRAM

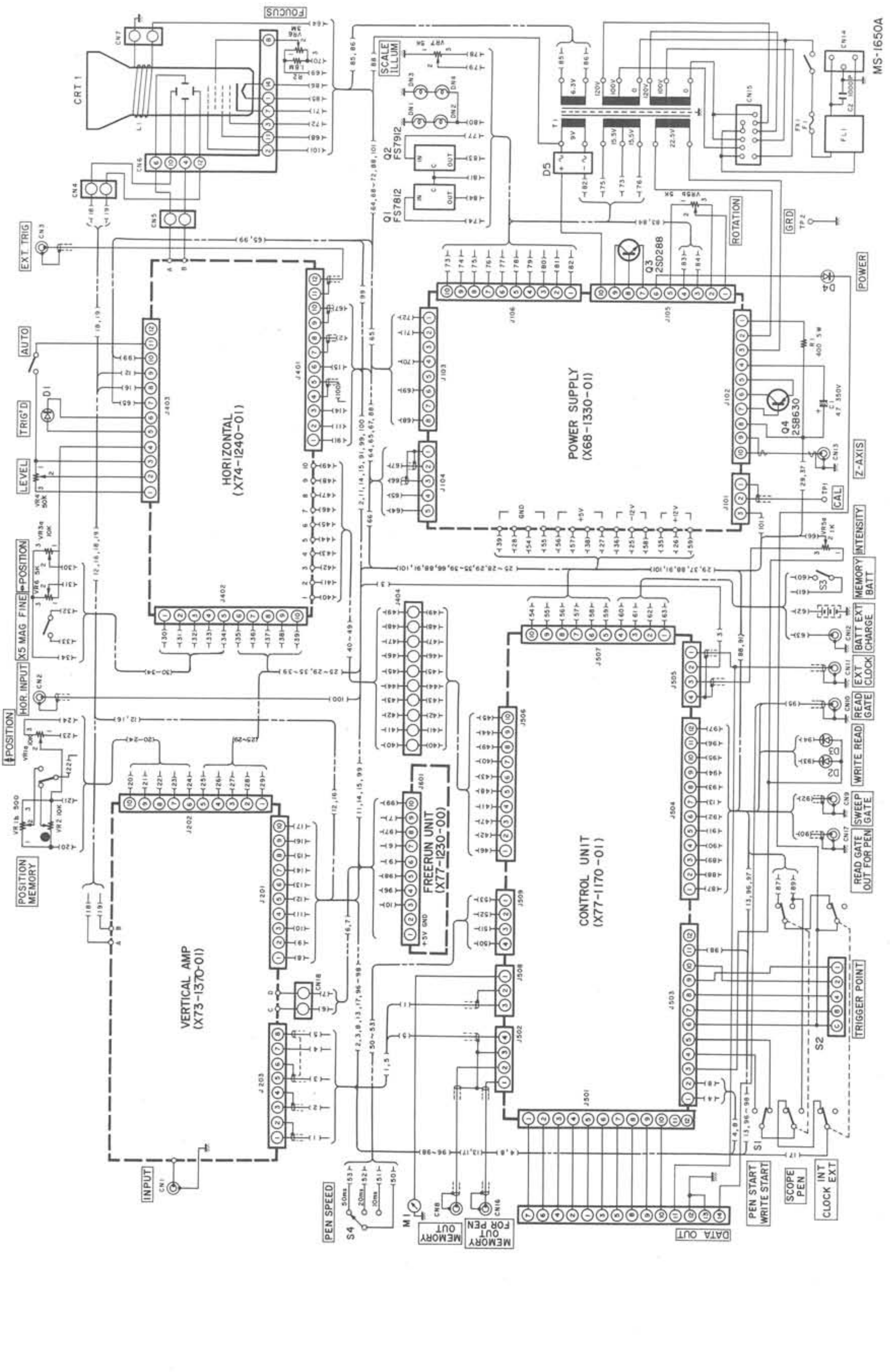
FREE RUN UNIT (X77-1230-00)



FREERUN UNIT (X77-1230-00)



CIRCUIT DIAGRAM



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