DIGITAL FUNCTION GENERATOR

MODEL: 72-380

INSTRUCTION MANUAL

TENMA TEST INSTRUMENTS

SECTION 1 GENERAL DESCRIPTION

INTRODUCTION

The DIGITAL FUNCTION GENERATOR provides square, triangle, sine, ramp and pulse waveforms over a frequency range from 0.2 Hz to 2 MHz, plus a VCF input, variable DC offset and TTL or CMOS pulse output.

The frequency counter A measurement range from 0.1 Hz to 10 MHz. High input sensitivity of 20mv RMS.

FRONT PANEL

The main output and all controls are located on the front panel. They are: the push button POWER switch, seven frequency RANGE push button switches, three push button FUNCTION switches, frequency MULTIPLIER (variable), DUTY potentiometer with invert switch, DC OFFSET control with level control, output AMPLITUDE control with output attenuation, OUTPUT, VCF (voltage controlled frequency) input, COUNTER input, TTL or CMOS pulse output, CMOS level control with CMOS/TTL selector SW, input sensitivity ATT, EXT/INT selector SW, counter display, Hz and KHz indicator, overflow indicator, Gate signal indicator.

REAR PANEL

On the rear panel is located the power cord receptacle.

PRINTED CIRCUIT BOARDS

Main Generator: All circuitry and the power supply are contained on the main P.C. board. All controls and the POWER switch are also contained on the main P.C. board.

FREQUENCY COUNTER: The frequency counter is contained on the main P.C. board.

ELECTRICAL DESCRIPTION

The DIGITAL Function Generator utilizes two constant current sources of opposite polarity for charging and discharging a timing capacitor to produce the triangular waveform.

A diode shaping bridge network shapes the triangle to produce the low-distortion sine wave. The level detector senses the voltage on the timing capacitor and connects and disconnects the current sources alternately. The square wave produced by the level detector is utilized to produce the output square wave.

SPECIFICATIONS

Specifications are listed below in table 1-1. Theory of operation is given in section 3.

Table 1-1 Specifications

Main Generator	
Frequency Range	0.2Hz to 2MHz (7 Ranges) 6 digit counter display
Frequency Accuracy	±5% of length scale
V.C.F. (Voltage Controlled Frequency)	Approx. 0 to 10V (±1V) input for 1000:1 (3 decades) frequency ratio input impedance, Approx. 10KΩ
Main Output Wave Forms	Sine, triangle, square, pulse and ramp
Amplitude	>20V p-p open circuit >10V p-p into 50Ω
Attenuation	-20dB & continuously Variable
DC offset	Variable +10 to -10V open circuit, +5 to -5V into 50Ω
Sine Wave	Distortion: 0.2Hz-200KHz<1% Response: 0.2Hz-200KHz<0.1dB 200KHz-2MHz<0.5dB
Square wave	Rise Time < 120 nS

Pulse Ouput	
Rise time	<25 nS will sink 5 TTL Loads
Level	Amplitude Fixed >+3V open circuit
CMOS Level	5V-15V adjustable
Frequency Counter	
Power Source	AC 115/230V±10% 50/60Hz
Accessories	Test lead GTL-101 x 3 Instruction manual x 1
Dimension	237(W)x85(H)x284(D)mm
Weight	3.2kg

Frequency counter:

a. INT, EXT Switch Selector.

b. Accuracy: ±Time Base accuracy ± 1 count.

c. Time Base: Oscillation frequency 10MHz

Stability 0°-50°C ± 2 X 10^{-5}

d. Counting Capacity: 6 digit (0.3" LED display).
e. Resolution: 0.1Hz, 1Hz, 10Hz, 100Hz.
f. Frequency Range: 0.1Hz - 10MHz.
g. Sensitivity: <20mV rms.
h. Max. Input Voltage: 150V rms.
i. Input Impedance: 1MΩ

SECTION 2 INSTALLATION AND OPERATION

UNPACKING AND INSPECTION

THE DIGITAL FUNCTION GENERATOR is packaged to absorb any reasonable shock encountered during shipping.

Carefully remove the instrument from the shipping container and inspect for shipping damage. If damage is found, notify the carrier immediately.

AC POWER REQUIREMENTS

This instrument operate on line voltages of either 110V, 220V, 240V AC ± 10% 50-60Hz, power dissipation approx. 10VA.

FUSE REPLACEMENT

If for some reason the fuse blows, first try to determine the cause of the failure and remedy if possible.

NOTE: Replace with the proper size fuse ONLY to prevent damage to the instrument.

CONTROLS AND INDICATORS

POWER SWITCH

The power switch applies power to the function generator.

RANGE SWITCH

Seven fixed decades of frequency are provided by the RANGE pushbutton switch. Each of the seven pushbutton RANGE switches is interlocked. Depressing one pushbutton will release all others.

FUNCTION SWITCH

Three interlocking pushbutton switches provide selection of the desired output waveform. Depressing one switch will release the switch previously depressed. Square, triangle, and sine waveforms are provided, satisfying most applications.

MULTIPLIER

The MULTIPLIER is a variable potentiometer allowing frequency settings between fixed ranges. Although the dial skirt is calibrated from .2 to 2.0, the dynamic range of the MULTIPLIER dial is 1000:1 (three decades). For example, this allows frequency settings between 200KHz and 200Hz without changing ranges.

NOTE: This is necessary when sweeping up in frequency over a three decade range 1000:1. (Voltage Control

Frequency Applications).

DUTY CONTROL WITH INVERT

Time symmetry of the OUTPUT waveforms, as well as the TTL or CMOS PULSE output, is controlled by the DUTY potentiometer.

When this control is set to the CAL position, the time symmetry of the output waveforms is 50/50 or approximately 100% symmetrical.

The variable symmetry allows the time period of onehalf the waveform to be changed while the other half remains fixed as determined by RANGE and MULTIPLIER settings. This unique feature provides ramp waveforms, variable pulse width and variable duty cycle pulses, and skewed sine waves.

The duty control potentiometer with INVERT switch when pull position is provided, inverts the time symmetry set by the Duty control.

Table 2-1 illustrates the effect of the INVERT switch and DUTY control.

NOTE: The time symmetry as illustrated below is for reference only. Any desired time symmetry ratio may be set as desired within the limits as described in Section 3, DUTY.

Table 2-1 Duty Control

DC OFFSET WITH LEVEL CONTROL

A DC OFFSET control (DC offset control potentiometer in pull position) is provided to allow the DC level of the OUTPUT waveforms to be set as desired.

NOTE: The amount of offset plus the amplilude setting can't exceed the maximum p-p amplitude or dipping will occur.

Ramp/Pulse Invert Switch	Duty Control	Square	MAIN OUTPUT Triangle	Sine	Pulse Output
pull	Cal				
push	Cal				
push	Max CW				
pull	Max CW				

Table 2-1 DUTY Control

Table 2-2 below illustrates the effect of the DC OFFSET control. The clipped waveform is caused by too much amplitude and too much offset.

Offset	Amplitude	Output
0	Max	+10V -10V
Max CW	Max	+10V 0V
Max CCW	Max	0V -10V
Mid CW	Max	+10V -10V
Mid CCW	Max	+10V -10V

AMPLITUDE WITH ATT

The AMPLITUDE control provides 20dB of attenuation of the output waveform selected by the FUNCTION switch. When the switch is pulled, in addition to 20dB provided by amplitude control, a maximum of 40dB of attenuation, at the output.

OUTPUT

Square, triangle, sine, ramp and pulse waveforms are provided at up to 20V P-P amplitude (open circuit) at the OUTPUT. (When ATT pushbutton switch is pulled).

The VCF input and PULSE outputs, utilize BNC connectors.

VCF INPUT

A VCF (voltage-controlled frequency) input is provided for externally sweeping the frequency. Approximately +10V applied at the VCF input will sweep the generator frequency down three decades or 1000:1. The generator may also be swept up in frequency by applying a negative voltage at the VCF input.

PULSE OUTPUT

The PULSE OUTPUT is a TTL or CMOS output signal suitable for driving TTL or CMOS logic. The rise and fall time of the PULSE output is typically 10ns. The pulse width and repetition rate may be set as desired, utilizing the RANGE and MULTIPLIER and DUTY control. The symmetry of the PULSE output is controlled in the same manner as the output waveforms described in Table 2-1.

CMOS LEVEL CONTROL

The CMOS LEVEL CONTROL potentiometer (pull position) provides CMOS LEVEL OUPUT from 5V to 15V continuously variable.

PULSE OUTPUT SWITCH

Depress the potentiometer switch and observe the TTL and CMOS output push is TTL, pull is CMOS.

FREQUENCY COUNTER

-20dB SELECTOR SWITCH

Select the frequency counter input sensitivity, push on is 200mV rms (-20dB). Push off is 20mV rms (1/1).

EXT, INT SELECTOR SWITCH

Selector the frequency counter is INT or EXT, push on is EXT, push off is INT.

EXT INPUT CONNECTOR

For EXT frequency counter, BNC type connector.

COUNTER DISPLAY

LED indicator display measured INT or EXT input frequency.

Hz KHz LED

Hz, KHz and the position of the decimal point are indicated when the gate time switch is pressed to the 10Sec, 1Sec, 0.1Sec, 10mSec.

GATE LED

Gate signal indicates when the gate time switch, is pushed.

OVER LED

Lamp which indicates that the counter display value is an overflow.

NOTE: Before applying power to the Digital FUNCTION GENERATOR, be sure the proper line voltage is available.

Plug the power cord into the proper source of 110V AC 50-60 Hz. All instruments are wired for 100V AC unless otherwise order made.

FIRST TIME OPERATION PROCEDURE

Set the digital function generator controls as follows:

RANGE-Hz	10K
MULTIPLIER	2.0
FUNCTION	∿
DUTY	CAL
AMPLITUDE	MAX
OFFSET	PUSH
ATTENUATOR	0dB

MAIN OUTPUT

Connect an oscilloscope to output.

Observe a 20V P-P 20KHz triangle wave.

FUNCTION SWITCH

Select and observe a 20V P-P square wave and sine wave.

AMPLITUDE CONTROL

Rotate the AMPLITUDE vernier from maximum to minimum and observe greater than 30dB of attenuation.

ATTENUATION

Connect the oscilloscope to the OUTPUT and push the ATT pushbutton switch and the signal will be attenuated by a factor of 20dB.

DC OFFSET

Reconnect the oscilloscope to the OUTPUT and select the triangle waveform. Rotate the DC OFFSET control potentiometer (pull position) and observe the peaks of the triangle waveform will "clip" when the DC OFFSET plus the peak amplitude exceeds ± 10V.

Reduce the output amplitude and observe the amount of DC OFFSET may be increased by the same amount the peak amplitude has been decreased.

Return the potentiometer to "PUSH" position and the AMPLITUDE to maximum.

DUTY CONTROL

While observing the triangle waveform on the oscilloscope, rotate the DUTY control CW from the CAL position.

Observe one slope of the triangle remains constant while the other slope is variable over typically a 20:1 range, producing a ramp waveform.

INVERT SWITCH

Depress the INVERT potentiometer (pull position) and observe the positive and negative slopes of the ramp waveform reverse (invert).

By selecting the Square wave and repeating the same procedure, this model DIGITAL FUNCTION GENERATOR become very versatile pulse generators.

The pulse width may be determined by the following formula:

PULSE WIDTH = the reciprocal of 2 X freq. setting.

In other words, the pulse width equals one-half the time period of the frequency set by the RANGE and MULTIPLIER controls.

The time symmetry of the Sine wave may be set in the same manner, providing additional versatility.

NOTE: The DUTY control and INVERT switch provide the same flexibility for the PULSE output.

PULSE OUTPUT

Connect the oscilloscope to the PULSE output. By adjusting the generator frequency, the DUTY control and the INVERT switch, the high-speed TTL pulse or CMOS pulse may be utilized as a very versatile pulse generator, With the INVERT switch in the NORM position, the pulse width "on time" is determined by the RANGE and MULTIPLIER setting and the repetition rate "off time" is set by the DUTY control.

NOTE: When the INVERT switch is set to INVERT, the pulse "off time" is determined by the RANGE and MULTIPLIER setting and the pulse "on time" is set with the DUTY control.

SECTION 3 THEORY OF OPERATION

GENERAL

This section describes the operation of this DIGITAL FUNCTION GENERATOR in detail as well as a brief description relating to the Block Diagram. (see Section 4). The drawings contained in this Section are included to aid in the description as well as to supplement the schematics in Section 4.

MAIN GENERATOR

A DC Voltage from the MULTIPLIER potentiometer is connected to the Summing Amplifier U201 and Q201. The output of the Summing Amplifier drives the Positive Current Source U203, Q203 and the inverter U202, Q202. The Invert in turn drives the Negative Current

Source U204 and Q204.

Two constant current sources of opposite polarity charge and discharge a timing capacitor producing the triangle waveform figure 3-1.

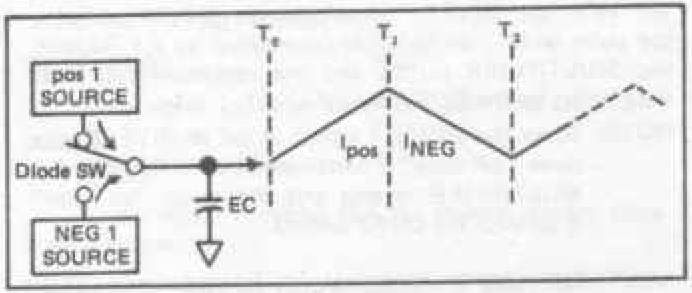


Fig. 3-1 Triangle Waveform

The Positive Current Source charges the timing capacitor during the time period T_0 - T causing the voltage on the timing capacitor to increase from T_0 to T linearly. At time T the Diode Switch disconnects the Positive Current Source from the timing capacitor and connects the Negative Current Source at time T_1. The voltage on the timing capacitor will now discharge or decrease linearly until time T_2 when the Diode Switch will disconnect the Negative Current Source and connect the Positive Current Source, etc.

R_{t1} and R_{t2}, Figure 4-1 are equal in value and determine the positive and negative voltage at the Positive and Negative Current Source. The DUTY potentiometer varies the voltage and thus the current of the Positive or Negative Current Source depending upon the position of the INVERT switch.

By varying the current from one current source and not the other, the timing capacitor will charge and discharge at different rates causing an unsymmetrical triangle waveform (Ramp) Figure 3-2.

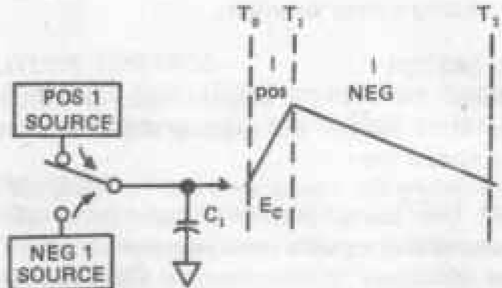


Fig. 3-2 Unsymmetrical Triangle (Ramp) Waveform

The RANGE switch selects different timing resistors and timing capacitors which determine the frequency of the generator. A high input impedance BUFFER Q301, U301. A and B is necessary to prevent loading of the timing capacitor at small timing currents. The triangle waveform is connected to the LEVEL DETECTOR U301, C,D,E, Q302 and Q303. The LEVEL DETECTOR switches when the voltage at its input reaches a pre-determined level. The output from the LEVEL DETECTOR causes the CURRENT SOURCE Diode Bridge to switch, disconnecting one current source and connecting the other. By connecting and disconnecting and current sources at the proper level of voltage on the timing capacitor the triangle waveform is produced. The square wave from the LEVEL DETECTOR drives another diode switch producing a symmetrical square wave for use at the OUTPUT AMPLIFIER.

A TTL GATE is also driven by the square wave from the LEVEL DETECTOR. The output of the TTL GATE provides a TTL pulse at the PULSE output connector.

A diode shaping bridge network uses the log curve of silicon diodes to simulate a sinusoidal curve. Figure 3-3.

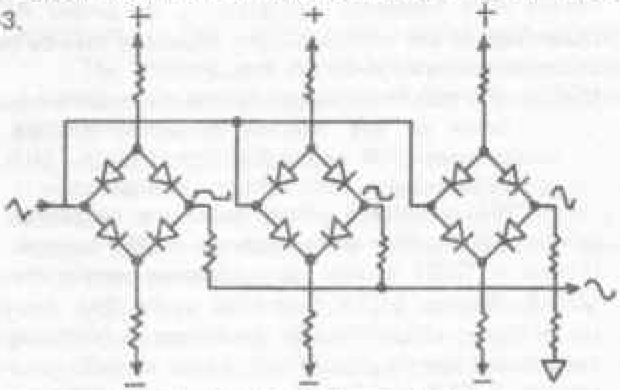


Fig. 3-3 Diode Shaping Bridge

Sine amplifier U401, boosts the amplitude of the sine wave to the proper level for the OUTPUT AMPLIFIER.

A square, triangle or sine wave may be selected by the FUNCTION switch. The desired waveform is connected to the AMPLITUDE potentiometer. OUTPUT AMPLIFIER Q501 thru Q506 is a non inverting amplifier which supplies the necessary output amplitudes of the desired waveforms as selected by the FUNCTION switch and AMPLITUDE control.

CIRCUIT DESCRIPTION (Main GENERATOR)

POWER SUPPLY

The power supply shown in the Block Diagram, figure 4-1, consists of a full wave unregulated ±20V supply and a regulated ±15.5V supply.

NOTE: Unregulated ±20V supply: Refer to the schematic diagram figure 5-4.

Line voltage is applied to transformer T101 through power switch S101.

Jumpers wire provide for line voltages selected of 110V, 220V and 240V AC 50-60Hz.

NOTE: If it is necessary to change the wiring on the transformer primary to accept other line voltages, refer to proper wiring, jumpers and fuse data for different line line voltages that indicated that the printed circuit board.

BD101 is a full wave rectifier which converts the line voltage to approximately ±20V DC across filter capacitors C101 to C104.

U101, Q101, and U102 are dual regulator supply ±15.5V.

SVR101 and SVR102 are adjust balances the ±15.5V supplies. This small amount of adjustment (approximately ±0.1V) helps adjust the waveform symmetry for minimum sine distortion.

SUMMING AMPLIFIER

Refer to Figure 4-2 U201 is an operational amplifier. Q201 is an emitter follower buffer used in conjunction with the operational amplifier. U201 and Q201 are connected as a summing amplifier with a closed loop gain of-1 (inverting). The MULTIPLIER, (VR201) supplies a negative voltage to the summing amplifier input (pin 2) through summing resistor R204. The negative voltage of approximately -2V to 0V is inverted by the summing amplifier and appears as +2V to 0V at Q201 emitter.

The frequency may be swept (adjusted) over a three decade range (1000:1) by the MULTIPLIER or by applying the proper AC or DC voltage at the VCF input. With the MULTIPLIER set at 2.0, the voltage at the summing resistor R204 is approximately 2V. By applying approximately +10V DC at the VCF input, approximately +2V is applied at summing resistor R202. The -2V from the MULTIPLIER and the +2V at the VCF input add to provide 0V at the summing amplifier output. This will cause the frequency to decrease approximately three decades or 1000:1. If it is desirable to sweep up in frequency rather than down, set the MULTIPLIER at maximum counter-clockwise (approximately 0V at the summing amplifier output). This will set the frequency approximately three decades below the selected frequency RANGE. By applying approximately 10V at the VCF input, the summing amplifier output will be forced to +2V causing the frequency to increase three decades or to the maximum frequency indicated on the selected frequency RANGE. By setting the MULTIPLIER at the desired start frequency and applying the proper AC or DC voltage at the VCF input, the frequency may be swept as desired over a three-decade range.

NOTE: The maximum frequency and minimum frequency limits on any selected frequency RANGE are between .002 and 2.0 (1000:1) on the MULTIPLIER dial.

Q201 provides a voltage-to-current conversion for driving the positive current source. Q201 converts the voltage at Q201 emitter to a constant current through R214A. Assume DUTY control is in the CAL position. By varying the MULTIPLIER the voltage on R208A varies, causing the current through R214A to vary. The current through R208A and R214A are equal except for a small amount of base current for Q201 and bias current for U202.

INVERTER

The INVERTER (U202, Q202) inverts the voltage at the summing amplifier output (Q201 emitter) and appears across R209A which is equal in value to R208A. U202 is an operational amplifier connected for a closed-loop gain of -1 (inverting). The +2V at Q201 emitter is inverted and becomes -2V at Q202 emitter. Q202 is an emitter follower buffer used in conjunction with the operational amplifier U202. The voltage across R209B is equal to the voltage across R208B, therefore: the current through R214B is equal to the current through R214A (assuming VR202 is in the Cal position). Q202, like Q201, provides a voltage-to-current conversion.

POSITIVE AND NEGATIVE CURRENT SOURCE

The positive and negative current sources provide a constant current for charging and discharging the timing capacitors.

U203 and Q203 form a voltage follower. U203 is an operational amplifier with very low input bias currents necessary to prevent timing current errors. Q203 is an emitter follower providing the voltage-to-current conversion for the current source.

U204 and Q204 perform the same function for the negative current source. Equal voltages appear at the current source inputs and outputs dependent upon the MULTIPLIER setting as previously explained.

Since the current through R214A and R214B are equal the voltage at U203 and U204 inputs is equal and opposite in polarity. The voltage appearing at Q203 and Q204 emitters is also equal and opposite in polarity.

The timing current is determined by the voltage across the timing resistors (R216 to R219 and R220 to R223).

The RANGE pushbutton switches select the proper timing resistors and capacitors according to the frequency range selected.

DUTY

S202 INVERT switch and VR202 VAR DUTY control are utilized to obtain pulse and ramp waveforms. When the VAR DUTY control VR202 is in the CAL position. R208A and R208B are both connected to ground in either position of the INVERT switch S202.

As long as R208A and R208B are grounded, the current thus R208A and R208B is equal as previously explained. When the INVERT switch is in the NORM position (in), R208A is grounded directly and R208B is grounded through VR202, the DUTY control. With VR202 in the CAL position, currents through R214B, R208B, R214A and R208A are equal; therefore the voltages at Q203 and Q204 are equal and opposite in polarity. A triangle waveform is produced across the timing capacitor when the DUTY control is in the CAL position. When VR202 is not set to the CAL position, the resistance from Q202 emitter to ground is variable from 1K ohm to approximately 20K ohms. The voltage of Q202 emitter remains constant determined by the MULTIPLIER setting. This causes to vary over approximately a 20:1 range; approx. 2mA in the CAL position (1K) and approximately 1mA in the CW position (20K). Current thru R208 remains constant while current thus R208B is variable. The positive current source voltage remains fixed and the negative current source voltage is variable by the DUTY control. A variable slope ramp waveform is produced in this manner. The slope of the ramp is adjusted as desired over approx. a 20:1 range. When the INVERT switch (S202) is set to the INVERT position, the positive current source becomes variable and the negative current source remains fixed reversing the slopes of the ramp waveform.

NOTE: When VR202 is in the CAL position, the position of S202 has no effect because R208A and R208B are both grounded in either position of S202.

CURRENT SOURCE DIODE SWITCH

A diode switch is utilized for connecting and disconnecting the current sources. One output from the level detector sinks the current from either the positive or negative current source.

When the input to the switching bridge is positive, the level detector sinks the current from the negative current source thru diodes D205 and D206. This positive input signal reverse biases D201 and D202. The positive current source now charges the timing capacitor positive. When the voltage on the timing capacitor reaches approximately +1V, the level detector switches and the diode bridge input switches negative. This negative voltage at the input to the switching bridge sinks the current from the positive current source thru D201 and D202. This negative voltage reverse biases D205 and D206. The negative current source now discharges the timing capacitor. When the voltage on the timing capacitor reaches approximately -1V, the level detector switches and the timing capacitor charges positive again, etc.

BUFFER

Q301 and U301A and B form the high input impedance buffer. Q301 is an FET with a very high input impedance. U301B is used as current source supplying bias current for Q301. The ZERO BAL adjust SVR301 sets the bias current thru the FET (Q301) to the proper level to obtain a GATE to source voltage equal to the base emitter drop of U301A. The gate to source voltage of the N-channel FET Q301 is opposite in polarity to that of the emitter follower U301A. The input to output error is adjusted to 0V in this manner. The emitter follower output (pin 10) provides the necessary current to drive the level detector and associated circuitry.

LEVEL DETECTOR

The level detector senses the voltage on the timing capacitor from the buffer output and switches the diode switch at the proper level producing the triangle waveform. U301C and D forms a differential amplifier with current source U301E. Q302 and Q303 form a second differntial amplifier driven from the input differential amplifier

U301C and D. Positive feedback is applied to U301D base thru the reference switching bridge D304 thru D307. This positive feedback and high open loop gain provide very fast switching times for the level detector. Q302 collector drives the reference switching bridge providing the positive and negative and negative reference current thru R311. When Q302 is on, the collector holds the input to the reference bridge positive. Q302 sinks the current from the negative supply thru SVR303, R313 and D307. Current thru R311, D304, SVR302 and R312 establishes the positive reference voltage of approximately +.5V at U301D base. Q302 collector is also connected to the current source switching bridge at D201 and D206 junction. This positive signal allows the timing capacitor to charge in the positive direction as explained in Section 3. (Theory of Operation)

The input to the level detector is a voltage divider consisting of R304 and R305 +1V at R304 input equals approximately +.5V at U301C base. When the voltage at U301C base rises above the reference voltage at U301D (+.5V), the level detector will switch. Q302 will turn off, causing the voltage at the reference bridge (D304 to D307) and the current source switching bridge (D201 to D204 and D205 to D208) to switch negative. This negative voltage will cuase the reference voltage at U301D to switch negative and cause the timing capacitor to begin charging negative (discharge). When the timing capacitor had charged to approximately -1V, the sinal at U301C will become more negativen than the reference voltage at U301D (now approximately -.5V) and the level detector will switch again etc. Q303 collector supplies the square wave signal to drive the Square Diode Switch and the TTL Gate U302.

TTL GATE

U302 is a Dual 4 Input Positive Naud Gate providing the TTL PULSE OUTPUT. D320, D321 and D322 provide the necessary level shifting of the square wave at Q303 collector for driving the TTL GATE inputs (pin 1 and 9). ZD301 is a zener diode providing approximately a +5V power supply for the TTL GATE. The outputs of the two nand gates (pin 6 and 8) are paralled to provide the capability of sinking 20 TTL GATES.

Output levels of the TTL GATE are approximately +3V and 0V open circuit at typically 10ns rise and fall time. The PULSE out is a square wave as long as the DUTY control is in the CAL position. A variable pulse width and variable duty cycle pulse are easily set up utilizing the DUTY control and INVERT switch as shown in Section 2, Table 2-1.

SQUARE WAVE DIODE SWITCH

The square wave diode switch D323 to D326 provides a clean square wave of approximately ±1V amplitude from the ±2V signal at Q303 collector. The signal from

Q303 collector is routed thru S501C to the diode switch. The diode switch is activated only when the square wave is selected by S501 the FUNCTION switch. The positive signal sinks the current thru D323 R318. The positive portion of the square wave is developed across the amplitude potentiometer (VR501) thru SVR304, D326 and R317. The negative portion of the square wave is developed across VR501 thru SVR304, D326 and R318, when the square wave at Q303 collector reverse polarity SVR304 provides a small amount of adjustment for calibration of the square wave amplitude.

SINE SHAPER

Three diode bridges are utilized to produce a sine wave from the triangle waveform. D401, D402 and D403 are three matched diode sets of 4 diodes in each set. The triangle waveform from the buffer output is connected to these three diode bridges thru R401. As the triangle voltage rises above 0V, the current thru R404 increases exponentially in the positive direction thru BD401B and R402 while the current thru BD401D and R403 is being shunted thru BD401C as the triangle voltage rises toward its positive peak. When the triangle has reached its positive peak, the current thru R404 to the +15V supply has reached a maximum. The current now decreases exponentially as the triangle rises toward its negative peak. When the triangle has reached approximately 0V, the current thru R404 is nearly zero because an equal current is passing thru BD401D and BD401B. As the triangle increases in the negative direction, current increases thru BD401D and R404 exponentially, as the triangle rises toward its negative peak. Current thru R402 is now being shunted thru BD401A as the tirangle rises toward its negative peak. The current thru R404, R407 and R410 increase in the positive and negative direction exponentially thru each of the three bridges in the same manner. The current thru each bridge is determined by the resistors in each bridge. By summing or adding the exponential currents of the three bridges across R412, a sine wave is produced. By proper selection of resistor values in each brdige a low distortion sine wave of typically <5% is produced.

SINE AMPLIFIER

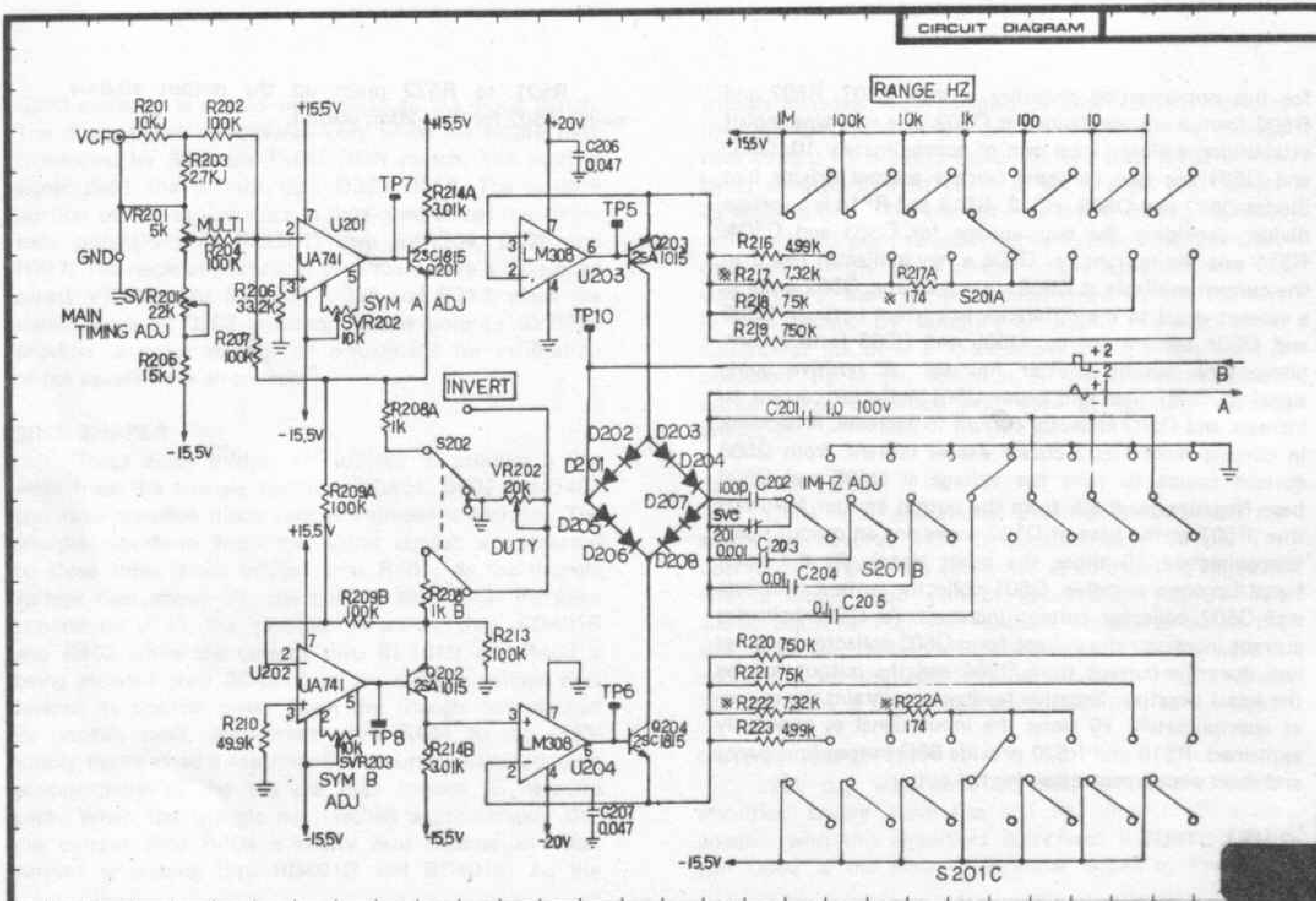
U401 is an operational amplifier which boosts the small sine wave at R412 to approximately 2V pp. The operational amplifier is connected as an inverting amplifier with a closed loop gain of approximately-6, SVR401 allows adjustment of the feedback resistor to adjust the sine wave amplitude during calibration. The sine wave is connected to the AMPLITUDE control VR501 when the sine wave is selected by the FUNCTION switch S501.

OUTPUT AMPLIFIER

±20V p.p. waveforms are produced by the output amplifier, square wave rise and fall times <120ns are possible with this amplifiers 200V/usec slew rate. Q501 and Q502 is the input differential amplifier. Feedback for this non-inverting amplifier is thru R507; R507 and R506 form a voltage divider at Q502 (the inverting input) establishing a closed loop gain of approximately 10. Q503 and Q504 are two constant current sources driving bias diodes Q507 and Q508. R512, R513 and R514 is a voltage divider providing the bias voltage for Q503 and Q504. R511 sets the current for Q504 a few milliamps less than the current available at Q503 current source. Q502 supplies a current equal to the difference in current between Q503 and Q504 current source. Q505 and Q506 form a complementary output emitter follower. A positive going signal at Q501 base will cause Q501 collector current to increase and Q502 collector current to decrease. A decrease in current from Q502 cuases excess current from Q503 current source to raise the voltage at Q505 and Q506 base Negative feedback from the output emitter followers thru R507 to the base of Q502 maintains an output signal approximately 10 times the input signal. As the input signal becomes negative, Q501 collector current decreases and Q502 collector current increases. As Q502 collector current increases, the current form Q503 collector becomes less than the current from Q504 and the output follows the input negative. Negative feedback maintains the output at approximately 10 times the input signal as previously explained. R519 and R520 provide 50Ω output impedance and short circuit protection for the output.

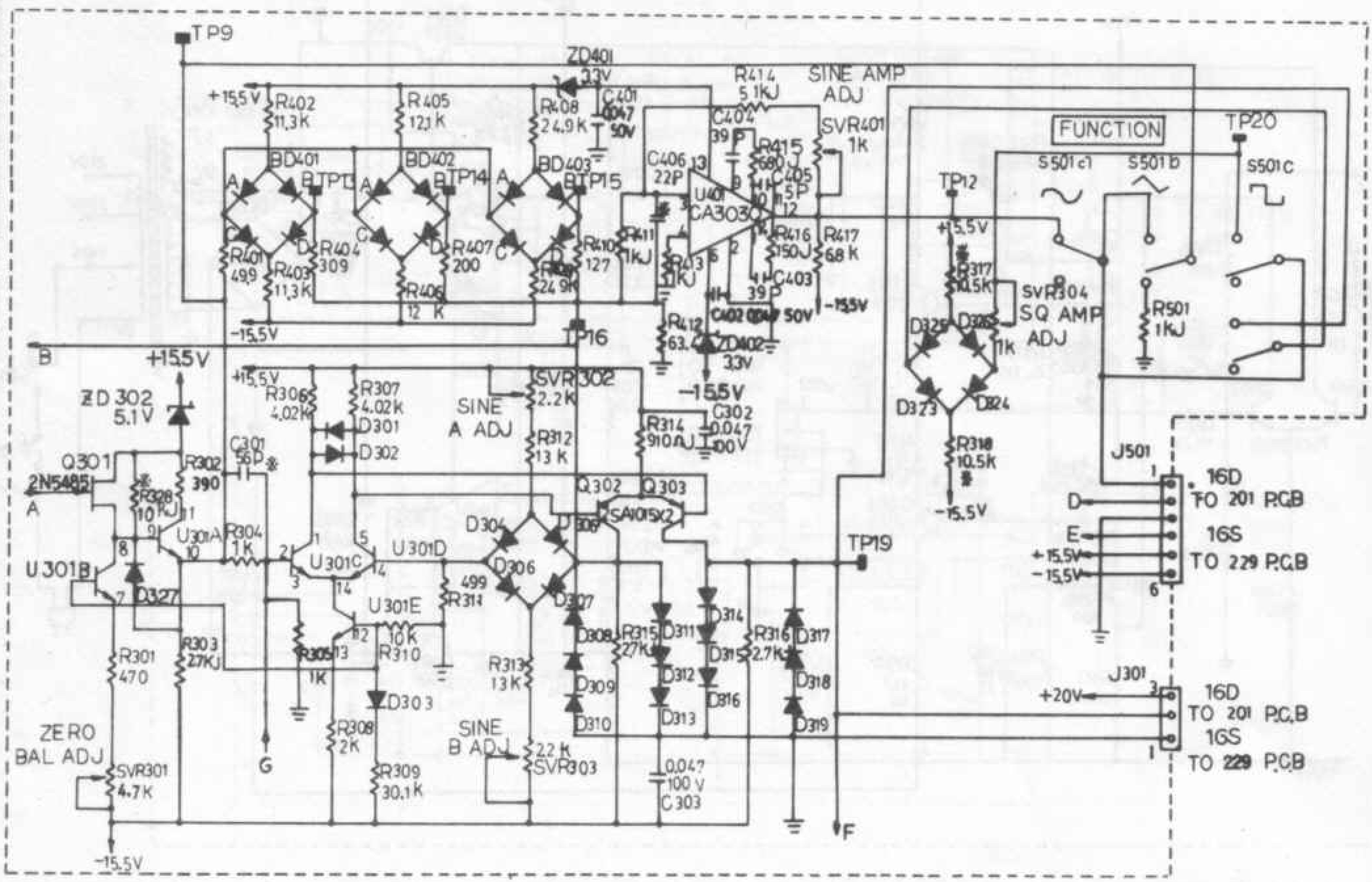
-20dB OUTPUT

R521 to R522 make up the output attenua switch S502 for the -20dB output.



1 ※ ADJUSTED IN FACTORY. 2 CIRCUITRY ARE SUBJECT TO CHANGE WITHOUT NOTICE FOR FUTHER IMPROVEMENT. 3 RESISTANCE VALUES IN Ω ¼ WATT AND CAPACITANCE IN μF UNLESS OTHERNISE SPECIFIED.	DRAWN BY J.R. Ye..	CHECKED BY	APPROVED BY	NAME DESCRIPTION DRAWING NO	FUNCTION [illegible]

CIRCUIT DIAGRAM



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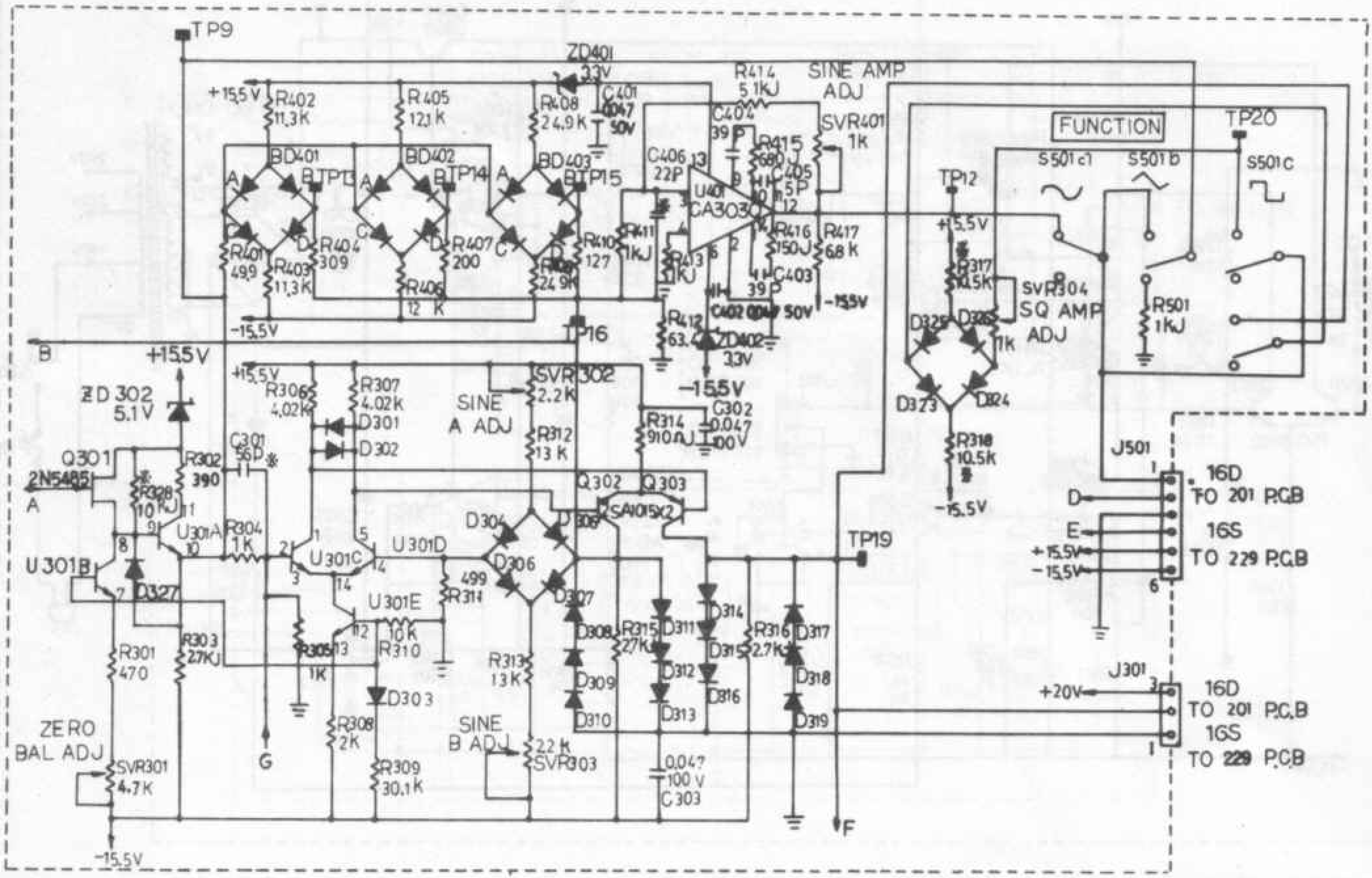
DRAWN BY	CHECKED BY	APPROVED BY	NAME	
			DESCRIPTION	
			DRAWING NO	

CIRCUIT DIAGRAM



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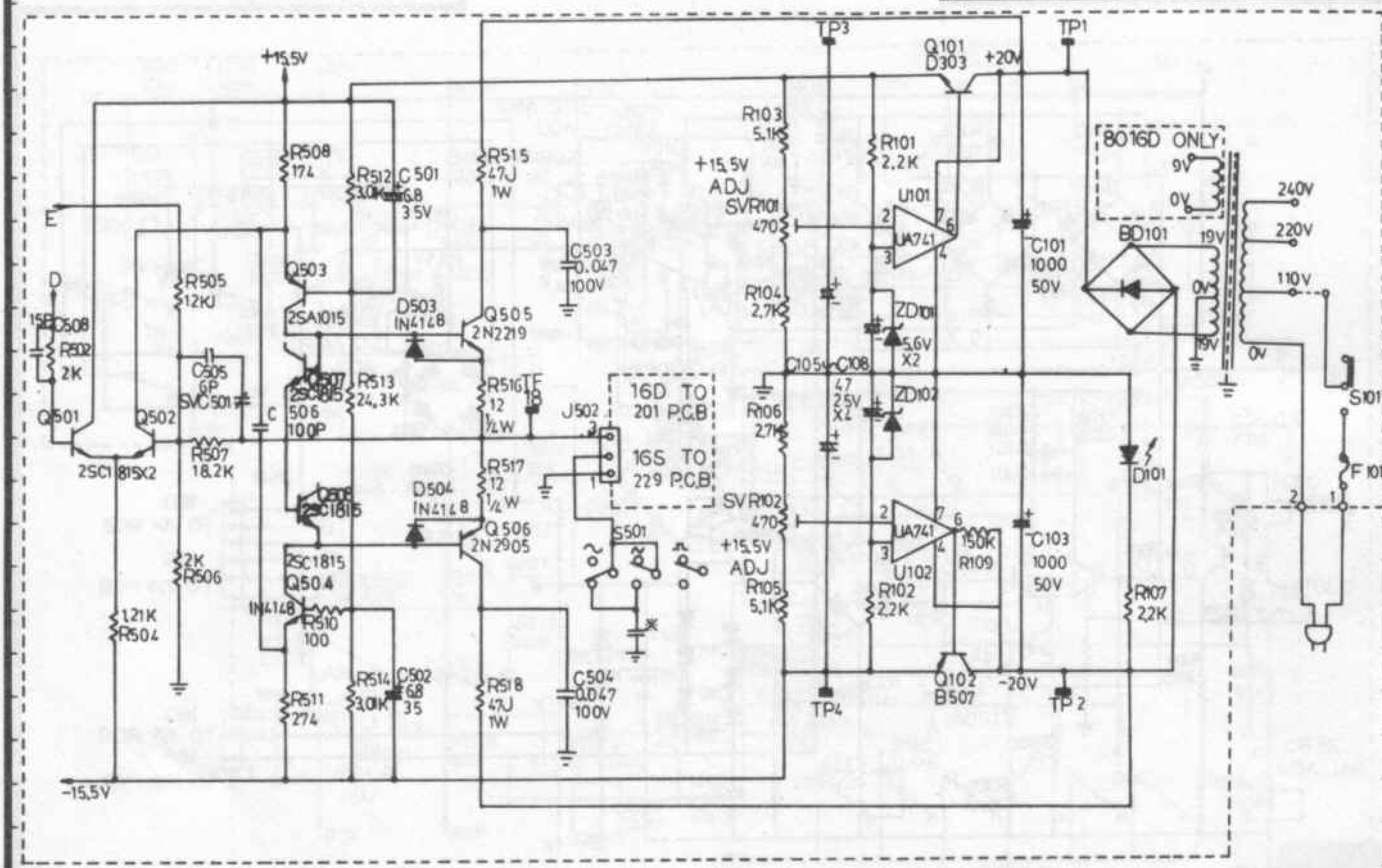
			DRAWING NO	

CIRCUIT DIAGRAM



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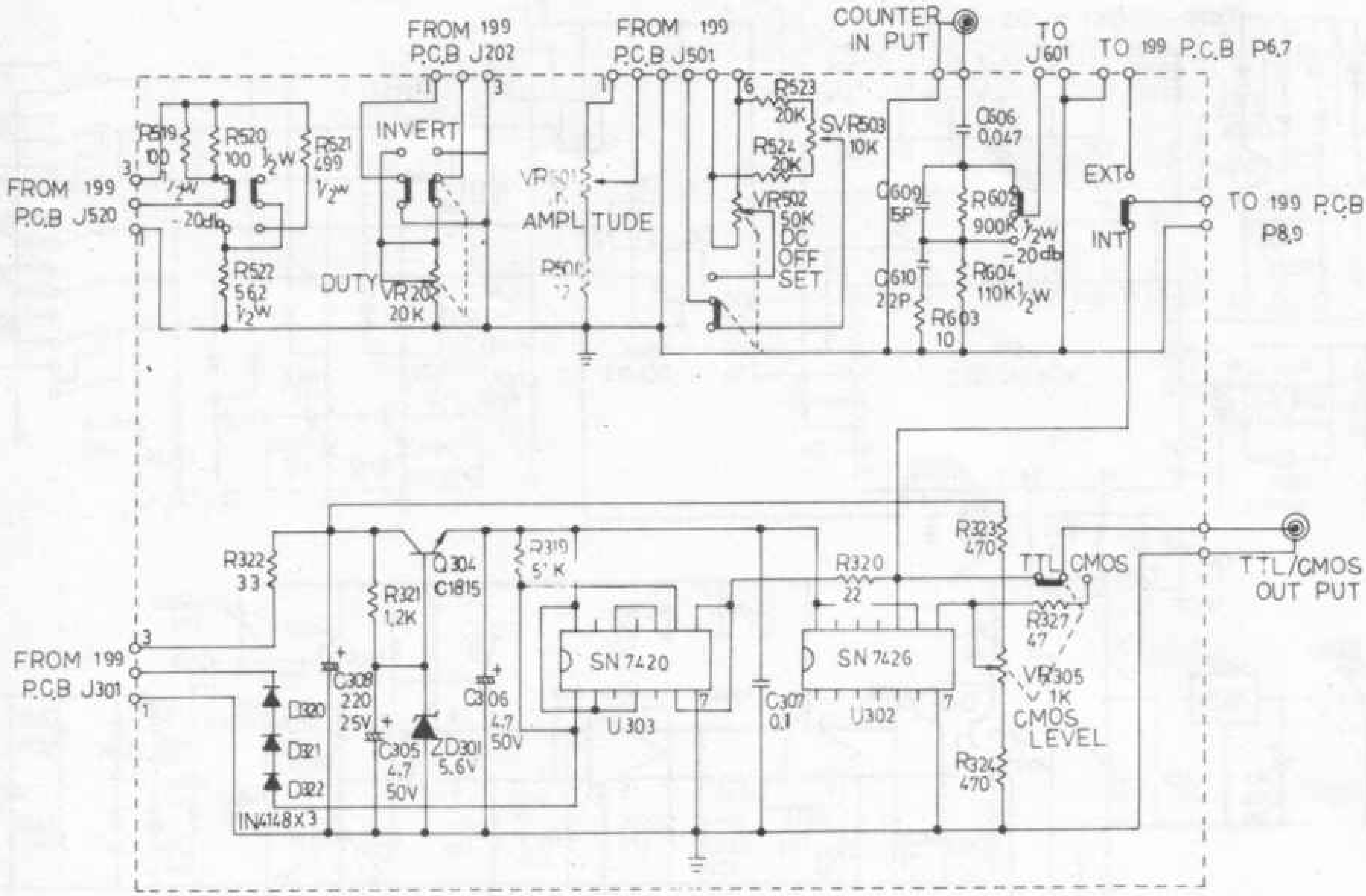
			DRAWING NO	

CIRCUIT DIAGRAM



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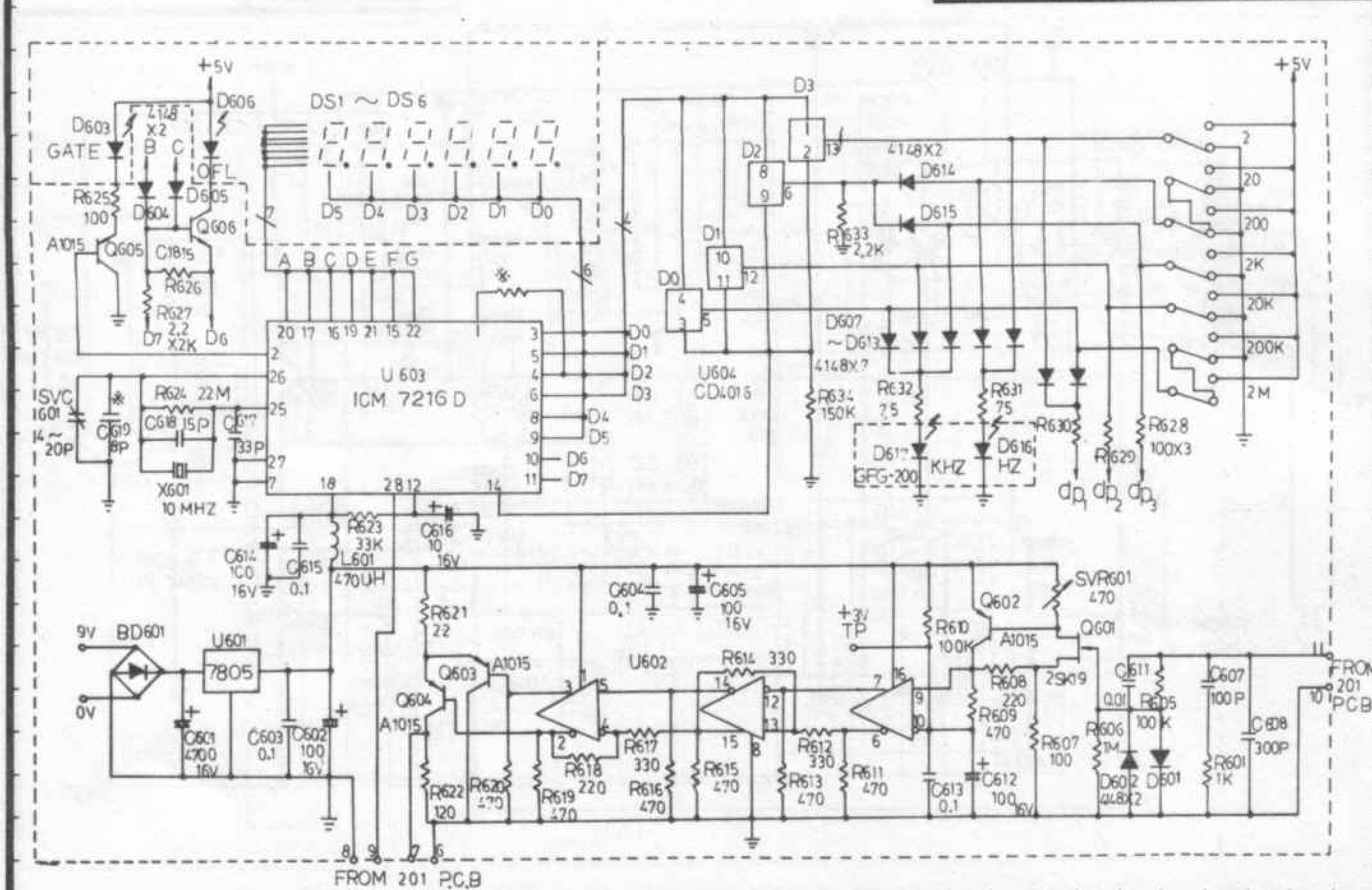

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			DESCRIPTION
			DRAWING NO

TENMA

TEST INSTRUMENTS

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