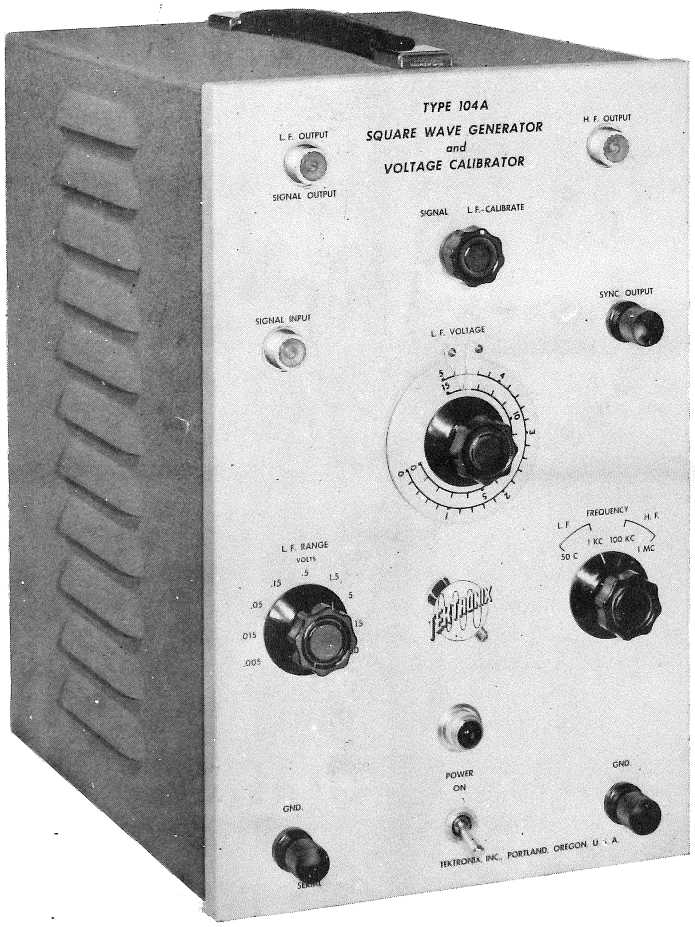
TEKTRONIX

TYPE 104A

Ser. No. 402

SQUARE WAVE GENERATOR AND VOLTAGE CALIBRATOR

INSTRUCTION MANUAL



TEKTRONIX Inc.

Manufacturers of Cathode-Ray and Video Test Instruments

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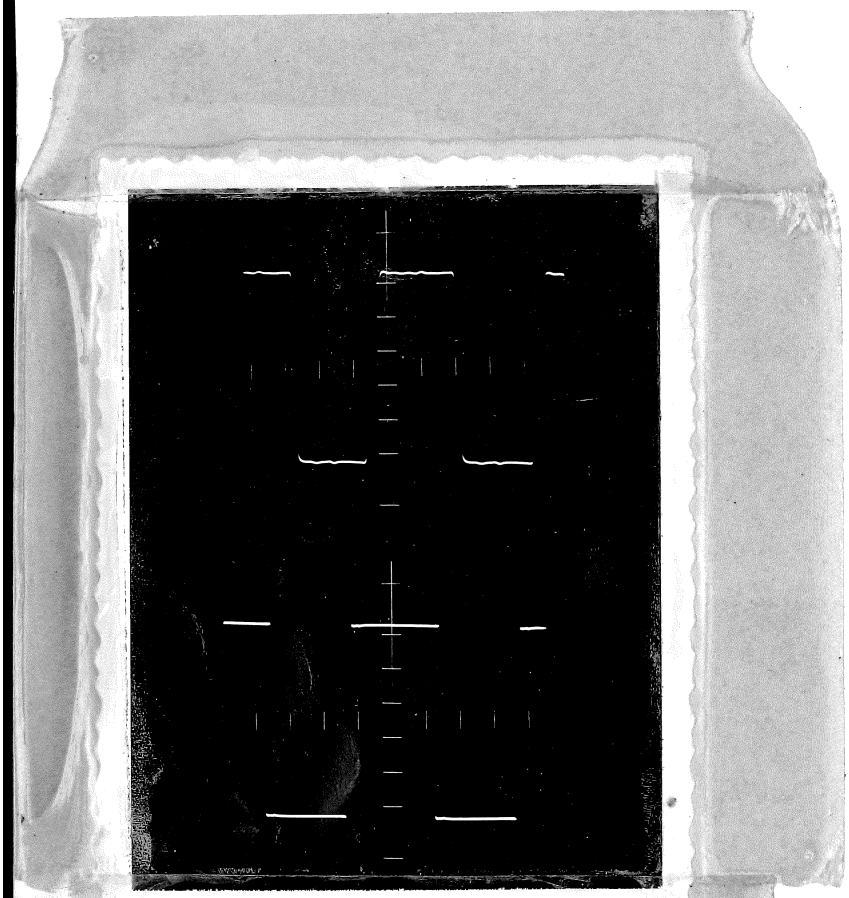
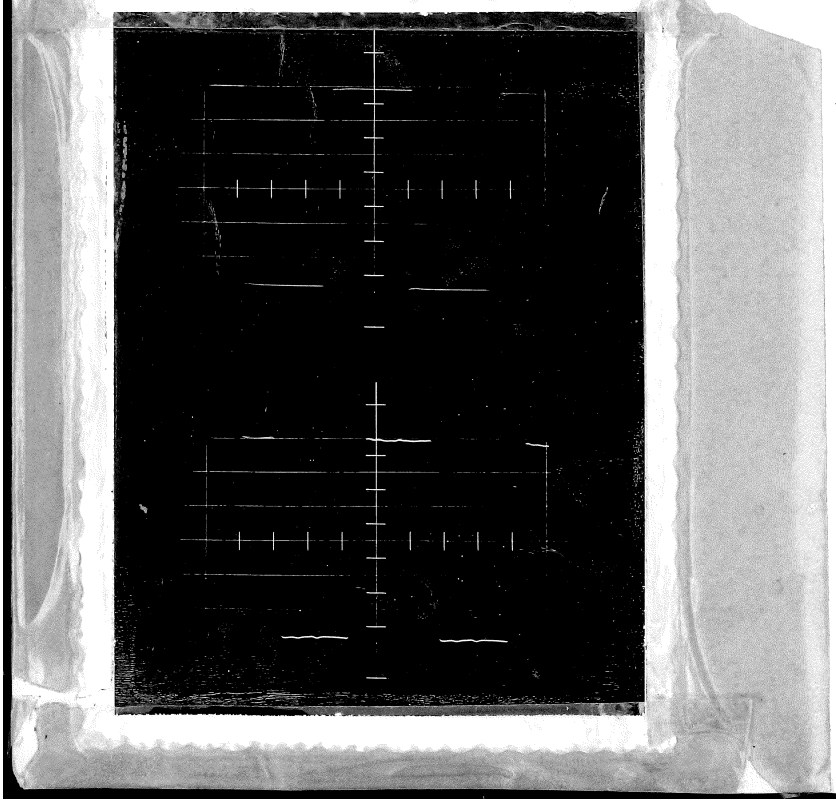


TI 175.3

Viewed on 514
12/3/54

Top Picture 1 mc.
Wave form ~~[redacted]~~ 104
Set for Max
Scope settings .3 to 1
Vert Amp Att full
Counter clockwise
Sweep time .2 μ sec/cm
Bottom picture
100 KC Wave form at
2 μ sec/cm on same Scope



TI 175.1

Viewed on 514 12/3/54
Top picture 100 K C AT 2μ sec/cm
with generator set for MAX OUT.
Scope set for .3 TO 1 V. DEF. SENS.
& VER. ATTN. FULLY C.C.W.

BOTTOM picture ON SAME
Scope. Freq one meg. &
Sweep Time .2 μ sec/CM.

SECTION I

General Description

The TEKTRONIX type 104A Square Wave Generator and Voltage Calibrator is a compact, portable instrument, providing precision square waves at four frequencies. It is well adapted to production testing and general laboratory use.

The two low-frequency outputs, 50-cycle and 1-kc square waves, are well suited for adjustment of low-frequency compensating circuits and r-c attenuators, as well as general audio-frequency work. Since the output amplitude is controlled by an accurate calibrating circuit, a convenient source of known potential is provided. Suitable connectors permit permanent connection to the signal input of an oscilloscope, and a switch enables the operator to compare the signal amplitude with the calibrated square wave without disconnecting the Type 104A.

The two high frequencies, 100-kc and 1-mc square waves, with a rise time of .02 microsecond, available via a terminated coaxial cable, are an excellent signal source for tests of compensating networks. The instrument can be supplied with other frequencies on special factory order.

The Type 104A will be found useful for many other applications involving square wave techniques.

Characteristics

Frequencies

Four fixed; 50 cycles, 1 kc, 100 kc, 1 mc. ± 2%

Rise Time

For 10% to 90% of peak amplitude,
Low Frequencies—less than 3 microseconds.
High Frequencies—.02 microsecond.

Amplitude

Low Frequencies—continuously variable 0 to 50 volts by means of a nine-range switch and calibrated potentiometer. Calibration accuracy within 2% of full scale.

High Frequencies—continuously variable 0 to 5 volts, not calibrated.

Output Impedance (Depending on attenuator setting).

Low Frequencies—0 to 10,000 ohms.
High Frequencies—0 to 93 ohms.

Sync. Output

Approximately 3 volts, all frequencies.

Power Input

105-125 or 210-250 volts 50-60 cycles. 115 watts at 117 or 234 volts.

Functions of Controls and Connections

L.F. OUTPUT, SIGNAL OUTPUT	UHF connector for low-frequency output. Connected to oscilloscope input when Type 104A is used as a voltage calibrator.
H.F. OUTPUT	UHF connector for high-frequency output.
SIGNAL INPUT	UHF connector for connection to circuit under observation when the Type 104A is used as a voltage calibrator for an oscilloscope.
SIGNAL, L.F.-CALIBRATE	Two-position switch. SIGNAL position connects SIGNAL INPUT to L.F. OUTPUT-SIGNAL OUTPUT. L.F.-CALIBRATE position connects arm of L.F. VOLTAGE control to L.F. OUTPUT, SIGNAL OUTPUT.
SYNC. OUTPUT	Binding post which makes available a portion of square wave output signal to synchronize oscilloscope or other equipment.
L.F. RANGE	Low-frequency output attenuator. Rotary switch selecting precision resistors provides 9 low-frequency amplitude ranges in two steps per decade.
L.F. VOLTAGE	Calibrated potentiometer permits continuously variable amplitude adjustment for each step of L.F. RANGE.
FREQUENCY	Four-position switch permits selection of square-wave frequency.
POWER	On-off switch in ac power input circuit.
GND	Binding post connection to chassis.

SECTION II

Operating Instructions

Connect the Type 104A to a 117- or 234-volt, 60-cycle supply, using the cord furnished.

CAUTION: DO NOT OPERATE ON 234-VOLTS BEFORE READING THE ADJUSTMENT AND MAINTENANCE SECTION OF THIS MANUAL.

Low Frequencies

The two lower-frequency squarewave signals are available at the connector marked L.F. OUTPUT, SIGNAL OUTPUT when the SIGNAL, L.F.-CALIBRATE switch is in the L.F.-CALIBRATE position. It is intended that connection be made by means of the supplied binding-post adapter and ordinary single test leads in order to maintain low output capacitance. The use of a coaxial or shielded output cable should be avoided at high output amplitudes, as the output impedance may be as high as 10,000 ohms, and the rise time will be increased because of the added capacitance introduced by the cable. A shielded cable may be employed when the L.F. RANGE switch is set for low output amplitude, provided that the L.F. VOLTAGE control is set at maximum. Under these conditions, the output impedance at the medium and low L.F. RANGE settings is approximately 400 ohms per output volt. In applications such as calibrating, where rise time is not critical, a shielded cable may be used at any output amplitude.

When the Type 104A is used as an oscilloscope accessory to provide accurate calibration of signal amplitude, permanent connection by means of a short length of RG62U 93-ohm cable is recommended. This cable, connected between the Type 104A L.F. OUTPUT, SIGNAL OUTPUT and the oscilloscope signal input, should be as short as practical to keep input capacitance low. An 8-inch cable fitted with UHF connectors for connection to TEKTRONIX Type 511A-AD oscilloscopes, and a special adapter are available. (See Accessory List.) With this method, the equipment under observation is connected to the Type 104A SIGNAL INPUT connector, using a single lead and the binding post adapter, or the r-c probe supplied with the oscilloscope.

NOTE: In case the probe is employed, it will be necessary to readjust the variable capacitor in the probe to compensate for the additional input capacitance introduced by the 104A and the SIGNAL OUTPUT lead. This readjustment may be accomplished by setting the FREQUENCY selector at 1 KC and utilizing the SYNC. OUTPUT signal. With the SIGNAL, L.F.-CALIBRATE switch set at SIGNAL and the L.F. RANGE and L.F. VOLTAGE controls fully counterclockwise (minimum output) clip the probe to the SYNC. OUTPUT binding post. Now adjust the probe capacitor until the squarewave is correctly reproduced.

Waveforms from the equipment under test are observed by setting the SIGNAL, L.F.-CALIBRATE switch in the SIGNAL position. Amplitude of any portion of the observed waveform may be accurately measured by moving this switch to L.F.-CALIBRATE. With the frequency selector at either L.F. position, adjust the L.F. VOLTAGE and L.F. RANGE controls until the extremes of the squarewave signal coincide with the waveform previously observed. The amplitude, in volts peak to peak, may now be read directly from these controls with an accuracy within 2% of full scale. Highest accuracy may be expected with the L.F. VOLTAGE control set near maximum, but in any case excellent accuracy is obtainable because sufficient L.F. RANGE steps are provided to make it unnecessary to operate the L.F. VOLTAGE control below 30% of full scale.

High Frequencies

Because of the much faster rise time required of the two higher-frequency signals, a matched coaxial cable (Tektronix Type P93A) is provided for their output. The cable supplied has a characteristic impedance of 93 ohms and is terminated by a 93-ohm potentiometer, which serves as the high-frequency attenuator, as well as the output load for the 6AG7 output amplifier. The attenuator end of this cable is fitted with a UHF connector which may be attached directly to the signal-input connector of all Tektronix oscilloscopes except the early Type 511 oscilloscopes, which require a Type PL40 adapter (see Accessory List). An adapter is furnished employing two quite short clip leads to permit connection of the Type 104A to equipment not having the proper fittings. In case longer clip leads are required, care should be taken to keep them as short as possible, as additional lead length at this point may introduce serious distortion of the waveform, depending upon the bandwidth of the amplifier being tested.

IMPORTANT NOTE: The output waveform of the Type 104A has an exceptionally short rise time and is capable of "ringing" any l-c-r network having a resonant frequency less than 30 mc. Any spurious oscillations or distorted waveforms observed are probably the result of circuit "ringing" or improper load impedance. These sources should be carefully investigated before abnormal operation of the Type 104A is suspected. If distortion of the waveform within the instrument is suspected, it may be checked by connecting the Type 104A via the terminated output cable, directly to the vertical-deflection plates of an oscilloscope cathode-ray tube. The leads should be as short as possible, preferably less than two inches. Despite these short leads, the series inductance and shunt capacitance of deflection-plate connections within some cathode-ray tubes may cause a noticeable "ringing" effect.

For applications where the best possible waveform is required, further attention must be given to the H.F. termination. The variable H.F. attenuator supplied with the Type 104A should not be operated at less than 10% of full amplitude when waveform accuracy is important. Reflections due to reactive components of the load impedance, especially when increased length of output cable is employed, may be minimized by inserting an additional terminating resistor at the input end of the output cable. This additional load will reduce the maximum output voltage to one-half its former value. For applications where a low-level signal is required, symmetrical T-pad attenuators are available (see Accessory List). These may be used singly or in cascade to reduce the output to the desired level. When a T-pad attenuator is employed, it is also necessary to terminate the cable with an L-pad or terminating resistor. When impedance matching is unnecessary, it is advisable to use an L-pad to terminate the output cable. This method is preferable because it provides lower output impedance, and therefore reduces the distortion introduced by reactive load components. L-pads with attenuation ratios of 5:1 and 10:1 are available.

An increase in load resistance will provide increased output amplitude, but at the expense of increased rise time. If the high-frequency output cable is removed and a single lead substituted, an output of approximately 125 volts having a rise time of 0.25 microseconds is available. Since the output amplitude will vary in direct proportion to the effective load resistance from zero, for zero resistance, up to 125 volts for an infinite external resistance, the optimum compromise between output amplitude and rapid rise time may be selected for any given application by choice of the proper external load resistance.

SECTION III

Circuit Description

High-Frequency Circuits

The high-frequency squarewaves are generated by a multivibrator using two 6AG7 tubes, V1 and V2. Variable capacitors C1 and C2 permit balancing the duration of the positive and negative portions of the output. Frequency in the 1 MC position of the FREQUENCY switch is set by varying potentiometer R4. Potentiometer R13, sets the frequency in the 100-kc position.

The multivibrator output is taken from the cathode of V2 and applied to the grid of the 6AG7 limiter, V3, via a parastic suppressor, R14. The signal at this point is a squarewave with a "spike" on the top of its leading edge. Its amplitude is sufficient to reduce the plate current of V3 to cutoff well before maximum negative grid swing is reached, thus producing a waveform at the plate with the same duration but amplified, inverted and flat topped.

This signal is impressed on the grid of the 6AG7 output amplifier V4, and appears at the plate as a clean squarewave, the top being at plate-current cutoff, and the bottom an inverted replica of the flat top of the grid waveform.

A potentiometer shunted to 93 ohms, R25, is used as output load resistor and attenuator.

Short rise time is obtained by the use of small load resistors, thus requiring relatively large plate currents in all the 6AG7 tubes. Shunt compensation by means of L1 permits a sufficiently large load resistor to be used in the plate of V3 so that enough output is available to swing the grid of V4 from full conduction to cutoff.

To provide a synchronizing signal, a portion of the high-frequency output is fed to one grid of the 6J6 cathode follower, V5. This circuit isolates the SYNC. OUTPUT connection.

Low-Frequency Circuits

The low frequencies are generated by a separate multivibrator using a type 12AU7 tube, V6. In the 1-kc position, frequency is set by varying potentiometer R29.

R28 and R33, in conjunction with poteniometer R32, set the 50-cycle frequency. Compromise balance between 1-kc and 50-cycle operation is obtained by proper choice of R30 and R31.

The multivibrator output is fed to the grid of the output cathode follower, one section of V7 (12AU7), via C12 and R37. A divider, R35 and R36, maintains the signal at proper operating level for the diode-connected limiter section of V7. Maximum positive amplitude is determined by the divider R38, R39 and R40. The variable section, R39, labeled L.F. ADJ., permits accurate adjustment to the specified 50 volts. The output is square, as the top is limited by the diode, and the bottom limited at ground by current cutoff in the cathode follower.

Accurate control of the output amplitude is provided by the L.F. RANGE control, R43-R51, a nine-step attenuator, having two ranges per decade. The L.F. VOLTAGE control, R52, permits continuously variable adjustment for each step.

The SIGNAL, L.F.-CALIBRATE switch, SW3, in conjunction with the SIGNAL INPUT connector, facilitates use of the Type 104A as an oscilloscope amplitude calibrator, by feeding either the signal or the squarewave calibrating voltage to the oscilloscope input, without the necessity of removing the connection to the signal source.

A synchronizing trigger signal is obtained from the divider R41 and R42 and applied to the cathode follower, V5.

Power Supply

Rectified current for the 200-volt supply is provided by V8, a 5V4G.

An electronic regulator is employed to reduce the effects of load changes and line-voltage fluctuations over the range of 105 to 125 volts. This circuit reduces 120-cycle ripple to below .1 volt.

The cathode of the 6AU6 amplifier, V10, is maintained at a fixed voltage by the OC3/VR105 reference tube, V11. Any fluctuations in the 200-volt supply are impressed on the grid of V10, amplified, and applied to the grid of the 6AU5 series regulator, V9. This varies the plate-to-cathode voltage drop across V9, which opposes the output-voltage fluctuation, thus stabilizing the 200-volt supply.

Additional current required for high-frequency operation is supplied by a shunt resistor, R58.

High-Frequency Compensation

L1 is factory adjusted for best waveform and should not require resetting. Adjustment in the field is not recommended, as oscilloscopes with sufficiently good transient response are not generally available.

Operation on 234-Volt 60-Cycle Line

The Type 104A power transformer is wound with two 117-volt primaries. These windings are ordinarily connected in parallel at the factory for 117-volt operation. If 234-volt operation is desired, remove the jumpers connecting terminals 1 to 2 and 3 to 4. Connect terminal 2 directly to terminal 3. With the line still connected to terminals 1 and 4, the instrument is now ready for 234-volt operation.

SECTION IV

Adjustment and Maintenance

Replacement of Components

Most of the components used in the construction of TEKTRONIX instruments are standard parts obtainable from any well-equipped parts distributor. Some of the components carrying 1% and 2% tolerances may not be so readily obtainable but may be purchased from the manufacturer at these tolerances. The remainder of the low-tolerance components are standard 10%- and 20%-tolerance parts that are checked at the factory for proper value or performance. Replacement parts are available on order from the factory at current net prices but in the case of standard parts it is probably more economical of time to purchase them locally. It is not feasible to attempt to check out low-tolerance parts or matched pairs without a reasonably large stock to choose from as the rejection percentage is quite high in most cases.

A TEKTRONIX instruction manual will usually contain hand-made changes of diagrams, parts lists, and text, appropriate only to the instrument it was prepared for. There are good reasons why this is true.

First, TEKTRONIX engineers are continually working to improve TEKTRONIX instruments. When the improved circuitry is developed or when better components become available, they are put into TEKTRONIX instruments as soon as possible. As a result of constant improvement TEKTRONIX instruments are always built as good as we can build them, but the changes caused by these improvements must frequently be entered by hand into the manual.

Second, when TEKTRONIX instruments go through our exhaustive test procedure, TEKTRONIX technicians adjust them individually to obtain optimum operation. This kind of hand tailoring occasionally requires substitution of components differing from the nominal values printed in the manual.

Third, because of procurement difficulties, equivalent but different parts are sometimes used. Usually such parts are directly interchangeable with those originally specified. No alternate parts have been used which have adversely affected the instrument, and you were able to receive your instrument much earlier than you might have otherwise.

To assure that you will receive the correct replacement parts with the minimum of delay it is therefore important that you include the instrument serial number with your order, along with the instrument type and part numbers, of course. And as a further precaution, get ordering information from the instruction manual whose serial number agrees with the instrument.

Equivalent parts, supplied by the factory when the exact replacement parts ordered are not available, will be accompanied by an explanation and will be directly interchangeable in most cases.

200-Volt Regulated Supply

Connect an accurate voltmeter to the cathode (pin 3) of V9, (6AU5), and adjust potentiometer R61 for 200 volts. This reading should remain nearly constant for line voltages of 105 to 125.

Low-Frequency Amplitude

It is necessary that the maximum low-frequency amplitude be accurately set to 50 volts peak to peak in order to maintain the calibration of the L.F. RANGE and L.F. VOLTAGE controls. This may be conveniently done by a comparison between the low-frequency output and a known dc voltage, by connecting them alternately to a cathode-ray tube or direct-coupled oscilloscope. A suggested dc source is a 45-volt B battery, measured with an accurate voltmeter. As an example, assume the meter indicates 47 volts. Set the L.F. controls to an indicated 47 volts, and connect the L.F. OUTPUT to the direct-coupled oscilloscope input (or directly to crt deflection plates). Connect the battery (with voltmeter connected) to the 104A SIGNAL INPUT. Comparison may now be made by switching the SIGNAL, L.F.-CALIBRATE switch. If the amplitudes do not agree, adjust R39, labeled L.F.ADJ., until equal amplitudes are observed.

CAUTION — THE CRT DEFLECTION SHOULD BE SUFFICIENTLY LARGE FOR AN ACCURATE COMPARISON.

Frequency

Adjustment of frequency is accomplished by observing the output waveform of the Type 104A on an accurately calibrated oscilloscope, such as the Tektronix Type 511-A, Type 513, or Type 514, and adjusting R4, R13, R29 and R32 until proper frequencies are indicated on the oscilloscope. As this adjustment does not affect rise time, it is not critical for most squarewave applications. If the range of high-frequency adjustment is not adequate, it may be changed by varying C1 and C2.

High-Frequency Balance

Set the frequency selector at 1 MC and adjust C1 and C2 until the positive and negative portions of the output observed on the oscilloscope are equal in duration. A setting between ⅔ and maximum capacitance is recommended. Replace V1 and V2 if balance cannot be obtained within this range. The balance at 100 kc should now be substantially correct. A compromise setting of C1 and C2 for 1 mc and 100 kc may be desirable.

IMPORTANT

Include INSTRUMENT TYPE and SERIAL NUMBER in all correspondence regarding any Tektronix instrument. The serial number stamped in the instruction manual must match the instrument serial number if parts are to be ordered from the manual. Observance of the above precautions will assure your receipt of the correct replacement parts with a minimum of delay.

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WARRANTY

This instrument is guaranteed to the original user to be free from defects in material and workmanship for a period of one year from date of purchase. Our responsibility under this warranty is limited to the repair or replacement of the instrument, or any part thereof, failure of which is not due to abuse.

For service under this warranty, promptly advise the factory of all details pertinent to the failure. Replacement parts will be shipped, via air transportation upon request, prepaid to any point within the continental United States or Canada. Should it be more convenient to ship the entire instrument, transportation prepaid, to the factory, it will be serviced as required, at no charge and returned via surface transportation.

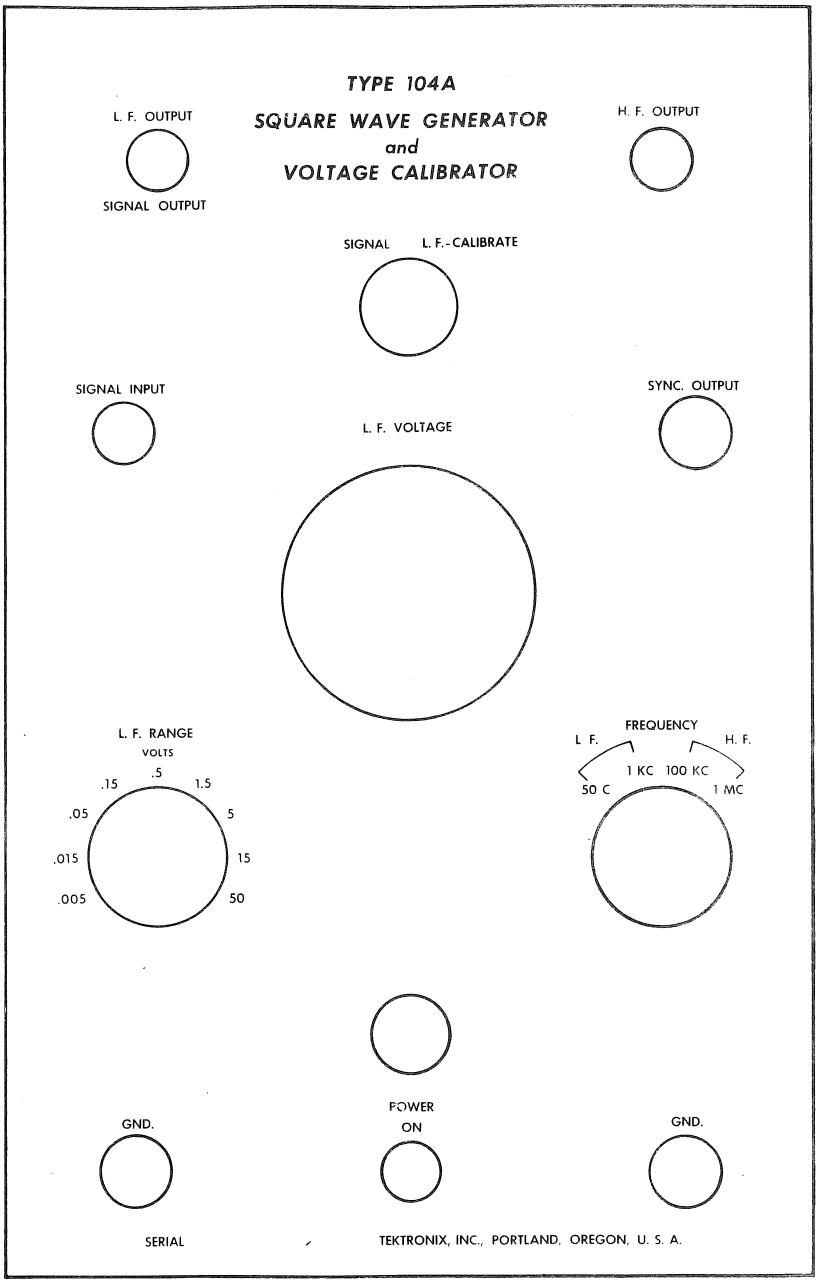
Replacement parts ordered after termination of warranty will be billed at current net prices and shipped via air prepaid to any point within the continental United States or Canada.

TYPE 104A SQUARE WAVE GENERATOR AND VOLTAGE CALIBRATOR

INSTRUCTION MANUAL

SECTION VI

DIAGRAMS



Section VI Fig. 1

NOTES

STANDARD TERMINATION ACCESSORIES

(Equipped with UHF Connectors)

ITEM	ATTEN. RATIO	IMPEDANCE	PRICE
B52R Resistor		52 Ω	8.50
B52L5 L Pad	5:1	52 Ω	8.50
B52L10 L Pad	10:1	52 Ω	8.50
B52T10 Symmetrical T Pad	10:1	52 Ω	11.50
B93R Resistor		93 Ω	8.50
B93L5 L Pad	5:1	93 Ω	8.50
B93L10 L Pad	10:1	93 Ω	8.50
B93T10 Symmetrical T Pad	10:1	93 Ω	11.50
B93-50L Minimum loss L Pad		input 93 Ω/output 50 Ω	11.50
P50 42" Coaxial Cable		50 Ω	4.00
P93 42" Coaxial Cable		93 Ω	4.00
P93A H. F. Output Cable and Attenuator		93 Ω	13.50
A100 Clip Lead Adapter			2.50
A510 Binding Post Adapter			1.88
PL40 Input Adapter for Type 511 Oscilloscope			2.80

PARTS LIST

ABBREVIATIONS

Cer.	Ceramic	μ	Micro or $x10^{-6}$
Comp.	Composition	p	Pico or $x10^{-12}$
Dep. Carb.	Deposited Carbon	PBT	Paper, Bath Tub
EMC	Electrolytic, Metal Cased	PMC	Paper, Metal Cased
f	Farads	Prec.	Precision
GMV	Guaranteed Minimum Value	PTM	Paper, Tubular Molded
H	Henries	Var.	Variable
K	Kilo or $x10^{3}$	WW	Wire Wound
M	Meg or $x10^{6}$		

CAPACITORS

C1	7-45 $\mu\mu$f	Cer	Var	500 WVDC	
C1.1	47 $\mu\mu$f	Cer.	Fixed	500 WVDC	20%
C2	7-45 $\mu\mu$f	Cer.	Var.	500 WVDC	
C2.1	47 $\mu\mu$f	Cer.	Fixed	500 WVDC	20%
C3	20 μf (1/2 2x20)	EMC	Fixed	450 WVDC	-20%+50%
C4	20 μf (1/2 2x20)	EMC	Fixed	450 WVDC	-20%+50%
C5	.01 μf	PT	Fixed	400 WVDC	20%
C6	.01 μf	PT	Fixed	400 WVDC	20%
C7	.01 μf	PT	Fixed	400 WVDC	20%
C8	.5 μf	PT	Fixed	400 WVDC	20%
C9	.1 μf	PT	Fixed	400 WVDC	20%
C10	.001 μf	PT	Fixed	600 WVDC	10% Paired
C11	.001 μf	PT	Fixed	600 WVDC	10% within 5%
C12	.1 μf	PT	Fixed	400 WVDC	20%
C13	6.25 μf	ET	Fixed	300 WVDC	-20%+50%
C14	40 μf (2x20)	EMC	Fixed	450 WVDC	-20%+50%
C15	.01 μf	PT	Fixed	400 WVDC	20%
C16	.01 μf	PT	Fixed	400 WVDC	20%

INDUCTORS

L1	Var.	.38 - .7 μh	CV381

RESISTORS

R1	680 Ω	2 watt	Fixed	Comp.	10%	
R2	680 Ω	2 watt	Fixed	Comp.	10%	
R3	330 Ω	1 watt	Fixed	Comp.	10%	
R4	50 k	2 watt	Var.	Comp.	10%	1 MC
R5	330 k	1/2 watt	Fixed	Comp.	10%	
R6	22 k	1/2 watt	Fixed	Comp.	10%	
R7	10 k	2 watt	Fixed	Comp.	10%	
R8	22 k	1/2 watt	Fixed	Comp.	10%	
R9	330 k	1/2 watt	Fixed	Comp.	10%	
R10	680 Ω	2 watt	Fixed	Comp.	10%	
R11	680 Ω	2 watt	Fixed	Comp.	10%	
R12	330 Ω	1 watt	Fixed	Comp.	10%	
R13	50 k	2 watt	Var.	Comp.	20%	100 KC
R14	47 Ω	1/2 watt	Fixed	Comp.	10%	
R15	27 k	2 watt	Fixed	Comp.	10%	
R16	220 Ω	1/2 watt	Fixed	Comp.	10%	
R17	330 Ω	1 watt	Fixed	Comp.	10%	
R18	15 k	2 watt	Fixed	Comp.	10%	
R19	22 meg	1/2 watt	Fixed	Comp.	10%	
R20	470 k	1/2 watt	Fixed	Comp.	10%	
R21	1 meg	1/2 watt	Fixed	Comp.	10%	
R22	2 k	10 watt	Fixed	WW	10%	
R23	470 Ω	2 watt	Fixed	Comp.	10%	
R24	4.7 k	2 watt	Fixed	Comp.	10%	
R25	93 Ω*	1/2 watt	Var.	Comp.	3%	H. F. Atten.
R26	100 k	1 watt	Fixed	Comp.	10%	
R27	470 k	1/2 watt	Fixed	Comp.	10%	
R28	5.6 meg	1/2 watt	Fixed	Comp.	10%	
R29	50 k	2 watt	Var.	Comp.	20%	1 KC
R30	330 k	1/2 watt	Fixed	Comp.	10%	
R31	220 k	1/2 watt	Fixed	Comp.	10%	
R32	50 k	2 watt	Var.	Comp.	20%	50~
R33	4.7 meg	1/2 watt	Fixed	Comp.	10%	
R34	22 k	2 watt	Fixed	Comp.	10%	
R35	1.5 meg	1/2 watt	Fixed	Comp.	10%	

*Including shunt.

R36	2.2 meg	1 watt	Fixed	Comp.	10%	
R37	220 k	1/2 watt	Fixed	Comp.	10%	
R38	33 k	1/2 watt	Fixed	Comp.	10%	
R39	20 k	1 watt	Var.	WW	20%	L. F. ADJ.
R40	120 k	1 watt	Fixed	Comp.	10%	
R41	100 k	1/2 watt	Fixed	Comp.	10%	
R42	18 k	1/2 watt	Fixed	Comp.	10%	
R43	13.23 k	1/2 watt	Fixed	Prec.	1%	
R44	5.25 k	1/2 watt	Fixed	Prec.	1%	
R45	1582 Ω	1/2 watt	Fixed	Prec.	1%	
R46	416 Ω	1/2 watt	Fixed	Prec.	1%	
R47	142 Ω	1/2 watt	Fixed	Prec.	1%	
R48	40 Ω	1/2 watt	Fixed	Prec.	1%	
R49	14 Ω	1/2 watt	Fixed	Prec.	1%	
R50	4 Ω	1/2 watt	Fixed	Prec.	1%	
R51	2 Ω	1/2 watt	Fixed	Prec.	1%	
R52	20 k	1 watt	Var.	Comp.	2%	L. F. Voltage
R53	2.2 k	1 watt	Fixed	Comp.	10%	
R54	47 Ω	1/2 watt	Fixed	Comp.	10%	
R55	1 meg	1/2 watt	Fixed	Comp.	10%	
R56	6.8 k	1 watt	Fixed	Comp.	10%	
R57	6.8 k	1 watt	Fixed	Comp.	10%	
R58	1.5 k	25 watt	Fixed	WW	20%	
R59	220 k	1/2 watt	Fixed	Comp.	10%	
R60	680 k	1/2 watt	Fixed	Comp.	10%	
R61	500 k	1 watt	Var.	Comp.	20%	Adj. to 200 V
R62	680 k	1/2 watt	Fixed	Comp.	10%	

SWITCHES

SW1	SPST		Toggle	POWER ON	SWT1-1
SW2	3 Section	4 Position	Rotary	FREQUENCY	SWR3-4
SW3	2 Section	2 Position	Rotary	SIGNAL -L. F. CALIBRATE	SWR2-2
SW4	1 Section	7 Position	Rotary	L. F. RANGE	SWR1-7

TRANSFORMER

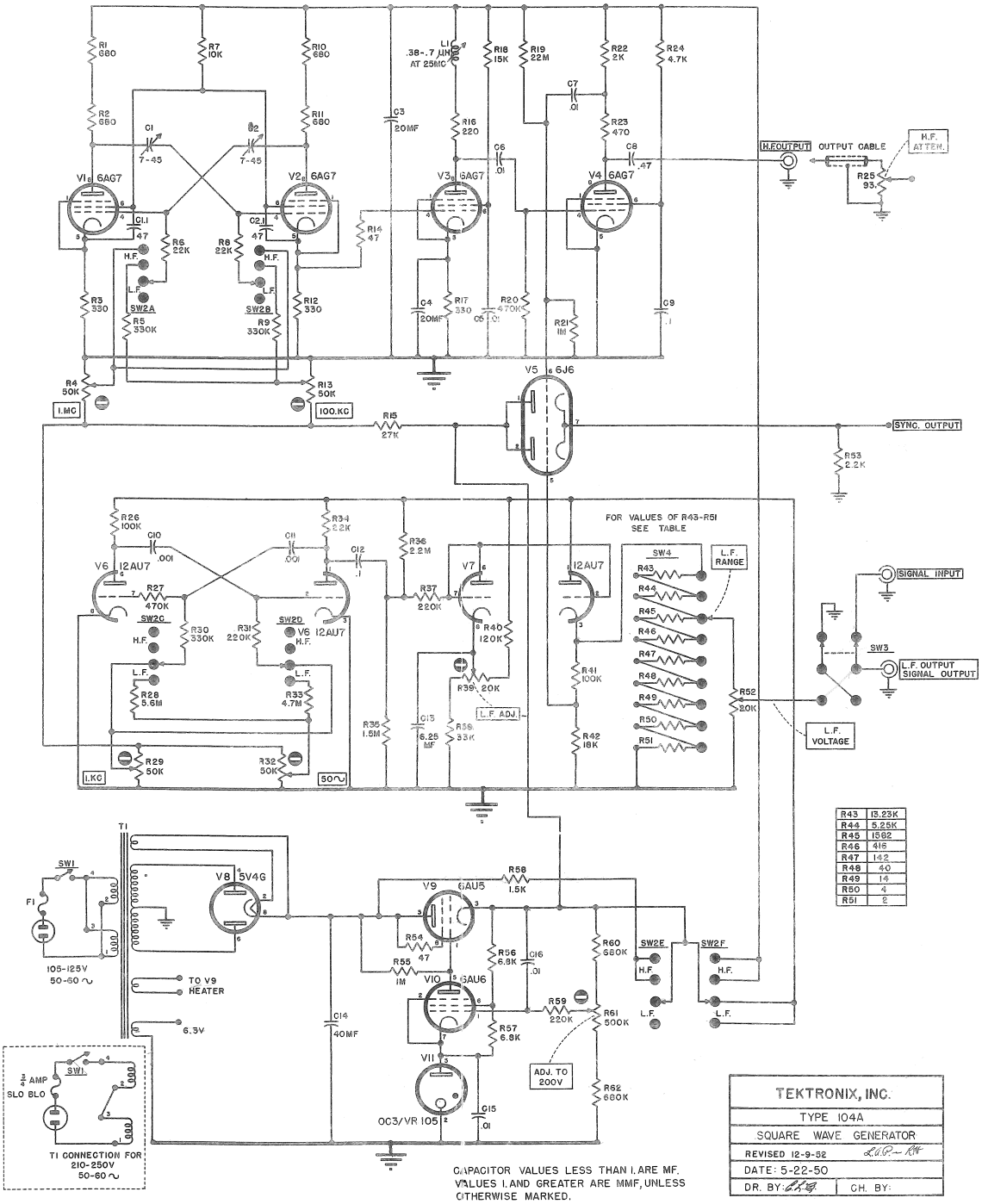
T1	Primary	117-234 volt, 50-60 cycle, 115 watts
	Secondary	275-0-275 volts, 135 ma. 5 volts, 3A, insulated for 350 volts 6.3 volts, 1.25 A, insulated for 200 volts 6.3 volts, 4 A.

VACUUM TUBE COMPLEMENT

V1	6AG7	Multivibrator, H. F.
V2	6AG7	Multivibrator, H. F.
V3	6AG7	Limiter, H. F.
V4	6AG7	Output Amplifier, H. F.
V5	6J6	Sync. Out. Cathode Follower
V6	12AU7	Multivibrator, L. F.
V7	12AU7	Limiter and Output Cathode Follower, L. F.
V8	5V4G	Power Supply Regulator
V9	6AU5	Series Regulator
V10	6AU5	Regulator Amplifier
V11	OC3/VR105	Voltage Reference

MISCELLANEOUS

F1	4AG	1 1/2 Amp.	Slo-Blo Fuse


R1 680
R7 10K
R10 680
L1 .38-.7 μH AT 25MC
R18 15K
R19 22M
R22 2K
R24 4.7K
C7 .01
R2 680
R11 680
C3 20MF
R16 220
R23 470
C1 7-45
C2 7-45
C6 .01
C8 .47
H.F.OUTPUT
OUTPUT CABLE
H.F. ATTEN.
R25 93.
V1 6AG7
V2 6AG7
V3 6AG7
V4 6AG7
C1.1 47
C2.1 47
R14 47
R6 22K
R8 22K
H.F.
L.F.
SW2A
SW2B
R5 330K
R9 330K
R3 330
R12 330
C4 20MF
R17 330
C5 .01
R20 470K
R21 1M
C9 .1
R4 50K
R13 50K
1.MC
100.KC
V5 6J6
R15 27K
SYNC. OUTPUT
R53 2.2K
FOR VALUES OF R43-R51 SEE TABLE
R26 100K
C10 .001
C11 .001
R34 2.2K
C12 .1
R36 2.2M
V6 12AU7
R27 470K
V7
R37 220K
12AU7
SW4
L.F. RANGE
SW2C
SW2D
V6 H.F.
R30 330K
R31 220K
R40 120K
R43
R44
R45
R46
R47
R48
R49
R50
R51
SIGNAL INPUT
SW3
L.F. OUTPUT SIGNAL OUTPUT
R28 5.6M
R33 4.7M
R39 20K
L.F. ADJ.
R41 100K
R52 20K
L.F. VOLTAGE
R35 1.5M
C13 6.25 MF
R38 33K
R42 18K
R29 50K
R32 50K
1.KC
50~
T1
SW1
F1
V8 5V4G
V9 6AU5
R58 1.5K
105-125V 50-60~
TO V9 HEATER
6.3V
R54 47
R55 1M
V10 6AU6
R56 6.8K
C16 .01
R60 680K
SW2E
SW2F
H.F.
L.F.
R59 220K
R61 500K
R57 6.8K
C14 40MF
V11
ADJ. TO 200V
R62 680K
4/10 AMP SLO BLO
T1 CONNECTION FOR 210-250V 50-60~
003/VR 105
C15 .01
R43 13.23K
R44 5.25K
R45 1582
R46 416
R47 142
R48 40
R49 14
R50 4
R51 2
CAPACITOR VALUES LESS THAN 1. ARE MF. VALUES 1. AND GREATER ARE MMF, UNLESS OTHERWISE MARKED.
TEKTRONIX, INC.
TYPE 104A
SQUARE WAVE GENERATOR
REVISED 12-9-52
DATE: 5-22-50
DR. BY:
CH. BY:

Form TEK 196

CALIBRATION RECORD

Tektronix Type 104A — Serial No. 402

1. ✓ Connect H.F. output cable.
2. ✓ Adjust 200v. ✓ regulation. ✓ ✓ OK
3. 112 Watts. Power consumption at 1 MC. ✓
4. 66 Watts. Power consumption at 1 KC. ✓
5. ✓ Adjust 100 KC and 1 MC ✓ balance.
6. ✓ Check cable attenuator.
7. 6.5 Volts. Output thru cable.
8. 4.2 Volts. H.F. sync output.
9. ✓ 50 cycle timing ✓ balance.
10. ✓ 1 KC timing ✓ balance.
11. ✓ Zero set CAL. dial.
12. ✓ Adjust 50v.
13. ✓ Check L.F. range steps and ✓ CAL. dial linearity.
14. 6 Volts. L.F. sync output.
15. ✓ Adjust H.F. compensation.

By P. W. Jones
Test-Calibration Dept.

Date 12-29-53