MODEL 589E
CURVE TRACER

OPERATION MANUAL

KIKUSUI ELECTRONICS CORP.

CONTENTS

1. INTRODUCTION

MODEL 589E CURVE TRACER is comprised of three units, TEST VOLT SOURCE UNIT, OSCILLOSCOPE and GATE POWER SUPPLY, which are accommodated in a case. The TEST VOLTS SOURCE UNIT is for generating half-wave or sine wave of 0 ~ 30V (10A peak), 0 ~ 300V (1A peak) and 0 ~ 3kV (0.1A peak).

The OSCILLOSCOPE can perform wide range measurement with a voltage axis range of 0.1V/DIV ~ 500V/DIV and a current axis range 0.01mA/DIV ~ 1A/DIV. The GATE POWER SUPPLY provided with a DC and a step (voltage and current) source can afford to measure the static characteristics of semiconductors with three terminals such as transistors, silicon controlled rectifiers (SCR) bi-directional triode thyristors and the like as well as the semiconductors with two terminals such as diodes.

Furthermore, a peak voltage indicator of test volts, a over current protective relay, etc. are provided so that the characteristic tests of semiconductors can be performed safly and rapidly.

2. SPECIFICATIONS

Power Source	_____V, 50/60Hz	about 150VA
	(in case of the peak load of 3kV, 0.1A and full load of GATE)	about 330VA
Dimensions (max.)	510(540)W x 710(725)H x 457(505)Dmm	
Weight		about 70kg
Accessories Supplies	Operation manual	1
	Test data	1
	Connector for remote control	1
Scale	10DIV x 10DIV, 8mm/DIV. Illuminated by white or red light.	
Cathode Ray Tube	5 UP 1 F Acceleration voltage	about 1400V
Internal Test Volts Source	Line frequency, half-wave and sine wave.	
Range (three ranges)	0 - 30V peak, max. 10A peak ..... low voltage	
	0 - 300V peak, max. 1A peak ..... high voltage	
	0 - 3kV peak, max. 0.1A peak. ..... high voltage	
Function (three ranges)	FORWARD Half-wave $T_2(+)$, $T_1(-)$	
	REVERSE Half-wave $T_2(-)$, $T_1(+)$	
	SINE Sine wave	
Over current protective relay	Operates in 6-8DIV from the center of graticule upwards or downwards interlocking current axis sensitivity.	
TEST CIRCUIT FUSE	Fast blow FUSE 0.1A (only for the range of 0 - 3kV)	

Peak Voltage Meter — Peak value indicator type, (with 1 and 3 steps interlocked with the range)

MF -28	Class 2.5
Accuracy	5% of the full scale in half-wave of sine wave

Dissipation Limiting Resistor

for high voltage (6 ranges)	0/10k/30k/100k/300k/1 MΩ
for low voltage (6 ranges)	0/ 1 / 3 / 10 / 30 / 100Ω

Parallel Capacity Compensation

Range for low voltage max. approx. 5000pF

Range for high voltage max. approx. 200pF

Gate Power Supply

DC Power Supply

Output voltage 0 ~ 30V continuously variable

Output current max. 0.5A

Output voltage meter (4 ranges)

1/3/10/30 V

MF-28 class 2.5

Output current meter (4 ranges)

10/50/100/500mA

MF-28 class 2.5

Series Resistor (4 ranges)

0 ~ 50, 50 ~ 100, 100 ~ 150,

150 ~ 200Ω continuously variable

Step Generator	Step	Voltage or current step of 4 ~ 12 50 or 100 STEPS/SEC and single family.
		(60 or 120 STEPS/SEC in case of 60 Hz)
	Current step	1 μA/STEP ~ 200mA/STEP 17 ranges
	Voltage step	0.01V/STEP ~ 0.2V/STEP 5 ranges.
	Series resistor	1 Ω ~ 22kΩ 24 ranges
Gate Selector		DC (+,-), OFF, STEP (+, -) the polarity is indicated in regard to T_1.
Voltage axis (Horizontal) Sensitivity		For low voltage 6 ranges Accuracy of 3% 0.1/0.2/0.5/ 1/ 2/ 5V/ DIV
		For high voltage 6 ranges Accuracy of 3% 10/20/50/100/200/500V/DIV
Current axis (Vertical) Sensitivity		16 ranges Accuracy of 3% 10/20..... 200/500 μA/ 1 ....500/1000 mA/DIV
Calibration Voltage (Amplifier Sensitivity)	Voltage axis	1Vp-p square-wave/10DIV
	*Current axis	0.5Vp-p square-wave/10DIV

3. COMPOSITION

MODEL 589E CURVE TRACER is composed of the following three units which are accommodated in a case, each of which can be removed individually.

1. SPEC 60081 OSCILLOSCOPE

This oscilloscope has the deflection sensitivity of 100mV/DIV on the horizontal (voltage) axis and of 50 mV/DIV on the vertical (current) axis.

The sensiticity calibration can easily be performed by the calibration voltage included. The voltage divider and change-over switch for current detection resistors are provided for each amplifier input.

2. SPEC 60101 TEST VOLTS SOURCE UNIT

This unit generates test voltage which is impressed to the samples.

The polarity and range of voltage can be selected and the change-over of dissipation limiting resistors can be performed by the knob on the front panel.

3. SPEC 60091 GATE POWER SUPPLY

This is the power source for the gate of samples (Thyristor, Triac and the like) which is composed of a DC stabilized voltage source and step generator and can be used by changing-over.

This also can be utilized for characteristic observation of transistors as a power source for the Bases.

4. EXPLANATIONS OF PANEL

(SPEC 60081 OSCILLOSCOPE)

INTENSITY — This knob is for the brightness control of CRT. Turning it clockwise increases brightness.

FOCUS — This knob is for focus adjustment of CRT. Adjust it to obtain sharp bright lines.

ASTIG — This is the knob for adjusting ASTIGMATISM of CRT. Adjust it together with the focus knob to obtain the sharpest traces.

SCALE ILLUM — Knob for adjustment of illumination lamps that illuminates the scale of the graticule. Turning it clockwise increases illumination. If the scale is removed for turning it over, illumination can be changed from white to red.

POSITION — These knobs are for adjusting the trace line location on CRT. The left-hand knob is for vertical adjustment and the right-hand knob is for horizontal adjustment. When turned clockwise, the trace line moves upward and to the right respectively corresponding to the clockwise movement of each knob.

VERTICAL — This knob is for changing-over the sensitivity of the vertical (current) axis. Each figure on it indicates the current value (PEAK) which corresponds

to one division on the vertical direction of the scale.

HORIZONTAL — This knob is for change-over of the sensitivity of the horizontal (voltage) axis.

Figures on it indicate voltage value (PEAK) corresponding to one division in the horizontal direction of the scale.

When the knob of TEST VOLTS RANGE in TEST VOLTS SOURCE UNIT is set to LOW VOLTAGE (30V), the outside figure is read out, while it is set to HIGH VOLTAGE (300V or 3kV), the inside figure is read out.

INPUT A. B — These are the input terminals to amplifiers.

The terminals on the left side of CRT is for the vertical (current) axis and that on the right side of CRT is for the horizontal (voltage) axis.

The former is connected with CURRENT SAMPLING OUTPUT terminals A. B of TEST VOLTS SOURCE UNIT with the attached cords while the latter is connected with VOLTAGE SAMPLING OUTPUT terminals A. B in the same manner.

10 DIV CALIBRATION

Two sets are provided, one set is on the right side and the other is on the left side. These

are for selfcalibration of the sensitivity of vertical and horizontal amplifiers.

By pressing the pushbutton (PUSH TO CAL) the vertical trace line (upwards from the origin) or the horizontal trace line (on the right side of the origin) is seen on the fluorescent screen of CRT. Then, adjust the semi-fixed resistor of GAIN ADJ by turning it with a screw driver so that the trace line has a length of 10 divisions, and optimum calibration of the amplifier sensitivity (as well as both of the horizontal and vertical axis) is obtained. This adjustment may be performed without regard to the position of range switches for VERTICAL, HORIZONTAL and also during the measurement of characteristic of the sample.

If the pushbutton is turned clockwise keeping it pressed, it is locked. If the switches for the vertical and horizontal axis are pressed simultaneously, a trace line inclined about 45° is appears on the screen.

(SPEC 60101 TEST VOLTS SOURCE UNIT)

FUNCTION — Knob for selecting the waveform of test voltage.

The following three kinds of function knob are provided.

FORWARD — Waveform of half-wave rectification.

Test terminal T_2 is positive to T_1.

REVERSE — Waveform of half-wave rectification

Test terminal T_2 is negative to T_1

SINE — Sine wave.

TEST VOLTS — Knob for varying test voltage continuously.

It is necessary that the operator operating this curve tracer makes it a habit to turn this knob to zero position except when the actual test is being performed. It is also necessary to avoid all undue shock and vibration on the unit.

The variable range of voltage is from nearly zero to the maximum voltage which is indicated by the TEST VOLTAGE RANGE.

However, the sufficient range is given with due regard to the voltage drop in the source and by the load current.

TEST VOLTS RANGE

Range switch for the test voltage.

It has three ranges, LOW VOLTAGE 0 - 30V,

HIGH VOLTAGE 0 - 300V and 0 - 3kV.

It also has a function of range changing-over of the PEAK VOLTAGE METER described later.

HIGH VOLTAGE DISSIPATION LIMITING RESISTOR

This knob is for changing-over the dissipation limiting resistor of high voltage range (0 - 300V, 0 - 3kV). A suitable change-over prevents damage of the sample and test power source.

LOW VOLTAGE DISSIPATION LIMITING RESISTOR

This knob is for changing over the dissipation limiting resistor of low voltage range (0 - 30V).

CAPACITY BALANCE, FINE (in red)

When the characteristic of a sample in high voltage with a small current is measured, a loop will happen to be seen on the screen because of the parallel capacity of the sample. The knob, CAPACITY BALANCE, is for compensating this phenomenon. The red knob inside of it is for the fine adjustment.

POWER (ON, OFF)

This is a power switch. When turned upwards power is supplied to the CURVE TRACER. At the same time, one of the lamps which indicate the voltage range on the upper part of the peak voltage meter is lit.

TO SAFETY CONTROL (LINE VOLTAGE)

This is the terminal for outer connection of the safety switch for high voltage. When the outer switch is not used, the attached plug (two terminals are shorted inside) is inserted in this terminal.

The operation method is described in the article "Notice for operation".

CURRENT SAMPLING OUTPUT (A, B)

These are output terminals for measuring the current flowing through the sample. They are used by connecting with the terminals for the vertical (current) axis of oscilloscope. When the knob of above discribed FUNCTION is set to FOWARD or SINE, the terminal A is the output terminal and the terminal B is the output terminal for CAPACITY BALANCE. When set REVERSE the situation is vice versa.

VOLTAGE SAMPLING OUTPUT (A, B)

The output terminals for measurement of voltage on both sides of the sample, these are used by connecting with the terminals for the horizontal (voltage) axis of oscilloscope. The voltage to be inpressed on the sample in the high voltage range is divided into 1/100 in the unit to supply

to the output terminal. Therefore, if the connecting cord is disconnected, there is no danger of appearance of high voltage.

METER FULL SCALE RANGE (10, 30)

This is a range changing-over switch of Peak Voltage Meter (with volt as the unit of voltage) for indicating the voltage impressed on the sample. Ten times indicated value in 0 - 300V range and one hundred times indicated value in 0 - 3kV range make the full scale value.

SAMPLING T_2, G, T_1 SAMPLING

These are terminals for connection of samples. Especially for the case when the voltage drop in lead wire comes into question, the terminal of SAMPLING is connected with a voltage measuring point through other lead wire after removing SHORT BAR. T_1 is connected with the chassis through a resistor of 100kΩ.

T_2 is always kept at a higher potential than ground.

SPEC 60091 GATE POWER SUPPLY

POWER (OFF) This is the power switch for Gate Power Supply.

GATE SELECTOR This is the switch for selecting the polarity and waveform of the Gate Power Supply.

The gate output is always applied between the above-mentioned terminals for sample, $T_1 \sim G$ of SPEC 60101 TEST VOLTS SOURCE UNIT.

(+) and (-) indicate the polarity of terminal G to terminal T_1.

At the center, position of OFF the gate circuit is released from the terminal for sample.

(DC POWER SUPPLY)

VOLTS RANGE This is a knob for range change-over of the voltmeter of DC power supply for the gate.

OUTPUT VOLTS This is a knob for adjusting DC voltage for the gate by which voltage can be continuously varied from 0 to 30 V.

CURRENT RANGE This is the knob for changing-over the range of ammeter of DC gate power supply.

SERIES RESISTOR This is for adjusting the series resistor of the gate circuit (DC). The range which is indicated by the range switch on the left side can be continuously fine-adjusted by the vernier dial.

(STEP GENERATOR)

STEP SELECTOR (VOLTS/STEP, mA/STEP)

This is the knob for selecting voltage or current value per one step of step wave.
It can vary from 1 μA/STEP to 200 mA/STEP in case of the constant current step generator. and from 0.01 V/STEP to 0.2 V/STEP in case of the constant voltage step generator.

SERIES RESISTOR

This is the knob for selecting series resistor when the constant voltage step is used.
It indicates the internal resistance (1 Ω min.) of voltage step generator.

REPETIVIVE, OFF SINGLE FAMILY

If this switch is turned upward (REPETITIVE), the repetitive step wave generates continuously.
If it is turned downward (SINGLE FAMILY), only once the single family of the step wave generates.
At the middle position (OFF) the output is not obtained.
When it is turned downward, if released, it is to be restored to the middle position (OFF). SINGLE FAMILY is specially used for the characteristic measurement which surpasses the continous rating of the sample.

STEPS/FAMILY — This knob is for changing the number of steps appearing in one family. It has the adjusting range of 4 ~ 12 steps per family.

STEPS/SECOND — This is the switch for selecting the number of steps appearing in a second. At the position of 50 STEPS/SEC, STEP WAVE is changed-OVER at the position of 0 volt of the test voltage waveform which is applied to the test terminals T_2 and T_1. It synchronizes with the positive rise point in FORWARD and SINE waveform, and with the negative rise point in REVERSE.

The position of 100 STEPS/SEC is mainly used when the test voltage waveform is SINE. At the positive and negative peak position of SINE wave, the STEP WAVE is changed over.

(In case of the power source of 60 Hz, indicates 60 STEPS/SEC or 120 STEPS/SEC.

5. OPERATION METHOD

5-1 First make mutual connection between three units, OSCILLOSCOPE, GATE POWER SUPPLY and TEST VOLTS SOURCE UNIT. On the panel, the terminals INPUT of OSCILLOSCOPE and the terminals OUTPUT of SOURCE UNIT are connected with accompanying four cords.

As for the connection of GATE circuit, GATE POWER SUPPLY and SOURCE UNIT are connected on the right side of the case, and the connection for over current protective circuit is performed on the rear side. The AC plugs for OSCILLOSCOPE and GATE POWER SUPPLY are inserted in the AC plug socket on the rear side of TEST VOLTS SOURCE UNIT.

5-2 Adjustment of OSCILLOSCOPE

Once the power switch of OSCILLOSCOPE is on, the pilot lamp lights and in approx. 2 minutes, the OSCILLOSCOPE is in operational condition.

After setting the knobs for VERTICAL and HORIZONTAL position at their middle position, the INTENSITY knob is turned clockwise and then a bright spot appears on the fluorescent screen. Adjust the FOCUS and ASTIGMATISM knobs to obtain a well focussed bright spot. Set the spot at the lower corner point on the left on the scale of 10 DIV x 10 DIV taken as the origin by means of the knob POSITION. If the push button of

10 DIV CAL is pressed, the horizontal or vertical bright line of 10 DIV lenghs will appear on the screen. Illuminate the scale by turning the knob of SCALE ILLUM if necessary. When affected by ground magnetisum, the vertical and horizontal trace line may be brought out of parallel to the scale. Therefore, readjustment may be necessary in accordance with the fitting position of this apparatus, the readjustment is performed as follows.

That is, the OSCILLOSCOPE is removed from the case and after the clamp on the neck of CRT is loosened, the adjustment is performed by turning the handle of CRT slowly.

As the part with a high potential for the cat hod ray tube is exposed inside, be careful not to be electrically shocked.

5-3 Operation of TEST VOLTS SOURCE UNIT

As an example, the procedure of observing transistor characteristics is described below. Its rating is as follows.

Sample 2SC515 (TOSHIBA)

Voltage between collector and emitter	V_{CE}	300 V max.
Collector current	I_C	100 mA max.
Emitter current		-100 mA max.
Collector power dissipation (Tc = 70 C)		6 W max.
Temperature at the junction		150° C
DC current amplification factor		60 std.

(V_{CE} = 10 V I_C = 50 mA)

When V_{CE} - I_{CE} characteristic of 2SC 515, grounded emitter is measured, first set the Gate Source " OFF " position.

Before the sample is connected, the knobs and the like on the panel are set as shown below.

TEST VOLTS SOURCE

- FUNCTION ..... FORWARD
- TEST VOLTS ..... ZERO
- TEST VOLTS RANGE ... 300
- METER FULL SCALE RANGE 30
- HIGH VOLTAGE DISSIPATION LIMITING RESISTOR ..... 1 M
- CAPACITY BALANCE .. MINIMUM

OSCILLOSCOPE

- BRIGHT SPOT — at the origin at the lower corner on the left side as described before
- VERTICAL — 100 μA/DIV
- HORIZONTAL — 20 V/DIV

Next, the sample is connected as follows

- Collector — T_2
- Base — G
- Emitter — T_1

When the test voltage is increased by turning the knob TEST VOLTS slowly, the trace line on the fluorescent screen of CRT extends to the right on horizontally, at the same time the peak voltage meter indicates the peak value of the voltage.

At the normal temperature (25° C) I_{CBO} of 2SC515 is less than 100 μA, the vertical deflection of trace line is to be within 1 DIV at the voltage of up to 300 V.

If the VERTICAL sensitivity of OSCILLOSCOPE is increased, the value of I_{CBO} can be read out. However, at this moment the loop due to the parallel capacity of the sample is seen on the screen. By adjusting the knob CAPACITY BALANCE the loop is made minimum. The equivalent parall capacity of the semi conductor can not be perfectly compensated on several occasion because of the influence of impressed voltage.

5-4 Operation of GATE POWER SUPPLY

Next, operatingthe base current I_B flow, the static characteristic of V_{CE}-I_{CE} when the emitter of the transistor is grounded with I_B taken as a parameter. The constant current step is utilized as I_B and the knobs for GATE POWER SUPPLY on the panel are set as follows.

GATE POWER SUPPLY
- GATE SELECTOR ..... + STEP
- STEP SELECTOR ..... 0.01 mA/STEP
- REPETITION-OFF-SINGLE FAMILY ..... OFF
- STEPS/FAMILY ..... (4) min.
- STEPS/SECOND 50 (60)

TEST VOLT SOURCE UNIT is set as follows.

In this case LOW VOLTAGE RANGE is used for VCE.

TEST VOLTS SOURCE UNIT	TEST VOLTS RANGE	0 ~ 30 V
	LOW VOLTAGE DISSIPATION LIMITING RESISTOR	100 Ω

The sensitivity of oscilloscope is changed as the follows.

OSCILLOSCOPE	VERTICAL	1 mA/DIV
	HORIZONTAL	2 V/DIV

After TEST VOLTS is once set to ZERO, the knob for the gate source is set to REPETITIVE.

If TEST VOLTS is steadily rotated in the direction of increase several lines of a characteristic curve are seen on the fluorescent screen.

If the knob for STEPS/FAMILY is rotated clockwise, the number of curves is increased. The pattern suitable for required observation is to be put on the screen by changing-over the knobs of VERTICAL and HORIZONTAL.

If STEPS/SECOND is changed-over to 100, the flicker of pattern is made less. As the step rise point of base current becomes 90° out of phase and comes to the maximum point of waveform of the test voltage (half-wave) at this moment, the load line (corresponds to DISSIPATION LIMITING RESISTOR) is seen on the pattern.

5-5 Over Current Protective Circuit

If the trace on the flurescent screen goes beyond the graticule of . 10 DIV X 10 DIV by more than 6 ~ 8 DIVs from the center in the verticale direction, the over current protective circuit operates to switch the test power source OFF. It will not reset as long as TEST VOLTS is not restored to ZERO.

Accordingly, if VERTICAL RANGE of OSCILLOSCOPE is properly set, damage of the sample can be prevented.

The operation sensitivity of this circuit can be adjusted by the adjustment of semi-fixed resisistor after opening the door on the left side of the OSCILLOSCOPE.

Especially in case of the range 0 ~ 3 kV, a high- voltage fuse (0.1 A rapid blow type) is inserted in series with the terminal for sample. It can be replaced with a new one by removing the cover on the right side of TEST VOLTS SOURCE UNIT.

5-6 Peak Voltage Meter

The voltmeter for TEST VOLT SOURCE UNIT indicates the peak value of TEST VOLTS for monitoring the impressed voltage to the sample at a glance. When TEST VOLTS is of SINE wave the meter indicates the peak value of the positive polarity. (direction of that T_2 is positive to T_1 portion on the right of the origin on the screen of the OSCILLOSCOPE CRT).

Where the deflection of the meter pointer is small being affected by the characteristic of the rectifier of the voltmeter circuit, error is increases.

Therefore, it is desirable to change-over the range switch if - the indication on the peak voltmeter is less than 10 when the range of 30 is used.