

# INSTRUCTION MANUAL

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**BK PRECISION®**

## MODEL 4011



## 5 MHz FUNCTION GENERATOR

with DIGITAL DISPLAY

MUA USEEP - Operators Copy Volume 1  
KKSC - Khon Kaen University - Science Fac.  
KKSC29 - Physics  
Supplier: Labquip International Limited



M00004DC21

Mfr. B & K PRECISION

Function Generator/counter 5 Mhz

Item: FT02/32 Model: 4011

# **BK PRECISION®**

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## TEST INSTRUMENT SAFETY

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### **WARNING**

Normal use of test equipment exposes you to a certain amount of danger from electrical shock because testing must sometimes be performed where exposed voltage is present. An electrical shock causing 10 milliamps of current to pass through the heart will stop most human heartbeats. Voltage as low as 35 volts dc or ac rms should be considered dangerous and hazardous since it can produce a lethal current under certain conditions. Higher voltages pose an even greater threat because such voltage can more easily produce a lethal current. Your normal work habits should include all accepted practices to prevent contact with exposed high voltage, and to steer current away from your heart in case of accidental contact with a high voltage. You will significantly reduce the risk factor if you know and observe the following safety precautions:

1. Don't expose high voltage needlessly. Remove housings and covers only when necessary. Turn off equipment while making test connections in high-voltage circuits. Discharge high-voltage capacitors after removing power.
2. If possible, familiarize yourself with the equipment being tested and the location of its high voltage points. However, remember that high voltage may appear at unexpected points in defective equipment.
3. Use an insulated floor material or a large, insulated floor mat to stand on, and an insulated work surface on which to place equipment; and make certain such surfaces are not damp or wet.
4. Use the time proven "one hand in the pocket" technique while handling an instrument probe. Be particularly careful to avoid contacting a nearby metal object that could provide a good ground return path.
5. When testing ac powered equipment, remember that ac line voltage is usually present on some power input circuits such as the on-off switch, fuses, power transformer, etc. any time the equipment is connected to an ac outlet, even if the equipment is turned off.

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## INTRODUCTION

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The **B-K Precision** Model 4011 Function Generator is a versatile signal source which combines several functions into one unit. Additionally, the instrument provides the added convenience of a built-in frequency counter. This permits more accurate determination of output frequency than is possible with a simple calibrated dial. Coarse and fine tuning controls permit precision settability of the output frequency. High stability assures that the output frequency does not drift.

With this versatility, the unit has a vast number of applications in both analog and digital electronics in the engineering, manufacturing, servicing, educational, and hobbyist fields.

The heart of the function generator is a VCG (voltage-controlled generator) that produces precision sine, square, or triangle waves over the 0.5 Hz to 5 MHz range. This encompasses subaudible, audio, ultrasonic, and RF applications. A continuously variable dc offset allows the output to be injected directly into circuits at the correct bias level.

Variable symmetry of the output waveform converts the instrument to a pulse generator capable of generating rectangular waves or pulses, ramp or sawtooth waves, and slewed sine waves.

In addition to the above features, an external signal may be used to sweep the output frequency or control operating frequency. This is useful in situations where an externally controlled frequency is desirable.

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## SPECIFICATIONS

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### FREQUENCY CHARACTERISTICS

#### Waveforms

Sine, Square, Triangle,  $\pm$  Pulse,  $\pm$  Ramp

#### Range

0.5 Hz to 5 MHz in 7 ranges

#### Resolution

4 digits

#### Tuning Range

Coarse: 10:1, Fine:  $\pm 5\%$  of Coarse Setting

#### Variable Duty Cycle

15:85:15 Continuously Variable

#### Operating Modes

Normal, VCG (Voltage Controlled Generator)

#### Frequency Stability

Output frequency will not change more than 0.09% in 15 minutes after 1 hour warmup

### OUTPUT CHARACTERISTICS

#### Impedance

50  $\Omega$   $\pm 10\%$

#### Level

20 V p-p Open-circuit, 10V p-p into 50  $\Omega$

#### Amplitude Control

Variable, 20 db range typical

#### Attenuation

-20 db  $\pm 1$  db

#### DC Offset

Preset:  $\pm 0.1$  V typical

Variable:  $\pm 10$ V open-circuit,  $\pm 5$ V into 50  $\Omega$

### SINE WAVE

#### Distortion

1% typical at 1 KHz

#### Flatness

$\pm 5\%$  (.45 dB)

### SQUARE WAVE

#### Symmetry

0.5 Hz to 100 KHz  $\leq 2\%$

#### Rise Time

$\leq 20$  nS

### TRIANGLE WAVE

#### Linearity

$\geq 98\%$  to 100 KHz

**TTL OUTPUT**

Level 0.8V to 2.4V  
Rise Time  $\leq 20$  nS  
Duty Cycle 50% typical

**CMOS OUTPUT**

Max Frequency 2 MHz  
Level 4V to 14 V  $\pm 0.5V$  p-p,  
Continuously variable  
Rise Time  $\leq 120$  nS

**VCG (Voltage Controlled Generator) INPUT**

Input Voltage  
0 - 10V  $\pm 1V$  causes a 100:1 frequency change  
Impedance  
10K $\Omega$   $\pm 5\%$

**FREQUENCY COUNTER**

Accuracy  
Time Base Accuracy  $\pm 1$  count

Time Base Accuracy  
 $\pm 10$  PPM (23°C  $\pm 5^\circ$ C)

Display  
4 digit LED

**POWER SOURCE**

120 / 230 VAC  $\pm 10\%$ , 50 / 60 Hz, internal jumper selectable

**DIMENSIONS (H x W x D)**

10-3/8" x 3-3/8" x 11-7/16" (26.4cm x 8.6cm x 29.1cm)

**WEIGHT**

4 lb. (1.8 kg.)

**ACCESSORIES**

Instruction Manual  
Output Cable, BNC to Alligator Clips

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## CONTROLS AND INDICATORS

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### FRONT PANEL (Refer to Fig.1)

1. **POWER Switch.** Turns power on and off.
2. **RANGE Switch.** Selects output frequency range. Seven ranges from 5 Hz to 5 MHz. Switch indicates maximum frequency of range and is adjusted with COARSE FREQUENCY control to 0.1 times the maximum. For example, if the 500 KHz range is selected, the output frequency can be adjusted from 50 KHz to 500 KHz.
3. **FUNCTION Switch.** Selects sine, square, or triangle waveform at OUTPUT jack.
4. **OUTPUT LEVEL Control.** Controls the amplitude of the signal at the OUTPUT jack. Output level can be decreased by approximately 20db with this control.
5. **DC OFFSET Control.** Enabled by the DC OFFSET Switch (12). Clockwise rotation from center changes the DC offset in a positive direction while counterclockwise rotation from center changes the DC offset in a negative direction.
6. **OUTPUT Jack.** Waveform selected by FUNCTION switch as well as the superimposed DC OFFSET voltage is available at this jack.
7. **TTL/CMOS Jack.** TTL or CMOS square wave, depending on the position of the CMOS LEVEL switch (13) is output at this jack This output is independent of the OUTPUT LEVEL and DC OFFSET controls.
8. **CMOS LEVEL Control.** Rotating this control clockwise increases the amplitude of the CMOS square wave at the TTL/CMOS jack.
9. **VCG Jack.** Voltage Controlled Generator input. Permits external control of generator output frequency by a DC voltage input at this jack. A positive voltage will decrease frequency.
10. **DUTY CYCLE Control.** Enabled by the DUTY CYCLE Switch (14). Rotation from center position adjusts the duty cycle of the main OUTPUT signal.
11. **-20DB Switch.** When engaged, the signal at the OUTPUT jack is attenuated by 20db.
12. **DC OFFSET Switch.** When engaged, enables operation of the DC OFFSET control (5).
13. **CMOS LEVEL Switch.** When engaged, changes the TTL signal to CMOS signal at the TTL/CMOS jack.
14. **DUTY CYCLE Switch.** When engaged, enables operation of DUTY CYCLE control (10).
15. **FINE FREQUENCY Control.** Vernier adjustment of the output frequency for ease of setting frequency.
16. **COARSE FREQUENCY Control.** Coarse adjustment of the output frequency from 0.1 to 1 times the selected range.
17. **COUNTER DISPLAY.** Displays frequency of internally generated waveform.

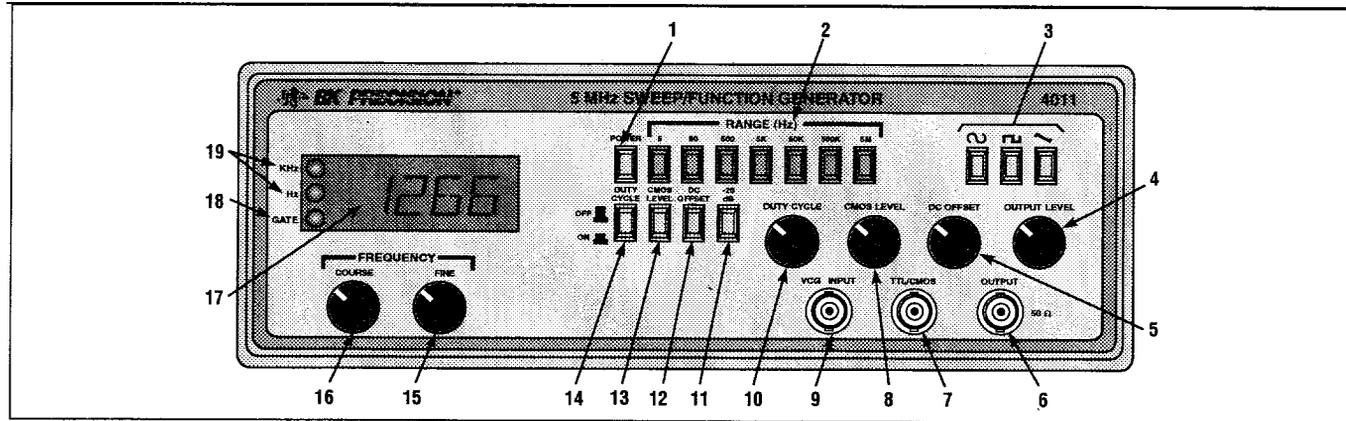


Figure 1. Model 4011 Controls and Indicators.

18. **GATE LED.** Indicates when the frequency counter display is updated. When the 50K through 5M ranges are selected, the LED will flash 10 times per second (every 0.1 seconds). When the 50 through 5K ranges are selected, the LED will flash once every

second and when the 5 range is selected, the LED will flash every 10 seconds. As the LED turns off, the display is updated.

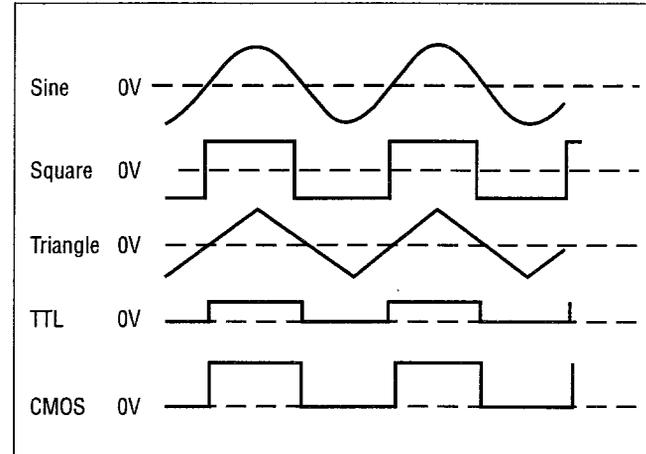
19. **Hz and KHz LED.** Indicates whether the counter is reading in Hz or KHz.

## OPERATING INSTRUCTIONS

The **B+K PRECISION** Model 4011 Function Generator is a versatile instrument, capable of producing a variety of output waveforms over a broad range of frequencies. To gain a working familiarity with the unit, it is recommended that it be connected initially to an oscilloscope, so that the effects of the various controls on the output waveforms can be observed. Use this manual as required for reference until becoming accustomed to the operating procedures.

### FREQUENCY AND WAVEFORM SELECTION

- Initially, verify that the **DUTY CYCLE** (14), **CMOS LEVEL** (13), **DC OFFSET** (12), **-20dB** (11), switches are in the OUT position (released). This will produce a symmetrical waveform unaffected by the other controls.
- Plug the unit into an appropriate power source and turn it on by engaging the **POWER** switch (1).
- Select the desired waveform (SINE, SQUARE, or TRIANGLE) by engaging one of the **FUNCTION** switches (3). Phase relationships of the waveforms are shown in Fig. 2.
- Select the frequency of the waveform by engaging one of the **RANGE** switches (2). The output frequency is displayed, along with the appropriate measurement units, KHz or Hz (19), on the LED display.
- Rotate the **COARSE** (16) frequency control to quickly set the output frequency to the approximate desired value. The **FINE** (15) frequency control can then be used to easily set the output to the specific desired value. The frequency selected is available at the **OUTPUT** jack (6). In addition, a digital signal, either TTL or CMOS is available at the **TTL/CMOS** jack (7) (refer to the "TTL/CMOS OUTPUT" section of this manual).



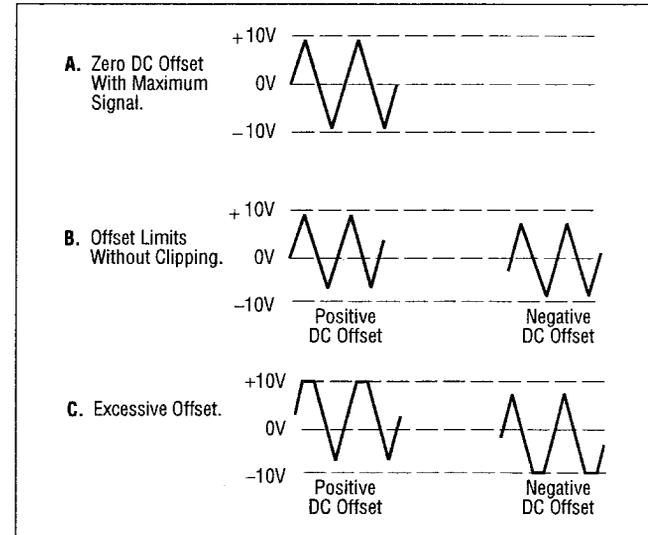
**Figure 2. Output Waveform and Phase Relationship**

- Adjust the amplitude of the output as desired using the **OUTPUT LEVEL** control (4). Rotation of this control varies the amplitude from maximum to 20 db below maximum. An additional attenuation of -20db is available by pushing in the **-20dB** switch (11). The attenuation factors can be combined for a total of -40db. The maximum signal level is 10 V p-p (into 50  $\Omega$ ).

7. A superimposed DC component can be added to the output signal by engaging the **DC OFFSET** switch (12) to enable operation of the **DC OFFSET** control (5). Rotation of this control adds a positive or negative DC component to the output signal. The DC component introduced is independent of the **OUTPUT LEVEL** control and can be varied by  $\pm 10$  volts open circuited or  $\pm 5$  volts into  $50 \Omega$ . The DC Offset does not affect the **TTL/CMOS** output jack. The effect of DC OFFSET is shown in Fig. 3.

### CONSIDERATIONS

1. Counterclockwise rotation of the **COARSE** frequency control decreases the output frequency to approximately one-tenth of the maximum for the range selected (10:1). For example, if the **50 K** range is selected and the **COARSE** frequency control is set to full counterclockwise, the output frequency is approximately 5 kHz.
2. It is advisable to set the **FINE** frequency control to the approximate center of its rotation before setting the **COARSE** frequency control. This assures that the **FINE** control will not reach its limit while trying to finalize the frequency setting.
3. The **FINE** frequency control provides approximately  $\pm 5\%$  frequency deviation from the **COARSE** control setting. This provides vernier adjustment to easily set the frequency to a precise value.
4. When the **5 Hz** range is selected, the gate time is 10 seconds and the display is updated once every 10 seconds. The result of a frequency change will not be displayed until 10 seconds later. Adjust the frequency in progressively smaller steps, waiting for the display to update until the desired frequency is obtained.
5. When outputting square waves or when using the TTL output, terminate the cable into  $50 \Omega$  to minimize ringing. Also, keep cables as short as possible.



**Figure 3. Use of DC OFFSET Control**

6. Remember that the output signal swing of the generator is limited to  $\pm 10$  volts open circuited or  $\pm 5$  volts into  $50 \Omega$ , and applies to the combined peak-to-peak signal and DC offset. Clipping occurs slightly above these levels. Fig. 3 illustrates the various operating conditions encountered when using the DC offset. If the desired output signal is large or if a large DC offset is required, an oscilloscope should be used to make sure that the desired signal is obtained without undesirable clipping.

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## DUTY CYCLE CONTROL

The **DUTY CYCLE** control can be used to alter the symmetry of the output waveform, to produce waveshapes such as those shown in Fig. 4. For a square wave, symmetry variation amounts to changing the duty cycle (ratio of "high" to "low" time), effectively converting the instrument into a pulse generator. For a triangle wave, the result is a ramp, and with a sine wave, a distorted waveshape called a slewed sine is produced. The Model 4011 provides for symmetry variation from 15% to 85%.

1. Select the waveform desired either SINE, SQUARE or TRIANGLE.
2. Engage the **DUTY CYCLE** switch (14) and adjust the **DUTY CYCLE** control (10) for the desired waveshape. Clockwise rotation from center results in an increase in square wave duty cycle, and changes the sine and triangle waves as shown in the top waveform of each pair of Fig. 4. Counter-clockwise rotation results in the bottom waveform in each pair.
3. Varying the duty cycle setting results in a slight change in frequency. Adjust the **COARSE** and **FINE** frequency controls as required.

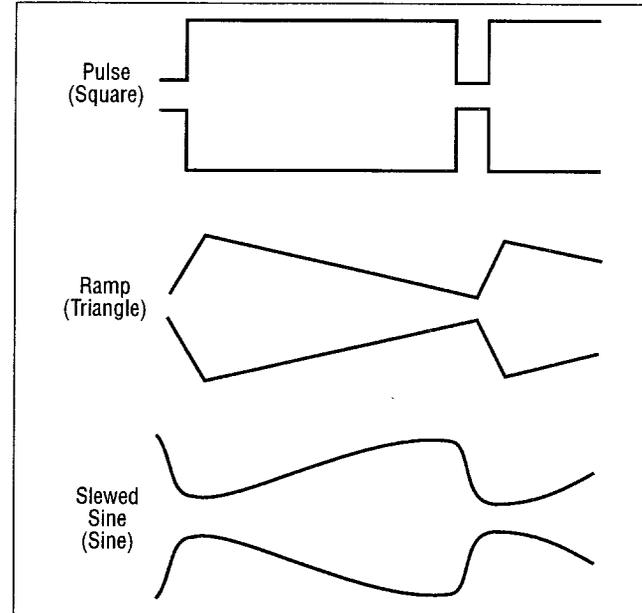


Figure 4. Effects of Symmetry Variation.

## TTL/CMOS OUTPUT

The **TTL/CMOS** output jack provides a fast rise time square wave output. Either a fixed TTL or a variable CMOS output level is available. The output is positive with respect to ground and can be used as an external sync pulse for oscilloscopes or as a variable frequency signal source for exercising logic circuits. Because of the fast rise time of this output, cable length should be minimized to limit ringing and overshoot.

1. Select the desired frequency range and adjust the frequency controls as required. The **OUTPUT LEVEL** and **DC OFFSET** controls have no effect on the signal at the **TTL/CMOS** jack.
2. When the **CMOS LEVEL** switch (13) is OFF, a TTL signal is output at the **TTL/CMOS** jack. Select a CMOS signal by engaging the **CMOS LEVEL** switch and adjust the level of the signal by rotating the **CMOS LEVEL** control (8).

## VOLTAGE CONTROLLED FREQUENCY OPERATION

The Model 4011 can be operated as a voltage-controlled generator by using an external control voltage applied to the **VCG INPUT** jack. The externally applied voltage will vary the frequency which is preselected by the range switches and the frequency controls. Applying approximately +10 V with the **COARSE** control at full clockwise decreases the output frequency by about 100 times (a 100:1 ratio).

1. Select the desired frequency range and waveform.
2. Set the starting frequency with the **COARSE** control. Apply a positive DC voltage to the **VCG INPUT** input jack (9) to decrease the frequency. A voltage from 0 to +10 V will cause the frequency to decrease by a factor of 100 if the **COARSE** frequency control is set at maximum CW rotation. For example, if the starting frequency

is 500 kHz, applying +10 V will change the output frequency to 5 kHz.

3. To operate the function generator as a sweep generator, apply a positive going ramp signal to the **VCG INPUT** jack. As the ramp voltage increases, the frequency decreases. The rate of sweep can be adjusted by varying the frequency of the ramp signal.
4. Specific frequencies can be selected by applying a fixed dc voltage to the **VCG INPUT** jack or the frequencies can be stepped by applying a stepped dc voltage.
5. Do not apply more than  $\pm 15$  volts (dc or dc + ac peak) to the **VCG INPUT** jack. Inputs of more than 15 volts will not cause any further shift in the frequency and could cause damage to the generator.

## OUTPUT PROTECTION CONSIDERATIONS

Use care when connecting the function generator output to a signal injection point. Excessive voltage at the point of signal injection of the function generator can cause internal damage. Under normal operation, the generator output should never be connected to an external voltage other than low dc values that can be matched with the **DC OFFSET** control. The Model 4011 is overload protected so that shorting the output, even continuously, will not cause damage. A fuse has been added in series with the **OUTPUT** jack to help protect the instrument from damage by connection to excessive external voltage.

Damage of this type usually occurs by accidentally connecting the output of the function generator to a voltage in the equipment under test. The following protective measures are strongly recommended:

1. The user should understand the equipment under test well enough to identify valid signal injection points (ie: the base of a transistor,

## OPERATING INSTRUCTIONS

a logic input of a gate, etc.). The voltage at valid signal injection points is rarely high enough to damage the instrument.

2. If in doubt about the safety of a signal injection point, measure the voltage present at the intended point of signal injection before connecting the function generator output to that point.
3. When applying the main output of the function generator to a circuit containing a dc level, adjust the **DC OFFSET** control so that the dc level at the main output matches the circuit voltage.
4. Connect the **TTL** output only to TTL-level circuits. Connect the **CMOS** output only to CMOS circuits. Measure the  $V_{cc}$  of the circuit under test and adjust the **CMOS LEVEL** control as instructed in the manual.
5. When the function generator is used by students or other inexperienced users, the circuit of Fig. 5 could be added into your TTL output probe or test clip set. It will protect the TTL output of the generator against external voltages up to  $\pm 20$  volts.

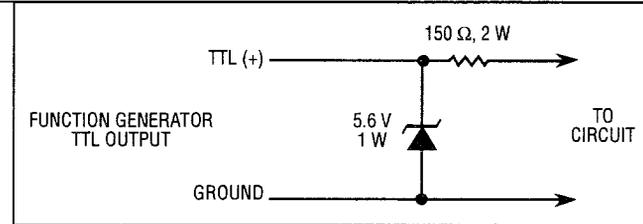


Figure 5. Circuit for Protection of TTL Output.

## FUNCTION GENERATOR APPLICATIONS GUIDEBOOK

**B+K Precision** offers a “Guidebook to Function Generators” which describes numerous applications for this instrument, including hook-up details. It also includes a glossary of function generator terminology and an explanation of function generator circuit operation. It may be obtained free of charge by filling out and mailing the postage paid card enclosed with the Model 4011.

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## MAINTENANCE

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### **WARNING**

*The following instructions are for use by qualified service personnel only. To avoid electrical shock, do not perform servicing other than contained in the operating instructions unless you are qualified to do so.*

*Remember that ac line voltage is present on line voltage input circuits any time the instrument is plugged into an ac outlet, even if turned off. Always unplug the function generator before performing service procedures.*

### **DISASSEMBLY AND REASSEMBLY**

In order to access the fuses and the line voltage selector, the bottom half of the case must be removed. Disassembly and reassembly procedures are as follows:

#### **Disassembly**

1. Unplug the function generator and turn the unit upside down.
2. Remove the four screws from the bottom of the case.
3. Lift off the bottom cover.

#### **Reassembly**

1. Line up the slots in the bottom case half with the front panel and the back panel.
2. Carefully push the bottom half down onto the top half.
3. Replace the four screws.

#### **FUSE REPLACEMENT**

1. To replace a fuse, disassemble the case as described above.
2. To replace the line fuse, locate the fuse holder. It is located at the rear of the circuit board, to the right of the power transformer. The fuse should not normally open unless a problem has developed with the unit. Try to determine and correct the cause of the blown fuse, then replace only with the correct value fuse (refer to fuse label near fuse holder).
3. To replace the Output fuse, locate the fuse holder. It is located on the output amplifier PC board mounted to the front panel. Replace only with the correct value fuse 0.2 A slow blow fuse.
4. Reassemble case as described above.

#### **LINE VOLTAGE SELECTION**

1. Disassemble the case as described above.
2. Locate the line voltage selection connector. It is located on the PC board behind the power transformer.

## MAINTENANCE

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3. Unplug the connector by pulling straight up.
4. Push the connector onto the desired voltage selection pin. Be sure that the correct fuse is installed in the fuse holder (refer to label near fuse holder).
5. Reassemble case as described above.

## INSTRUMENT REPAIR SERVICE

Because of the specialized skills and test equipment required for instrument repair and calibration, many customers prefer to rely upon **B+K PRECISION** for this service. We maintain a network of **B+K PRECISION** authorized service agencies for this purpose. To use this service, even if the instrument is no longer under warranty, follow the instructions given in the **WARRANTY SERVICE INSTRUCTIONS** portion of this manual. There is a nominal charge for instruments out of warranty.

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6. Some equipment with a two-wire ac power cord, including some with polarized power plugs, is the “hot chassis” type. This includes most recent television receivers and audio equipment. A plastic or wooden cabinet insulates the chassis to protect the customer. When the cabinet is removed for servicing, a serious shock hazard exists if the chassis is touched. Not only does this present a dangerous shock hazard, but damage to test instruments or the equipment under test may result from connecting the ground lead of most test instruments to a “hot chassis”. To test “hot chassis” equipment, always connect an isolation transformer between the ac outlet and the equipment under test. The **B+K Precision** Model TR-110 or 1604 Isolation Transformer, or Model 1653 or 1655 AC Power Supply is suitable for most applications. To be on the safe side, treat all two-wire ac equipment as “hot-chassis” unless you are sure it has an isolated chassis or an earth ground chassis.
7. On test instruments or any equipment with a 3-wire ac power plug, use only a 3-wire outlet. This is a safety feature to keep the housing or other exposed elements at earth ground.
8. Never work alone. Someone should be nearby to render aid if necessary. Training in CPR (cardio-pulmonary resuscitation) first aid is highly recommended.