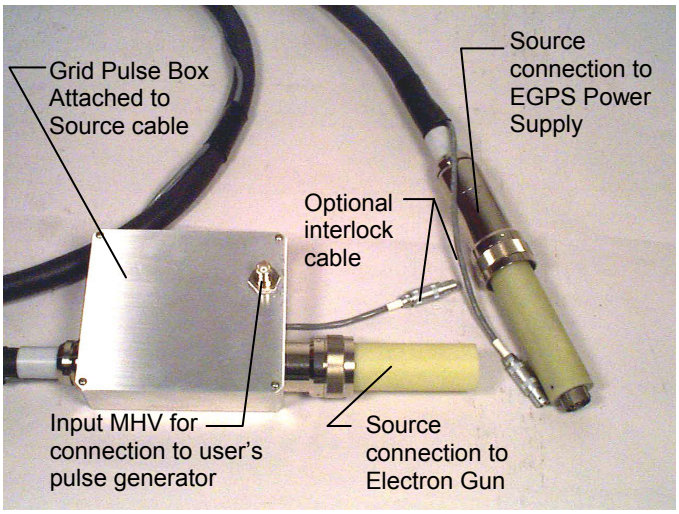
4.7 BEAM PULSING OPTIONS cont.

4.7.2 CAPACITIVE PULSING with H.V. GRID PULSING SOURCE CABLE



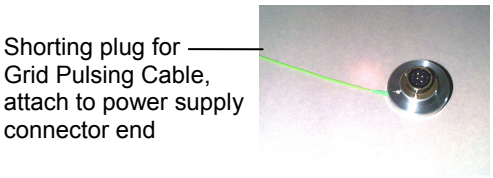


Fig. 4.7-2 H.V. Grid Pulsing Source Cable, (H.V. Multiconductor Source Cable with Grid Pulse Box attached).

The capacitive pulsing option, also referred to as fast beam pulsing, involves a H.V. Multiconductor Source Cable with an attached capacitor-containing device, the Grid Pulse Box. A separate, user-supplied pulse generator capable of producing appropriate voltages (equal to the Grid cut off value) is also required. In the Grid Pulse Box on the cable, the voltage outputs from the grid power supply and pulse generator are combined to produce the voltage at the grid in the gun to pulse the beam off and on.

This H.V. Grid Pulsing Source Cable is simply connected to the central feedthrough of the electron gun in place of the normal H.V. Multiconductor Source Cable. If there is an appropriate feedthrough on the gun, this capacitive pulsing option can be added to the gun system without modification.

Capacitive pulsing can provide the fastest rise/ fall time and shortest pulse length of the various pulsing methods. However, the capacitor does not permit long pulses or DC operation.

⚠ CAUTION

DO NOT EXCEED 5 WATTS AVERAGE INPUT due to 1 kΩ input impedance.

Do not use ECC mode when pulsing.
The ECC feedback may raise the cathode temperature and reduce cathode lifetime.

The input MHV on the Grid Pulsing Box on the Source cable must NOT be grounded, even when not in use.

POWER INPUT CAUTIONS

The maximum average power recommended for the H.V. Grid Pulsing Source Cable is 5 WATTS. The circuitry in the Grid Pulse Box includes a 1 kΩ resistor for termination to ground. The power input from the user's pulse generator must be kept low enough so that the resistor will not be damaged.

The power input can be calculated using the following equation: $\mathbf{V^2/R = P}$ (the total DC power).
For example, if 500 V from the user's pulse generator is applied to pulse the beam, 500 V squared divided by the 1 kΩ resistor equals 250 Watts continuous DC power, which would quickly destroy the circuitry in the box.

With pulsing, the overall power input is reduced, as calculated by the following equations:
Pulse width (duration of pulse) **x frequency = duty cycle** (fraction of time the beam is on) and
Duty cycle x total P = Avg pulsed Power.
For example, with a 20 µsec pulse at 1 kHz, the time on is $2x10^{-5}$ sec multiplied by 10^3 cycles/sec which equals 0.02 or a 2% duty cycle. Thus the average pulsed power with a 500 V input would be 0.02 times the 250 W which equals 5 Watts, the limit of what is considered safe for the H.V. Grid Pulsing Source Cable. Either a higher voltage input or longer pulses or a higher frequency could damage the circuitry.

Thus, before operating, it is important to calculate the expected pulsed power input. This is not generally a concern with low energy, low current operation in which the beam can be cut off with a low grid voltage. However, it may be a problem with higher energy, or higher current guns, which requires a higher grid voltage for cut off. There can also be a problem with very long pulses; the H.V. Grid Pulsing Source Cable is designed for fast pulsing. Pulse widths from 20 ns to 100 µs can be achieved with appropriated inputs. Some examples of allowable pulsing parameters are given in Table 4.7-2 on the next page.

4.7 BEAM PULSING OPTIONS cont.

H.V. GRID PULSING SOURCE CABLE: INSTALLATION

⚠ WARNING

HIGH VOLTAGE
can cause ELECTRIC SHOCK or BURN

For H.V. GRID PULSING CABLE ONLY: Discharge before handling. Do not touch pins.
The power supply connector end on the cable must be covered with its shorting plug

⚠ NOTE

Gun surfaces exposed to vacuum, and high voltage insulator ends on the cables, should not be handled with bare hands. **Use clean room gloves** to keep parts free of fingerprints and contaminants.

The minimum bend radius of the H.V. Source cable is 0.25 meters. **Do not twist cables.**

1. A H.V. Multiconductor Source Cable with a Grid Pulse Box attached (Grid Pulsing Cable) and a separate, user-supplied, pulse generator capable of producing appropriate voltages (equal to the Grid cut off value) are required for installation of the Fast Beam Pulsing Option.

HIGH VOLTAGE WARNING: DISCHARGE THE CABLE BEFORE HANDLING. If the cable is stored separately, the Power Supply connector end must be covered with the attached shorting plug.

The Grid Pulse Box on the Source Cable contains a capacitor which can charge up when the cable is disconnected after being energized. A H.V. potential can exist between the exterior ground shield and the internal conductors. **Do not touch the pins at the end of the cable and the metal connectors or box at the same time. Before touching the cable ends, discharge the pins to ground, for example with a discharging rod**. When the Grid Pulsing Cable is connected to the grounded Power Supply which is turned off, there will be no H.V danger, as the cable will be grounded. However, if the Power Supply has just been turned off, allow time for the Power Supply to bleed off the charge.

2. Refer to the installation procedures outlined in Section 2.2 and 2.3. Connect the optional Grid Pulsing Cable instead of the standard H.V. Multiconductor Source cable to the EGPS Power Supply connector labeled **SOURCE** and to the central feedthrough on the Electron Gun. Avoid touching the insulators on the cable ends, and do not twist the cable. Also, connect the interlock cable attached to the Grid Pulsing Cable to the lemo connectors on the EGPS and the Electron Gun.

3. Connect the user-supplied pulse generator to the input MHV on the Grid Pulse Box attached to the Grid Pulsing Cable. **The input MHV on the Grid Pulse Box should not be grounded** or else the grid in the gun will be grounded.

4. Optional: Set up a user-supplied oscilloscope or other equipment to monitor pulsing; a terminating resistor may be needed.

Table 4.7-2 Pulse Input Limits for H.V. Grid Pulsing Source Cable

Pulse Voltage Input (depends on gun model)	**Pulse Width**	**Pulse Frequency (Repetition Rate)**	**Average Power** (calculated)
100 V	20 ns	25 MHz	5 W
	100 µs	5 kHz	
500 V	20 ns	1 MHz	
	100 µs	200 Hz	
1000 V	20 ns	250 kHz	
	100 µs	50 Hz	

H.V. GRID PULSING SOURCE CABLE: DESCRIPTION of GRID PULSING VOLTAGES and BEAM RESPONSE

Pulsing of the electron beam current is accomplished by applying a pulse through the Grid Pulse Box to the electron gun control grid. The grid voltage is negative with respect to the cathode. To pulse the gun on, positive voltage pulses are required. The grid voltage on the EGPS Power Supply should be turned up so that the electron beam is cut off; data is supplied in the Data Section showing grid cut off values for the electron gun. By sending a pulse of the appropriate amplitude through the Grid Pulse Box, the gun will turn on for the duration of the pulse.

A capacitor located in the Grid Pulse Box isolates the high voltage of the energy supply from the pulse generator. The pulse is transmitted from a ground-referenced pulse generator, through this capacitor to the control grid which is floating at high voltage.

Figure 4.7-4 (below) illustrates the beam current response in fast beam pulsing. The grid power supply and pulse generator outputs superimpose to produce the voltage at the grid aperture; for example, a grid cut off voltage of -150 V plus a positive pulse of +100 V yields a pulse of -50 V applied to the grid inside the gun. This grid voltage then controls the beam current. The values shown for illustration purposes are for a standard EMG-12 Electron Gun at mid Energy range; the actual values of grid cut off and beam current will vary with the gun model and operating parameters (see Data Section).

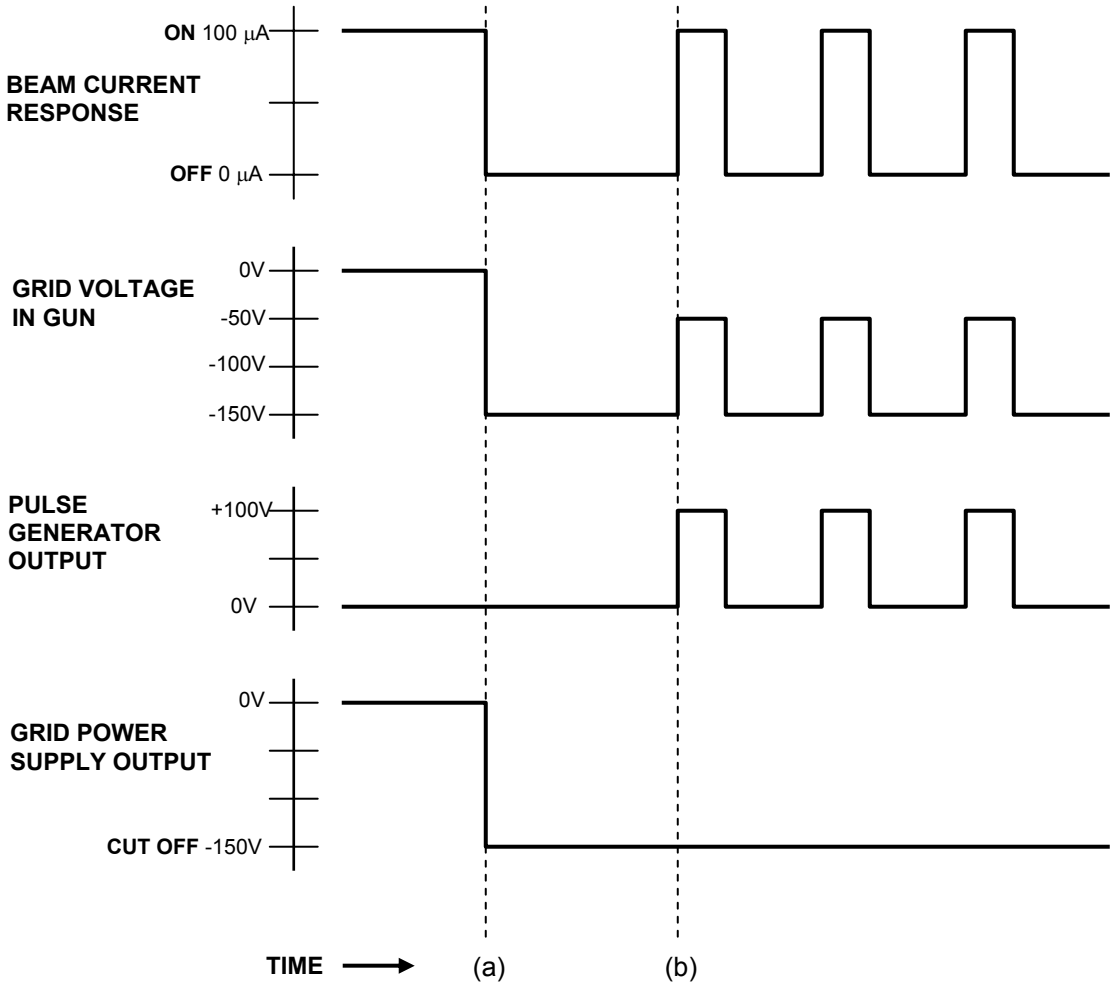


Fig. 4.7-3 Capacitive Fast Beam Pulsing diagram: At time (a) the grid power supply control is set to the cut off voltage, and at time (b) the pulse generator is turned on.

4.7 BEAM PULSING OPTIONS cont.

PULSING with H.V. GRID PULSING SOURCE CABLE: OPERATION

⚠ CAUTION

DO NOT EXCEED 5 WATTS AVERAGE INPUT due to 1 kΩ input impedance.

Do not use ECC mode when pulsing.
The ECC feedback may raise the cathode temperature and reduce cathode lifetime.

The input MHV on the Grid Pulse Box on the Source cable must NOT be grounded, even when not in use.

1. Calculate the expected power in the Grid Pulse Box, based on the desired pulse length and frequency and the grid cutoff value for the particular gun. See Power Input Cautions and
2.
3.
4. Table 4.7-2, above.

5. Start up the electron gun in normal Source mode according to Section 4.2.
   CAUTION: Do not use ECC mode when pulsing.

6. On the EGPS, adjust the Grid voltage to the point where it just completely cuts off the electron beam current using the **GRID** control (potentiometer, encoder wheel or computer remote control). The way the voltages control the beam is described below.

7. On the user-supplied pulse generator, set the input pulse to the grid:
   a. Turn on the generator, and set the desired pulse rate.
   b. Adjust the positive voltage input to the Grid Pulse Box so that the desired pulsed beam current is achieved. **CAUTION: Do not exceed 5 W average power input.**
   c. Using an oscilloscope, the pulse amplitude and the grid voltage can be fine-tuned to reduce ringing and improve beam output. Note: When monitoring the beam pulse, the input impedance of the oscilloscope may need to be changed by use of a terminating resistor.

8. When not using the pulsing option: Disconnect or turn off the user-supplied pulse generator. The input MHV on the Grid Pulse Box must NOT be grounded even when not in use. If the input BNC is grounded, the grid in the gun will be grounded, and not at the voltage set.

CAUTION: The input MHV on the Grid Pulse Box must NOT be grounded even when not in use.

⚠ WARNING

HIGH VOLTAGE
can cause ELECTRIC SHOCK
Internal capacitors in the Grid Pulse Box could remain charged. Use caution to avoid shocks.
Do not touch connectors immediately after use.

This completes the Beam Pulsing Instructions.