4.3 EMISSION CURRENT CONTROL (ECC)

This power supply offers the option of feedback stabilized Emission Current Control (ECC). Under normal circumstances, when a constant voltage source drives the cathode, emission current varies over time. The emission current changes are due to variations in the cathode's resistance as its temperature varies and physical changes such as evaporation and contamination. To provide a stable and constant emission current, the ECC option can be used. The ECC circuitry maintains a constant emission current by using feedback control to adjust the source voltage.

Note that while the emission current is held constant, the beam current may still vary. Many factors can cause the ratio of beam current to emission current to vary such as, but not limited to: Grid and Focus values, chamber pressure, electron gun and target contamination, and outgassing.

Although protection against excessive source current is built into the ECC circuitry, it is best to employ the ECC mode **after** the approximate operating parameters have been determined in Source mode. For example, as the grid voltage is increased toward beam cutoff, the ECC feedback will call for more source current in order to maintain the chosen emission current value. This increased source current will raise the cathode's temperature, thus reducing the cathode lifetime.

With FlexPanel Controls, the Source power supply voltages are gradually ramped up to the value set with the encoder wheel. The internal programming has a preset slew rate so that the voltage is increased in a number of steps. However, it is still advisable to make adjustments gradually and observe the effect.

When operating in ECC mode, turning the encoder wheel with **SOURCE** selected determines the desired emission current level. Turning the control to full scale will yield the maximum emission current. This is read on the **EMISSION** current meter on the display screen. The specific values for the ECC range vary with the electron gun model and cathode type.

CAUTION: In ECC mode, go slowly when increasing SOURCE with the encoder wheel and do not go past the point where increasing the called-for emission produces a parallel increase in source current and source voltage. The wheel is variable so it is easy for the user to turn it too far without realizing it. The Zener limit is set for a particular source voltage. With a given set of parameters, this source voltage will correspond to an particular emission current signal, but the wheel can be turned past this point, increasing the signal without increasing the actual emission or source voltage due to the limit. If the parameters, such as grid or focus, are later changed in a way that permits more emission, the unintentional higher signal will call for more emission and result in an unexpected change in source current or voltage. This may also produce unstable oscillations in the source.

Do not switch from ECC Mode to Source Mode while the electron gun is running.

When operating in Source mode, turning the encoder wheel with **SOURCE** selected determines the source voltage directly. Turning the control to full scale will yield the maximum source voltage. A high voltage will produce a high current through the cathode depending on the V-I characteristics of the cathode which vary with cathode type and size, cathode temperature and the slight variations in cathode geometry. A high source current and voltage can will result in short cathode lifetime. If the **SOURCE** control has been turned all the way up while operating in ECC mode and then the power supply is switched to Source mode, source current will immediately be switched to its maximum level, reducing cathode lifetime.

CAUTION: If the **SOURCE** voltage and current values on the display screen become highlighted (or if the **Overcurrent** button on the computer turns yellow), this is a warning that indicates that the Source current has reached or exceeds the recommended maximum operating current. Running the Source current this high greatly reduces the cathode lifetime.
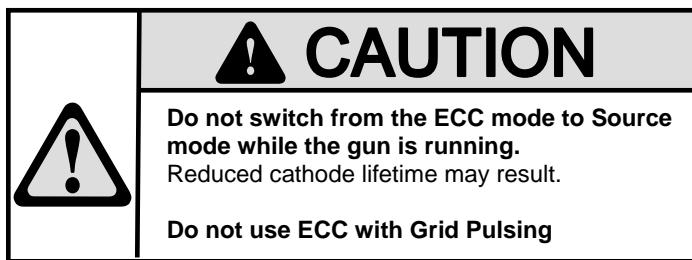
For systems with the Grid Pulsing option, do not operate the electron gun in ECC mode if using the Grid Pulsing. Reduced cathode lifetime may result. The ECC circuitry is designed to be a DC feedback system. During grid pulsing, the average emission current is close to zero and the ECC feedback will raise cathode temperature to try to compensate for the lack of emission current while the gun is pulsed off.

The Zener limit, which controls the maximum source voltage and the maximum emission current, has been preset at the factory for the Source board. If, under normal operating conditions, the desired emission current range cannot be achieved while the ECC circuit is in use, please call the Engineering Department at Kimball Physics at (603) 878-1616. Note that the Zener limit is meant to protect the cathode from high, life shortening, current. Achieving the full emission current range under all operating conditions will not be possible.

CAUTION: The Zener limit is calibrated for a particular gun and a particular cathode. When a different type of cathode is installed or the cathode is replaced by the user or the gun is rebuilt, the Zener limit may need to be recalibrated. Call Kimball Physics at (603) 878-1616.

OPERATING PROCEDURE FOR ECC MODE

> ⚠ **CAUTION**
>
> **Do not switch from the ECC mode to Source mode while the gun is running.**
> Reduced cathode lifetime may result.
>
> **Do not use ECC with Grid Pulsing**

1. Set-up:
   a. To assure low cathode temperatures, initial emission current adjustment should be done with little or no grid bias. Once operating in the ECC mode, the beam may be optimized by slowly adjusting the grid bias while maintaining source current. Excessive source current will reduce cathode lifetime.
   b. Using the **SOURCE** control (encoder wheel or computer control), decrease the Source voltage to zero.
   c. Turn on the ECC feedback circuitry by one of the following methods:
      i. On the EGPS, switch the amber **ECC ON/OFF** rocker switch on (**I** position) to enable the ECC feedback circuitry for ECC mode.
      ii. On the EGPS FlexPanel display screen, select **ECC ON (1) OFF (0)**, and turn the encoder wheel clockwise a few clicks until a **1** is displayed.
      iii. With the LabVIEW^{TM} program, set **Source/ECC** toggle switch on the computer to **ECC**. On the computer the Source control is relabeled **ECC** when in ECC mode.

2. Adjusting Emission Current Control:
   a. Slowly increase the **SOURCE** control (encoder wheel or computer **ECC** control) up to one tenth of the range or about one turn with the encoder wheel. Then wait.
   b. After a delay, the Source voltage and Source current will start to rise. It may take a few minutes to rise to the emitting range.
   c. GRADUALLY, turn up the **SOURCE** control until the desired emission current is achieved. Monitor the effect on the **EMISSION** current meter, as well as the **SOURCE** voltage and current meters. The ECC range varies with the gun model and cathode type.
   d. **CAUTION: With FlexPanel Controls, care must be taken not to increase the Source voltage too rapidly with the encoder wheel.** Due to capacitance in the cathode system and protection in the power supply circuitry, there is a delay in the response to voltage changes. Make small changes, and then wait until the Emission current has stopped drifting up, before continuing. Because the encoder wheel has a variable rate of increase/decrease, it is possible to turn the ECC up higher than is intended. **Do not go past the point where increasing the called-for emission produces a parallel increase in source current and source voltage.**

(Adjusting Emission Current Control cont.)
   e. **CAUTION:** If the **SOURCE** voltage and current values on the display screen become highlighted (or if the **Overcurrent** button on the computer turns yellow), this is a warning that indicates that the Source current has reached or exceeds the recommended maximum operating current. Running the Source current this high greatly reduces the cathode lifetime.

3. **For Remote Programming**: On a power supply with a 50-pin **EXTERNAL INTERFACE** rear panel connector, the ECC option can also be controlled by a 0 V to +10 V programming signal (such as might be provided by a D/A supply). A +10 V signal will yield the full-scale emission current value. (For example, with a 0 to 500 μA ECC range, +10 V will yield 500 μA, while +5 V will yield half the ECC range or 250 μA, etc.) See the following section on remote/ computer control.

4. **For Pulsing:** Do not use ECC mode; use normal Source mode.

5. Turning off the ECC option:
   a. Using the **SOURCE** control (encoder wheel or computer **ECC** control) turn down the emission completely, so that the Source voltage and current meters read zero. Failure to do so could severely damage the cathode and greatly shorten the cathode's lifetime.
   b. Turn off the ECC feedback circuitry by one of the following methods:
      i. On the EGPS, switch the amber **ECC ON/OFF** rocker switch off (**O** position) for Source mode.
      ii. On the EGPS FlexPanel display screen, select **ECC ON (1) OFF (0)**, and turn the encoder wheel counterclockwise until a **0** is displayed.
      iii. With the LabVIEW^{TM} program, set **Source/ECC** toggle switch on the computer to **Source**.

This completes the ECC Instructions.