BUILDING THE CDV700Pro Geiger-Mueller / Scintillation Counter

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George Dowell (A.K.A. K0FF, GeoElectronics) started the trend of modifying the Electro Neutronics CD V-700 model 6b into a Lionel CD V-700 model 6b clone. In George’s words:

“The Electro-Neutronics CD V-700 model 6b has had a bad reputation for 40 years. On the other hand, the Lionel CD V 700 model 6b is regarded by many as the best circuit ever. Surprisingly, of all the variations in CD V 700's I have seen, including Victoreen's various models, and the Antons, there is no circuit more similar to the Lionel's than the ENi! At least it is similar enough to make a logical transformation that is really significant electronically, but easy to do. In my opinion the physical layout of the ENi is better than that of the Lionel, so the merger of the Lionel circuit concept into the ENi mechanical layout really does give the best of both worlds. By performing the simple and inexpensive K0FF LENi mod, you can create a Lionel clone from an ENi.”
David Prutchi’s CDV700 Pro

- The “CDV700 Pro” is based on K0FF’s LENi, but adds the following features:

  - Preamplifier to make it compatible with scintillation probes (GM tubes can still be used)
  - Selectable, regulated bias voltage (900V or 1,200V) for connection to GM tubes and photomultiplier tubes. A blinking indicator warns of the high voltage selection.
  - Noise-reduction circuitry eliminates hum.
  - Internal piezo clicker.
  - Power input jack saves batteries when powered from car or AC-operated power supply.
  - 8-digit digital counter.
CDV700 Pro Controls

- Integrator capacitor reset
- Meter response selector (Fast/Slow)
- Probe type selector (GM tube or scintillator)
- External 3VDC power input
- Blinking indicator warns of 1,200V HV selection
- Headphone jack
- Probe connector
CDV700 Pro Displays

- 8-digit count totalizer
- Analog rate meter
Schematic of unmodified Electro Neutronics CD V-700 Model 6-b Geiger-Mueller Survey Meter
David Prutchi, July 2005
ENi CD V-700 model 6b PCB component location
Schematic Diagram of David Prutchi’s CDV700 Pro
Step 1: Convert the ENi CD V-700 into a LENi (almost…)

- Study the schematic diagram of the original ENi CD V-700 and identify the components on the PCB.
- Disconnect the GM probe.
- Follow George Dowell’s instructions for modifying the power supply section:
  - Remove Zener diode CR6 (sometimes 2 diodes in series) and discard, it will not be used.
  - Remove R13 and reinstall it in series with the base lead going to the oscillator transistor.
  - Add a 0.0022μF 50V capacitor between the base and collector of transistor V4 (Q4).
  - Substitute CR5 (D5) by a modern >5kV silicon diode. I use a Fuji ESJA53-20A, 20kV, 0.5A, 5mA diode.
  - Substitute C8 by a modern 0.01uF @ 3kV capacitor.
  - Substitute C5 by a 0.0022uF @ 3kV capacitor.
  - Replace R13 by a 1.8MΩ and a 3.3MΩ in series.
To Probe

- R12 3.3M

- C6 47uF 60V  D4 1N4001

- Q4 2N404A

- R13 1k

- ENI CD V-700 TRANSFORMER

- D4 1N4001

- C10 0.0025

- R17 1.8M

- D5 15kV Silicon

- C8 0.01uF 3kV
Check your progress

- Check that your DMM has a 10MΩ input impedance when set to a range suitable for measuring 200VDC (use a second multimeter to measure the resistance across the input terminals of your DMM).
- String 9 10MΩ resistors in series to make a X10 probe:
  - Body of plastic ballpoint pen contains 9 10MΩ resistors in series
  - Dab of epoxy
  - Wire-wrapping pin
  - Silicone-coated probe cable
  - Banana plug
- Use this probe to measure the voltage across C8. With no GM tube connected, you should measure between ~1,300 and ~1,900VDC (130 to 190V on your multimeter).
Step 2: Build the Zener Stack

- Build the Zener-diode stack using 9 1N5383 150V Zeners and 2 NTE5081A 24V Zeners.
- Use piece of perfboard as a substrate. Place 1 layer of Kapton insulation and add C15 to the back side of the board. Wrap the assembly with Kapton tape.
Step 3: Connect the Zener Stack

- Mount the Zener-diode regulator board onto the CD V-700 PCB. Make a small hole on the edge of the CDV’s PCB and connect the ground end of the regulator board directly to the ground line on the CDV’ PCB:

  ![Image of Zener Stack Connection](image_url)

  Make hole and connect directly to GND

- Check your progress: If you power the instrument, the voltage across C15 should be ~1,200V and ~900V if you short the cathode of D17 to GND.
Step 4: Add Biasing Circuit

- Add R14, R15, R16 and C9. Consult George Dowell’s instructions on modifying the CD V-700 PCB to accommodate these components.
Step 5: Modify Metering Circuit

• Remove CR7 (D7). Connect the emitters of the metering transistors in parallel and route them to the -3V line. Consult George Dowell’s instructions on modifying the CD V-700 PCB.

• Replace L1 with an 18kΩ 1/2W resistor (R18 in the CDV700 Pro schematic).

• Modify the circuit to insert a 10Ω 1/2W resistor between the anode of D4 and the “-15V” line feeding the metering circuit.

• Replace C6 by a 47μF 60V electrolytic capacitor.

• Replace C1 by two 100μF capacitors. Leave the negative terminal of one of these capacitors open so that it can be connected to the front-panel time-constant selection switch.
Step 6: Mount Probe BNC Connector

• Remove and discard the sealing nut through which the GM probe cable passed.

• Tap this hole using a 3/8” diameter 32 tpi pitch tap (McMaster-Carr 25705A64).

• Mount a non-isolated bulkhead BNC connector (Jameco 71589) on this tapped hole.
Step 7: Modify Front Panel

- Drill front panel (use casting marks on back side) to accommodate the extra switches, connectors, piezo speaker and LED:
Step 8: Wire the Front Panel to PCB

- Wire the instrument using clean, new cable with insulation for the appropriate voltage rating.
- Route cables next to the enclosure and keep connections as short, direct and clean as possible.
- Use high-voltage test lead wire between the PCB and the center terminal of the probe BNC.
- Use good heat-shrink tubing to dress all switch connections.
- Keeping things tidy will really pay off later. Once the PMT preamplifier is added, noise will creep into the system if you don’t pay attention to your wiring habits.
Step 9: Test your “Almost LENi”

- Measure the voltage at the BNC connector using the high-impedance X10 probe:
  - You should read ~1,200V with the probe selector switch in the “Scintillator” position. The blinking LED should light up and blink.
  - You should read ~900V with the probe selector switch in the GM position. The LED should remain off.

- Turn the probe selector switch to the “GM” position. Connect a GM probe (e.g. the original CD V-700 probe that has been connectorized). The unit should produce background clicks and be able to detect the radiation emitted by the operational check source.
Step 10: Install the Digital Totalizer

- Use a nibbling tool to cut a 68mm x 33mm rectangular hole on the enclosure bottom to accommodate the Veeder-Root A103-000 Totalizer.
- Connect the totalizer to the circuit and verify that the counter advances once for every “click”
Step 11: Build the Preamplifier

- Build the preamplifier circuit on a small piece of prototyping board. Keep wires short and the circuit neat and organized.
Step 12: Mount the Preamplifier

• Unsolder C5.
• Mount the preamplifier board directly onto the CD V-700 PCB as shown in the pictures and wire C5 and C12 between the preamplifier board and the CD V700 PCB:

• Add the ground wire and bypass capacitors C16 and C17.
Step 13: Complete Assembly

• Add a 2-D-cell plastic battery to make space for the preamplifier circuit. Make some mounting holes on the PCB and mount it using ¼” nylon spacers.

• Connect a scintillation probe (next section), set the probe selector switch accordingly and trim R26.

• CONGRATULATIONS! You have completed modifying the ENi CD V-700 model 6b into a CDV700 Pro!
David Prutchi’s Scintillation Probe for the CDV700 Pro

Thick cardboard tube ~2” ID

8” x 2” dia NaI(Tl) scintillation crystal in steel jacket

XP2102 PMT

Voltage divider

2” OD PVC
Schematic of Scintillation Probe for "CDV700 Pro"
Other Scintillation Probe Ideas

- Charlie Thompson’s paint can scintillator:

- Charlie Thompson’s Hamamatsu R1307 conversion circuit:
APPENDIX

A compilation of material by George Dowell on modifying the ENi CD V700 model 6b into a “LENi”
Fig. 6 — Printed Circuit Board (Component Side)
LENI Mods
P.C. Board Location Points

+ is also sound card positive
- is also sound card negative

Battery connection

Drill hole for Zener ground, solder to edge trace

10k X2 scale

+ X2 resistor pot location

V3
V2

BATTERY POS
BATTERY NEG

Zener string 900V worth

Cut-Traces.jpg

DO NOT CUT THIS
SEE TEXT

3. Extensions for Various Parts
HV Control Wire

VARIABLE HV POT LOCATION
K0FF’s Zener Diode Board
Schematic of "LENi": ENI CD V-700 Model 6-b modified per instructions by George Dowell (AKA GeoElectronics, K0FF) David Prutchi, www.prutchi.com July 2005