BAFARO ENGINEERING MODEL BE675B OWNERS MANUAL

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Figure 1: Front of BE675B

The BE675B is designed to replace the original zinc carbon 67.5V “B” battery used in the Nems Clarke 120B and similar portable vacuum tube radio receivers built in the 1950s. This also includes the AM broadcast radio receivers and other consumer equipment built with the 1.5V filament tubes. This unit can save these tube receivers from being scrapped because the zinc carbon “B” batteries are out of production and last of the stock is almost exhausted. This supply will replace the “B” batteries as long as “AA” batteries are available.

The BE675B uses 8 “AA” batteries along with a boost converter to boost the 12V basic battery voltage to 67.5V for use as a plate voltage supply. Since this unit has a boost regulator the 67.5V is regulated until the “AA” cells are down to 1V per cell. This is better than the original zinc-carbon “B” battery which was basically un-regulated.

Because this module is made to replace the zinc carbon 67.5V “B” battery its output voltage is above the safety limit of the SELV (safety agency) rated voltage of 60V and as such it is to be **used only by those familiar with the safe handling of HIGH VOLTAGE devices.**

The BE675B has magnetic design and filtering adequate to not disturb the meter reading of the Nems Clarke 120B measurements. The unit has a two terminal power distribution strip on the top of the unit that can be adapted to any connector scheme the owner desires. The supply is floating relative to the case of the unit so that the receiver bias voltage scheme used in the Nems Clarke 120B will not be disturbed. Note that the case is automatically grounded to the case of the 120B when it is installed in the meter. If the BE675B is to be run external to the 120B or similar receiver so that the case is not connected to the case of the receiver then a ground wire from the module to the chassis of the receiver must be provided so that the case of the supply is connected to the chassis of the receiver so that the shielding of the supply is complete to minimize interference in the radio reception. A ground solder lug is provided on the top of the unit for case grounding if necessary.

The basic current draw of the tested Nems Clarke 120B is in the range of 6mA and with the efficiency of the boost converter projected “AA” battery life in the 120B is about 20 to 30 hrs. The basic life of the “AA” batteries can be extended by turning **off** the boost converter when the module is not in use as the boost converter has a standby current draw (due to the switching losses) even when the tubes are not conducting. An on - off slide switch is provided on the top of the unit to turn it off when it is not in use.

The “AA” batteries can easily be replaced by removing the 2 screws that hold on the bottom of the module and pulling out the battery clip. The “AA” battery clip is connectorized for easy handling. When replacing the battery clip **do not over tighten** the 2 mounting screws.

The boost converter is current limited to a maximum of 60mA. At this level of current draw the “AA” battery life will be greatly reduced. Also note that if the unit’s output is shorted <12

Ohms (as might be the case if the radio has a shorted cap or a short in the wiring) the internal 1A pico fuse will be blown open. **Do not defeat this safety feature.** The current limiting feature of the boost converter does not work down to a short because of the basic topology of the boost converter. In the case of this boost converter topology there is a direct connection between the "AA" batteries and the output through the boost coil, diode and output filter choke even with the boost transistor not conducting.

Theory of operation:

The basic power source is eight series connected "AA" cells to make a nominal 12V power source. This voltage is boosted by a switching regulator with the ON semiconductor NCV8870 along with L1, Q1, D1 and the boost capacitor C5. When the input 12V is above the startup voltage set by R5 and R6, the enable comparator (inside U1) will activate the PWM. The regulator IC will send pulses to Q1 to make it conduct causing current to flow in L1 and hence causing energy to be stored in L1. When the clock cycle is completed in U1, Q1 is shut off and the voltage at is collector rises and D1 conducts dumping the energy in L1 into C5. The voltage at the top of C5 is divided down by R9, R3, and R4 and fed to negative input of the error signal amplifier inside U1. When this feedback voltage is equal to or exceeds the reference voltage at the positive input of the error signal amplifier of the PWM (1.2V) inside U1, it will turn off Q1 sooner, reducing it's "on" time and thereby limiting the output voltage by limiting the amount of energy stored in L1. The duty cycle of the regulator is set by the ratio of the input voltage to the output voltage desired.

C4 and C6 are bulk storage capacitors to keep the switching pulses from going back to the battery wiring. They also keep the VCC voltage to U1 stable in the short term. R1, C1, and C2 form a lead – lag network, which are the phase compensation components that keep the phase shift around the control loop to less than 360 degrees to insure stable operation. The phase margin of this loop is approximately 60 degrees.

R7 and C7 form an RC roll off to keep short duration spikes caused by the gate capacitance of the switching FET from falsely triggering U1's over current protection comparator. R2 senses the current in Q1 and sends it back to U1 which will trip at a current in the FET above 1A. C3 is a filter cap for the internal gate supply voltage U1 sends to Q1 during operation.

Secondary output filtering is provided by L2 and a 1uF cap (not shown on the schematic) mounted at the output terminal strip. This is an L – C low pass filter.

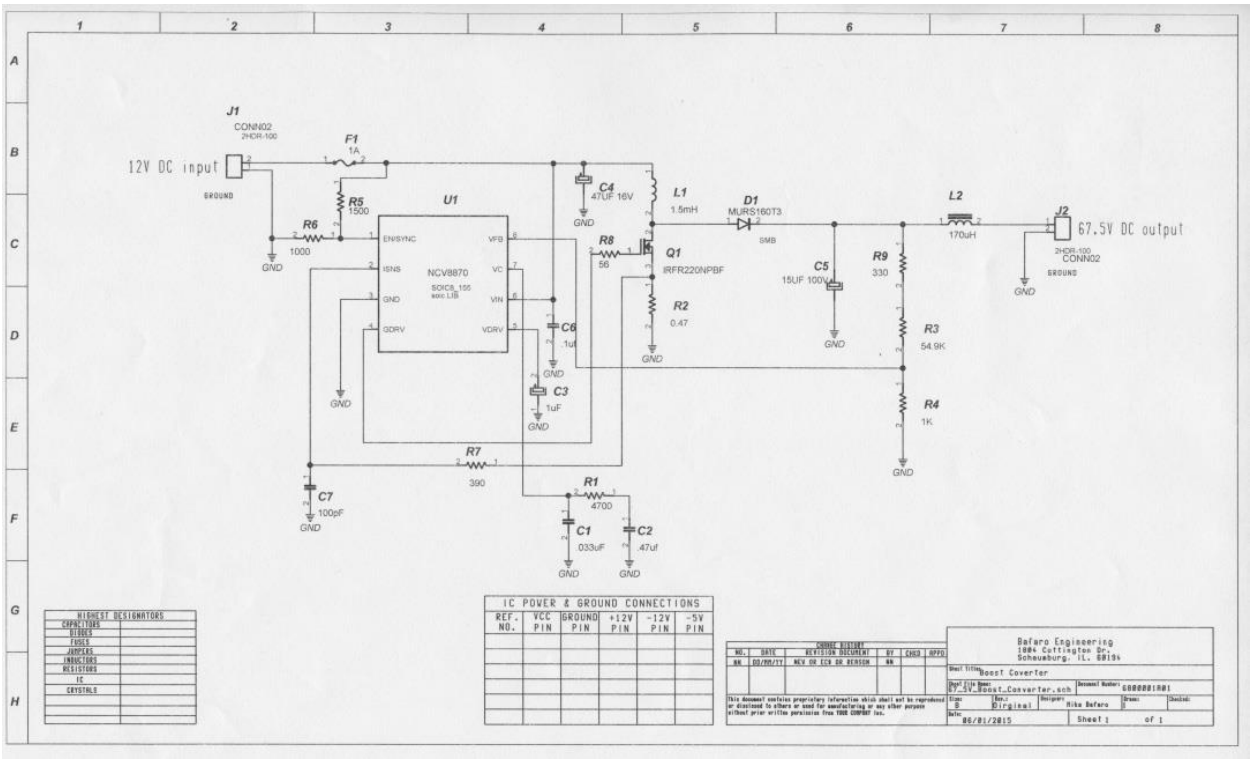

Figure 2: Schematic diagram

Parts list:

Ref Des	Quantity	value	part nunber
C1	1	.033uF	495-2545-1-ND
C2	1	.47UF	399-11514-ND
C3	1	1UF 50V	493-12567-1-ND
C4	1	47UF 16V	493-11507-1-ND
C5	1	15UF 100V	493-1660-ND
C6	1	0.1UF	399-1249-1-ND
C7	1	100PF	399-1122-1-ND
C8	1	Foil cap 1uf 100V	80-R82EC4100Z370J MOUSER
D1	1	1A 600V FAST REC	863-MURS160T3G MOUSER
L1	1	1.5mH Pulse Elec	PE-53614NL
L2	1	170UH Coil Craft	SPT30L-174MLB
F1	1	1A FAST LITTLE FUSE	576-0251001.MXL MOUSER
Q1	1	2A 200V FET	IRFR220TRLPBF
R1	1	4700	P4.7KACT-ND
R2	1	.47 3W	P0.47W-3BK-ND
R3	1	54.9K	P54.9KCCT-ND

R4	1	1K	541-1.00KAWCT-ND
R5	1	1500	RMCF0805JT1K50CT-ND
R6	1	1K	541-1.00KAWCT-ND
R7	1	390	RMCF0805JT390RCT-ND
R8	1	56	RMCF0805JT56R0CT-ND
R9	1	330	RMCF0805JT330RCT-ND
U1	1	NCV8870	863-NCV887001D1R2G MOUSER
BAT CL	1	8 AA BAT CLIP	27-1335 MCM
SW1	1	SPST SWITCH 3A	GF-123-3011
STAND OF	2	6-32 X 5/8"	728-FC2106-632-A
CN1	1	9v battery connector	29-130 MCM
PCB	1	PC board	84D675A04 FRED R
Case	1	CASE SHEET METAL	E-M METAL FAB
SCREWS	1	6-18 X 1/4 PHIL HD SCR	90190A144 MC MASTER
SCREWS	6	#4 X 1/4 FLT HD PHIL SCR	90048A106 MC MASTER
LUG	1	6 INTERNAL TOOTH LUG	7312K-ND
TERM ST	1	2 PLACE TERM STRIP	504-A50110207 MOUSER
SCREWS	4	6-32 X 1/4 ST SLOT	90283A144 MC MASTER
SCREWS	2	4-40 X 3/8 ST SLOT	90283A108 MC MASTER
NUTS	2	4-40 X 3/16 NUTS	90760A005 MC MASTER
LOCK WA	2	# 4 INT TOOTH LK WASH	91113A005 MC MASTER
WIRE	1	4 INCH RED WIRE	A2015R-100-ND DIGIKEY
WIRE	1	2 INCH BLK WIRE	A2015B-100-ND DIGIKEY
RIVET	4	3/16 INCH POP RIVET	97525A300 MC MASTER
TAPE	1	3 INCH OF BLACK TAPE	3M88A-ND DIGIKEY
SOLDER	AR	60/40 SOLDER	

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