Replacing the Mechanical Vibrator in the DY-88 Power Supply for the GRC-9 Transceiver

by Craig Vonilten, N6CAV with contributions by Tom Murphy W6TOM

As older mechanical vibrators fail (and they will ALL fail at some point) a suitable replacement is needed. I have gone through several different ways of doing this in keeping my DY-88 power supply functional. Initially I did this by repairing the mechanical units (opening and cleaning their contacts), then building my own solid state replacement and finally using ‘kits’ and designs by other amateur radio enthusiasts. All approaches have some merit…but I have settled on an indestructible approach using a small module made by Aurora Design originally intended for restoring commercial automotive radios. Consequently, this article is really more mechanical in nature than it is electrical ‘design’ related.

I am using this module because it is incredibly well designed for this application. It has eliminated any desire to “roll my own”. This module is microprocessor controlled. Yes, you read that correctly…it has an onboard microprocessor that provides numerous advantages over traditional designs based on RC timed ‘blind’ switching or 555 timer solutions. With a microprocessor on-board, this module brings some “smarts” to the traditional switching circuit such as: dead-band control, delayed start, soft start, delayed restart, short circuit protection and over-power protection. Better yet…it can help protect downstream devices like the transformer (which would normally be destroyed by a traditional vibrator or solid state module if a buffer capacitor were to fail to a short circuit…not uncommon).

<u>Step 1 – opening the can</u>

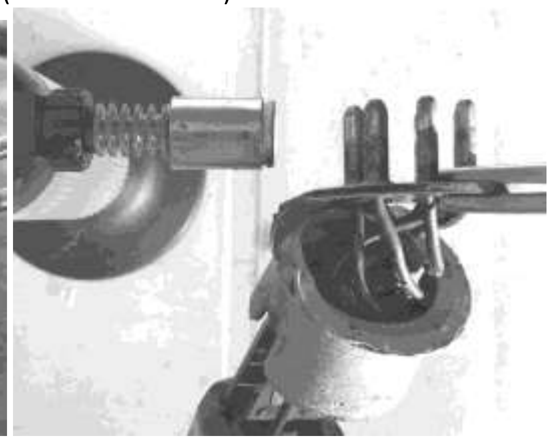
The best way to remove the guts of the old vibrator is to use a bench disc sander to remove the rolled lip at the bottom. With minor care, this will leave no tooling marks on the case and provide a nice platform for later re-assembly. Removing just the rolled portion of the lip (minimizing any sanding of the phenolic base) will allow you to pull the case off the round phenolic piece that has the pins and slide out the mechanical vibrator assembly.



Step 2 – Dis-assembly and Cleaning

The old vibrator internals should now be unsoldered from the pins. A small butane torch works best (shown)…but a soldering iron can be used to remove individual wires from the pins. Most of the solder should come out with the wires…but if not, you can use some solder wick or some stranded copper wire to wick and clean the inside of the pins or use a solder sucker. The inside of the can may have a dark residue; this should also be cleaned out. A scotch bright pad with soap and water works well (be careful not to cut your finger on the sharp edges of the can). The residue is probably from the rubber seals and noise dampeners and may have sulfur in it (which is corrosive).

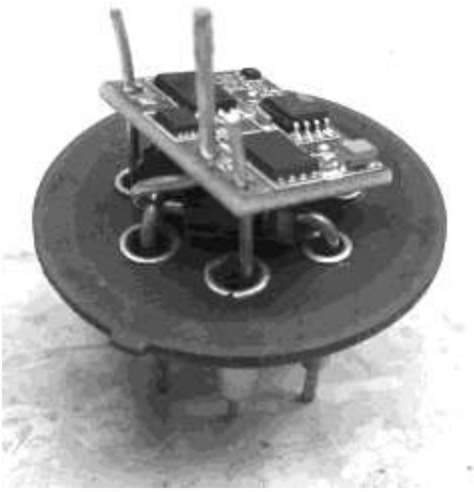


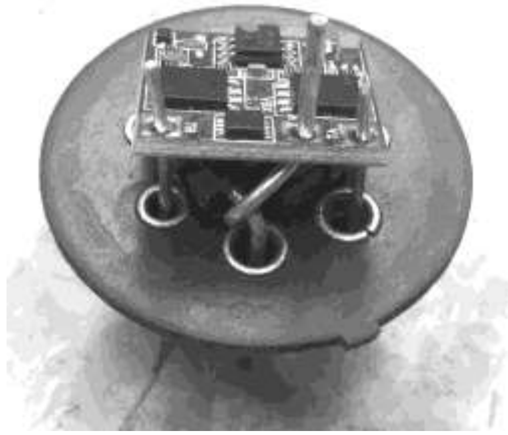


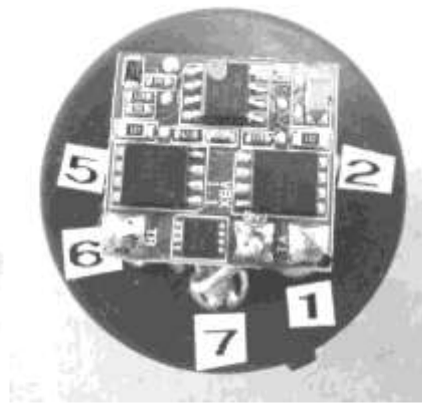
Step 3 – Re-building the Vibrator

Turn the phenolic piece with the pins so the pins are facing up, note there two large diameter pins and on my vibrator there was a tab in the phenolic between those two large diameter pins. The pins are numbered 1 to 7, pin 1 is the large diameter pin on the right, and pins are counted clockwise from that pin. You will need to locate pins 1, 2, 5, 6 and 7. NOTE: The connections are made from the top so once you have located the pins and are re-assembling the module; the direction of the pin count is counter-clockwise when looking at the pin cavities from the VBN-1 module side. Double check yourself. It would be a good idea to number the pins on the module side of the assembly.

The DY-88 typically uses a synchronous vibrator (versus a shunt vibrator) which simply means it also acts as a 'rectifier' with a few extra contacts used to direct current flow. This function is replicated with two diodes. Many different values can be used as long as the voltage and current ratings meet the needs of the circuit. Anything over 100V and 1A should be fine. I used two 1N5406 diodes rated at 600V and 3 amps for some added design margin. Install the diodes with the cathode (the end with the band) at pins 2 and 5, the anode ends of the two diodes will connect to pin 7. At pin 7 you will want the anodes of both diodes connected along with a wire extended up about an inch. I like to use one diode pin as the socket connection…and the other for connection to the GND point on the VBN-1 module as shown. The wires should extend out of the socket base pins. You will also want to be sure that the wires are bent in such a way that you can center the VBN-1 module on the socket base. If you use the VBN-1 module for 'fitting' be aware that it is a Static Sensitive Device so proper handling should be observed when you remove it from the static bag. ADJUST ALL WIRES BEFORE SOLDERING. At pins 1 and 6 solder a piece of solid 20AWG wire; so that they line up with points TA and TB on the VBN-1 module.





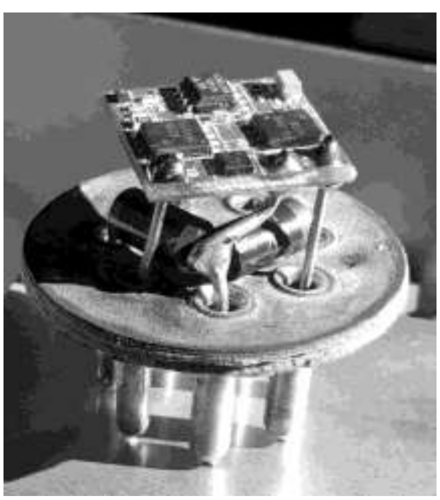


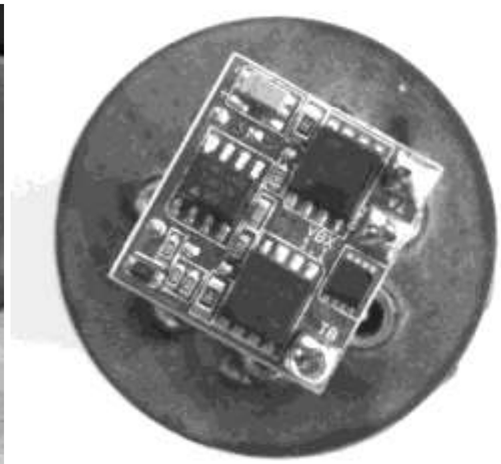
Looking at the component side of VBN-1 module there are 3 holes on one side, from left to right the holes are labeled TB, GND and TA. TB is on the left corner of the module, TA on the right corner, GND is just to the left of TA.

Holding the VBN-1 module, with the TB connection on the left, you should find that pin 6 aligns with TB and pin 1 aligns with TA and the pin 7 connection is bent to align with GND. This will center the module on the vibrator base. You are now ready to solder the wires to the pins but you might want to check this chart just in case.

Vibrator Pin Location	VBN-1 Connection
Pin 1	TA
Pin 6	TB
Pin 7	GND

Next you will solder the VBN-1 module to the pins. Be sure to flow the solder all the way through the plated hole and adjust the board with the first soldered connection so that it is centered and horizontal as a finished assembly. The wires can be soldered at the tips of the socket pins.





The assembly should be tested in your DY-88 power supply and once you've confirmed that you've assembled this correctly and that it works, it can be re-installed into the original case. Simply mix a small amount of JB Weld Epoxy (which I prefer both for color and strength) and apply this to the inside lip of the case. Place the assembly into the case and wipe away any excess from the lip of the can with a disposable rag. Wait 24hrs for full cure strength and you're ready to go.

(optional)
Use potting compound to give the vibrator the same weight/feel, and to further environmentally seal the VBN-1 module. To do this, you will need to be sure that the pins are ALL soldered closed at their tips. Then simply fill the case about halfway with the mixed/prepared potting compound before applying epoxy and setting the assembly into place. Then turn the entire assembly so that it is resting on the pins. You should have used enough epoxy to completely 'seal' the edge of the phenolic base to the case…and the pins must all be soldered closed, or the potting compound will drain out and you will have a mess.

<u>VBN-1 Reference Information</u>
Information: http://www.tech-retro.com/Aurora_Design/Accessories.html
Available: http://www.tech-retro.com/Aurora_Design/Auto_Dealers.html

Measured Results and Comparisons

Performed by Tom Murphy, W6TOM

Test Configuration

DY-88 connected to a GRC-9 set tuned to WWV @ 10MC and powered by deep-cycle lead acid batteries measuring 12.6Vdc under load. The volume was set at a comfortable non-migraine inducing level. Measurements were made using a Fluke 177 True RMS Meter and a Fluke clamp-on current probe for current measurements. Oscilloscope is a Tektronix 2235. Measurements were taken after more than 30min of operation.

Comparison Summary

	Mechanical Vibrator	**VBN-1 SS Module**
Current	1.0A	0.9A
Plate Voltage	99v	104v
Frequency	115Hz	115Hz
RFI	-tbd-	Low (see details)
Thermal	Low (see details)	Low (see details)
Waveform	Square	Sloped rise/fall

Table 1 – Operating Comparison Chart

RFI

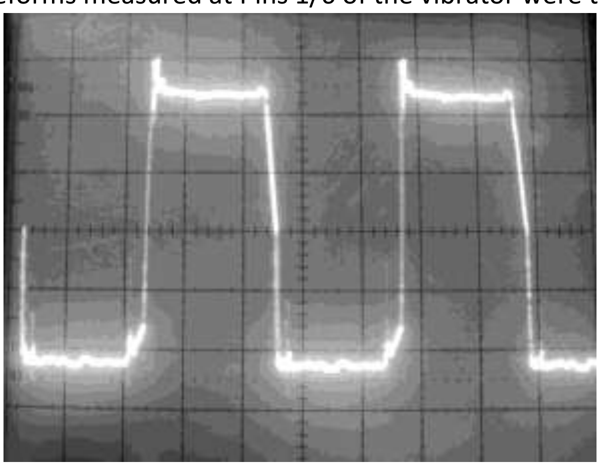
Using a small wire loop by the SS module (without the exterior can 'cover') and an Icom 756 Pro as a crude spectrum analyzer, there was no apparent RFI, looking at the 10MC, 7MC, 5MC and 3.5/4.0MC bands.

Thermal

The SS module and its switching devices were at room temperature after running for 30 minutes listening to WWV on 10MC. No noticeable heat rise on the switching devices.

Waveform Analysis

The waveforms measured at Pins 1/6 of the vibrator were the same. A 1X probe was used.



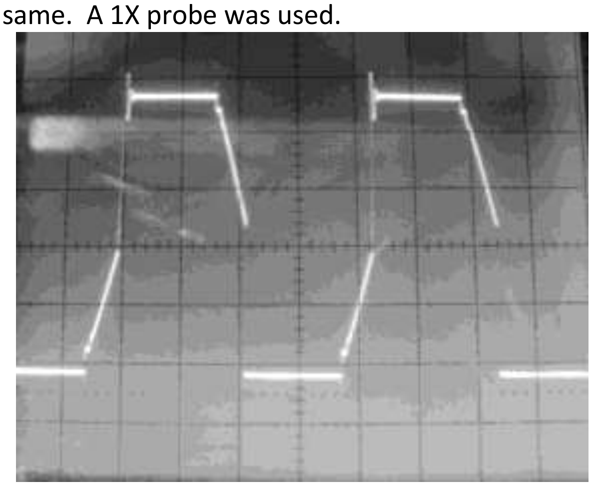


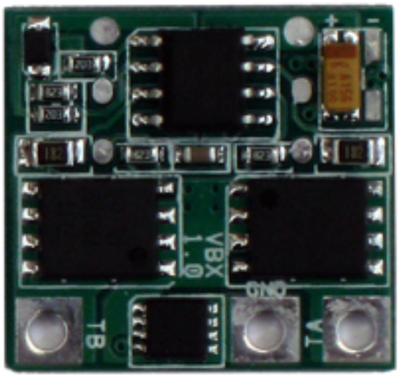
Figure 1 – Mechanical (left) and Solid State Vibrator (right) Waveform Analysis

The solid state waveform is 25 volts peak to peak (the DC is fed through the center tap of the transformer winding). The solid state waveform has symmetry, but shows the "on/off" ramp of the switching devices. Otherwise the switching waveforms between the solid state module and the mechanical vibrator were very similar. The period of both signals was close to the 8.7ms that a 115 Hz signal should have.

GRC-9 Power Requirements (reference)

Transmitter Plates: 475 - 580v @ 100ma
Transmitter Filaments: 6.5 - 6.6v @ 2 amps
Receiver Plates: 105 - 120v @ 45ma
Receiver Filaments: 1.35 - 1.5v @ 500ma
Keying Relay: 6.0 - 6.9v @ 575ma

Aurora Design VBx-1 Electronic Vibrator



The VBx-1 electronic vibrator represents a whole new paradigm in vibrator replacements. Microprocessor controlled for the highest accuracy and features available, nothing else even comes close!

Full protection against reverse battery, shorted outputs and over power, the VBx-1 is nearly indestructible. Because of this ruggedness, the VBx-1 can be hard wired into the circuit or wired to an original style vibrator base, even placed inside the can of an original vibrator! With this flexibility, hard to find 5, 6 and 7 pin vibrators are no longer an issue. Operating from 3.0 - 18V (12-36V for VBF-1), only one board is required for all positive ground installations and one for all negative ground installations.

Through the use of sophisticated algorithms, the microprocessor allows the VBx-1 to offer such unheard of features as deadband control, delayed start, soft start, delayed restart, short circuit protection and over power protection, all with astounding accuracy. The deadband control, delayed start and soft start features in particular greatly reduce the stresses on the transformer, rectifier and filters extending their lives.

Not only does the VBx-1 protect itself, but it also protects expensive parts in the radio like the transformer, rectifier and filters. Unlike simple “dumb” electronic vibrators that will burn a transformer up if something as simple as the buffer capacitor shorts, the VBx-1 immediately senses this condition, protecting itself and the radio components until the buffer capacitor can be replaced! No longer can a careless user destroy expensive parts in their radio simply by leaving it turned on after a failure.

Another great use for the VBx-1 is driving the synchronous seek motors as used in late 1950’s Ford-Benidx Town and Country® radios. By retaining the original motor and power transformer, no modifications to the mechanism are required saving time and money.

Always replace the buffer capacitor!

	VBN-1 (negative ground)	**VBP-1** (positive ground)	**VBF-1** (24V/32V)
Operating Voltage:	+3.0V to +18V	-3.0V to -18V	+12V to +36V
Trip Current:	~7A	~7A	~4A
Frequency:	115Hz ±2%	115Hz ±2%	115Hz ±2%
Deadband:	25%	25%	25%
Dimensions:	0.70” X 0.75” x 0.14” (18mm X 19mm X 3.5mm)		
Operating Temp:	-40°C to +65°C ambient (-40°F to +150°F)		

VBx-1 Connections:

The three terminals, TA, TB and GND are the only required connections to the VBx-1. The TA and TB connections go to each leg of the transformer while the GND connects to chassis ground. The unit can be mounted in any fashion as it does not generate any substantial heat. No other circuit modifications are required in the radio.

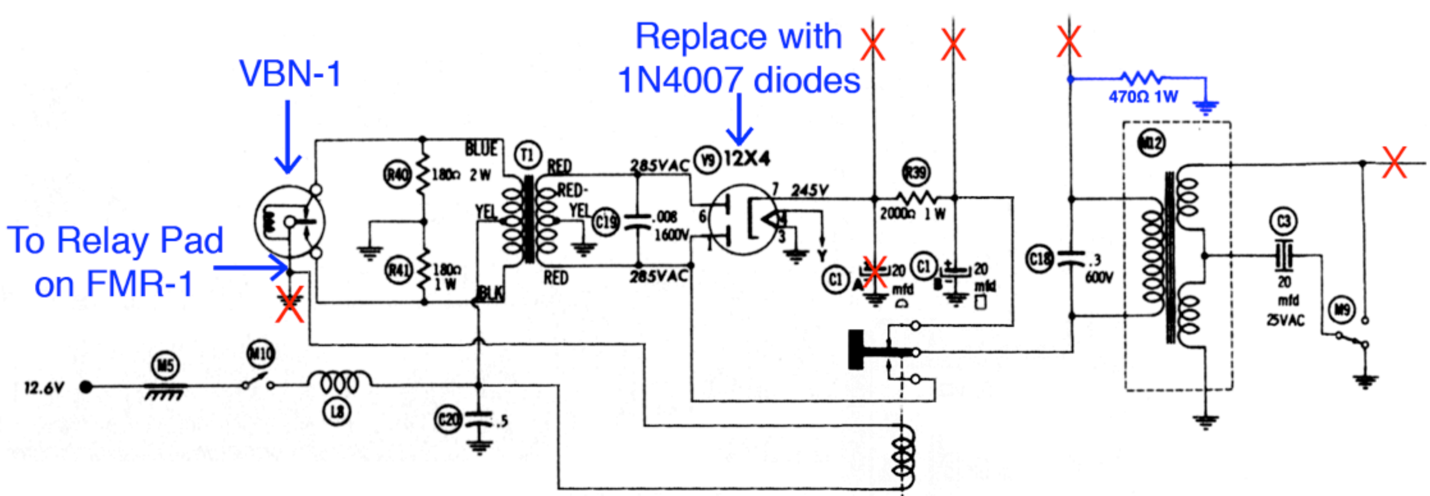
Since the VBx-1 uses such a revolutionary and robust design, there is no reason that it needs to be user serviceable. You would no more socket a modern capacitor or resistor than you would the VBx-1. The VBx-1 can be wired directly to the original vibrator socket.

If serviceability is desired, the VBx-1 can be mounted to an original base so that it can be plugged into the original socket. The metal can was originally required to reduce mechanical and electrical noise from the vibrator, so this is no longer needed but can be added for cosmetic reasons. The VBx-1 will wire to the base exactly the same as the original vibrator. On synchronous vibrators, two rectifying diodes will need to be added such as 1N4007's in place of the extra set of contacts on the original vibrator. Unlike with "dumb" electronic vibrators which will then create extremely high peak currents when starting up due to these diodes, the soft start feature of the "smart" VBx-1 controls the inrush current to the filter capacitors greatly reducing the stresses on them.

VBN-1 used with synchronous motors:

The VBN-1 is an ideal solution for driving the synchronous motors used in 1950's Ford-Bendix Town & Country® radios. These motors used the AC signal from the vibrator power supply and are extremely difficult and time consuming to change out.

Below is a partial schematic for a typical Bendix synchronous motor signal seeking radio. By replacing the vibrator with a VBN-1, replacing the rectifier with two 1N4007 diodes and retaining the power transformer and associated components including the buffer capacitor, filter capacitor, seek relay, the motor with it's two capacitors and the reversing switch, and removing all unnecessary components, no mechanical changes are required to the radio. The FMR-1's Relay output will drive the VBN-1 and seek relay directly thereby controlling the motor. The 470Ω 1W resistor is added to limit current to the motor.



Replacing a rectifier with silicon diodes:

When using silicon diodes, care must be taken so that the B+ voltage does not rise to high due to the efficiency of these diodes. Many times this voltage rise will be insignificant and can be ignored.

On radios using hard vacuum rectifiers like the 6X5, a resistor equivalent to the plate impedance should be used in series with the silicon diodes. For the 6X5 this would be 150 ohms. One common resistor or a resistor in each transformer leg can be used as long as they are of sufficient wattage.

On radios using gas rectifiers like the 0Z4 which typically have a fixed voltage drop, a zener diode or resistor should be chosen to provide this voltage drop. For instance the 0Z4 has a typical voltage drop of 24V. At a nominal current draw of 50ma, a resistance of about 470 ohms will achieve this voltage drop. Alternatively a 24V zener could be added in series with the diodes.

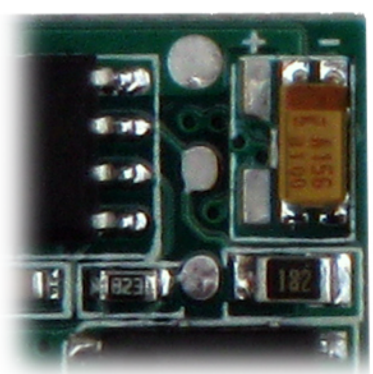
The B+ should be verified with the radio operating at normal input voltage after a warmup period.

Identifying model type:

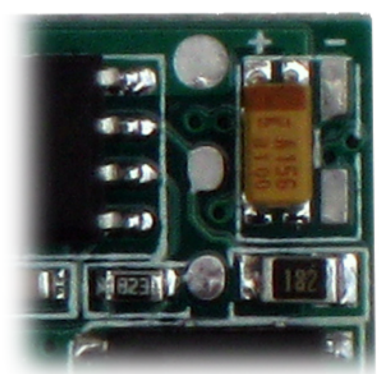
VBN models will have a GREEN dot on the backside of the module
VBP models will have a RED dot on the backside of the module
VBF models will have a YELLOW dot on the backside of the module

In the event the markings are lost on the module, the type can be determined by examining the position of the main capacitor as follows:

VBN/VBF



VBP



*All specifications @ 25°C and nominal voltage
Special order parameters/features available on request
All specifications subject to change