Correcting Bias and Soft-key Issues in the Collins 30L1 / Heathkit SB200

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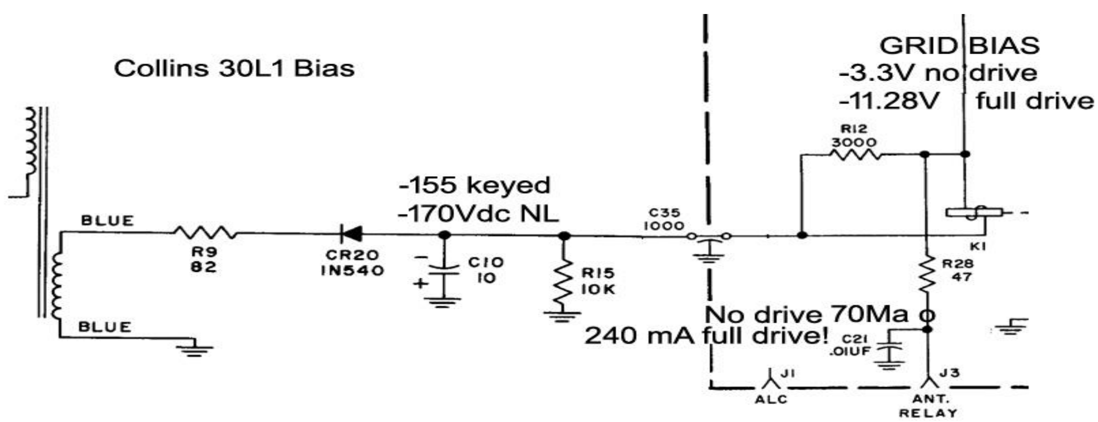
The Collins 30L-1 and Heathkit SB-200 share nearly identical grid and bias circuitry. Heath copied or patterned their SB200 antenna relay and grid bias system after the 30L-1. Yaesu and others also used a similar system, with a negative bias applied directly to control grids. This is a factual technical analysis of that style control grid system, although some details will not apply to all brands.

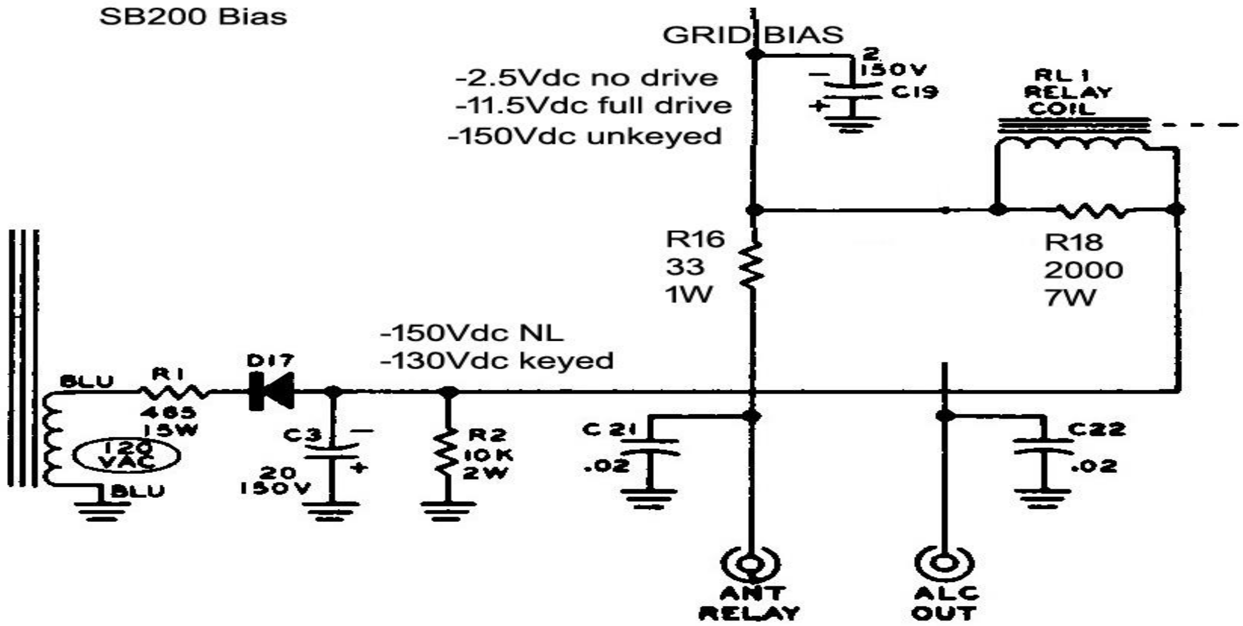
Bias Supply

The Heathkit and Collins bias supplies are unfused half-wave rectifiers using a nominal 120Vac transformer winding. Collins used a 10uF bias filter capacitor while Heathkit used 20uF. Both units can ruin the expensive power transformer if a rectifier or HV winding shorts.

While the Heathkit SB200 filter is an improvement, the negative supply in both drives about 70mA into the relay and resistor divider system. The bleeder (R15 Collins and R2 Heath) adds an additional small load. Both filters are too small for ripple-free operation with a halfwave rectifier ~85mA load.



SB200 Bias



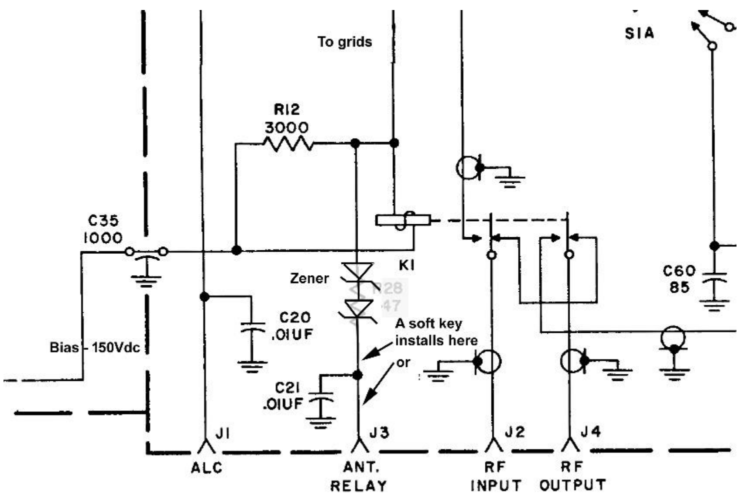
Control grids have the dominant effect on anode current. We never want ripple or anomalies in bias systems. Bias voltages should never waddle around with grid current with response rates slower than envelope modulation. This can cause IMD. (There are cases where bias can track RF envelope changes if in-phase and near audio or radio frequency rates, such as adding intentional negative feedback.)

Pushing the tube bias into cutoff places the amplifier into shorter conduction angles, causing the tube to have a distorted transfer. The tube becomes a mixer modulated by out-of-phase or delayed bias changes, increasing bandwidth.

Grid bias is very “loose”, following drive level changes in both amplifiers. While neither amplifier has stable predictable well-filtered operating bias, Heath added C19 to the already poor Collins bias system. C19 reduces bias hum and noise at the expense of increasing unwanted time lag in bias voltage RF envelope tracking. Latency in bias tracking decreases IMD performance on SSB.

Distortion varies with band, tuning conditions, the particular tubes, and exciter characteristics. Engineering always compromises complexity, cost, reliability, and acceptable results. This simple unregulated voltage divider bias system may well have been a reasonable compromise in the 1950’s or early 1960’s, before reliable high-power Zener diodes and transistors became common. Still, we can do much better using the 1980’s and onward components.

Correcting tube bias to a stable voltage, one that does not waddle around with grid current requires replacing the lower bias divider resistor (47-ohm R28 in Collins and 33-ohm R16 in Heathkit) with Zener diodes in this arrangement, anode toward grids and relay coil. The diode cathodes go toward relay control lines. We want only a little keyed (but no drive) plate current showing, about 5-12 mA per 811A in the Collins or twice that per 572 in the Heathkit.



Control Line Design Flaws

Virtually all RF power amplifiers require control line interfaces to present an open circuit on receive and a very low resistance to ground to transmit. Amplifier relay control system voltages commonly range from a few volts dc at small fraction of a milliampere up to 120 volts or more of any polarity and currents up to 100mA or more.

Most older radios could handle 120Vac or dc relay lines of any polarity at a few amperes current, while almost all modern radios can be damaged with voltages over a few dozen volts dc and a few hundred mA and require dc positive control lines.

Modern radios are generally more fragile than older equipment. Some modern radios are damaged by as little as 15Vdc and 50mA. Most will not work with negative relay voltage, let alone 100 volts negative. These radios require a relay control line buffer system.

Universal relay buffer systems or “soft keys” are very challenging to design. Amplifier relay systems and radios are not standardized with regard to interfaces. Harbach faced these challenges and has an interface that works in many cases, but is a less than ideal for certain radio, wiring, and amplifier combinations. The radio world would be better for consumers if everyone got on the same page with interfaces.

All Harbach relay buffers I’ve seen use a shunt path to turn off a device, either a transistor or an opto-coupler. The basic designs all have thresholds in the one-volt area with very little current. Such low threshold voltages and extremely low sink or wetting currents are prone to ground loop, RF, and relay system hum. A more reasonable control would have a design target in the TTL logic voltage range of 2-3 volts threshold. The target wetting or sink current would ideally be 5-25 mA. This gives a control system transfer impedance of around 150 ohms or so, keeping relay contacts clean and being more immune to radio design variations and wiring ground loops. Relays would have a long reliable life with such an operating range, systems would be much more immune to hum and noise, and sensitive reed relays or transistors would be in a very comfortable operating range.