# Relays Part 2

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# A Solid State Transceiver Except:

- Panel buttons
- Relays
  - Band switching filters
  - Transmit and receive switching
    - Push to talk is the safest
      - Typically no power on SSB till you start to talk
    - VOX one may have reasonable power to switch
      - May have some power
    - CW key down is full power!
      - If timing is not correct SWR is infinite at full power!

# How Fast Do Relays Need to Be?

- At 20 wpm a dot is about 50ms long
  - At contest speeds of 40 wpm it is 25ms
- Reed and vacuum relays normally take sub 10 ms to operate
  - As a reference: 60 cycle is 16.66 ms per cycle
- Larger mechanical relays ie the Drake L4b take 15 to 30 ms to operate with normal voltages
- This problem occurs every time you start to transmit

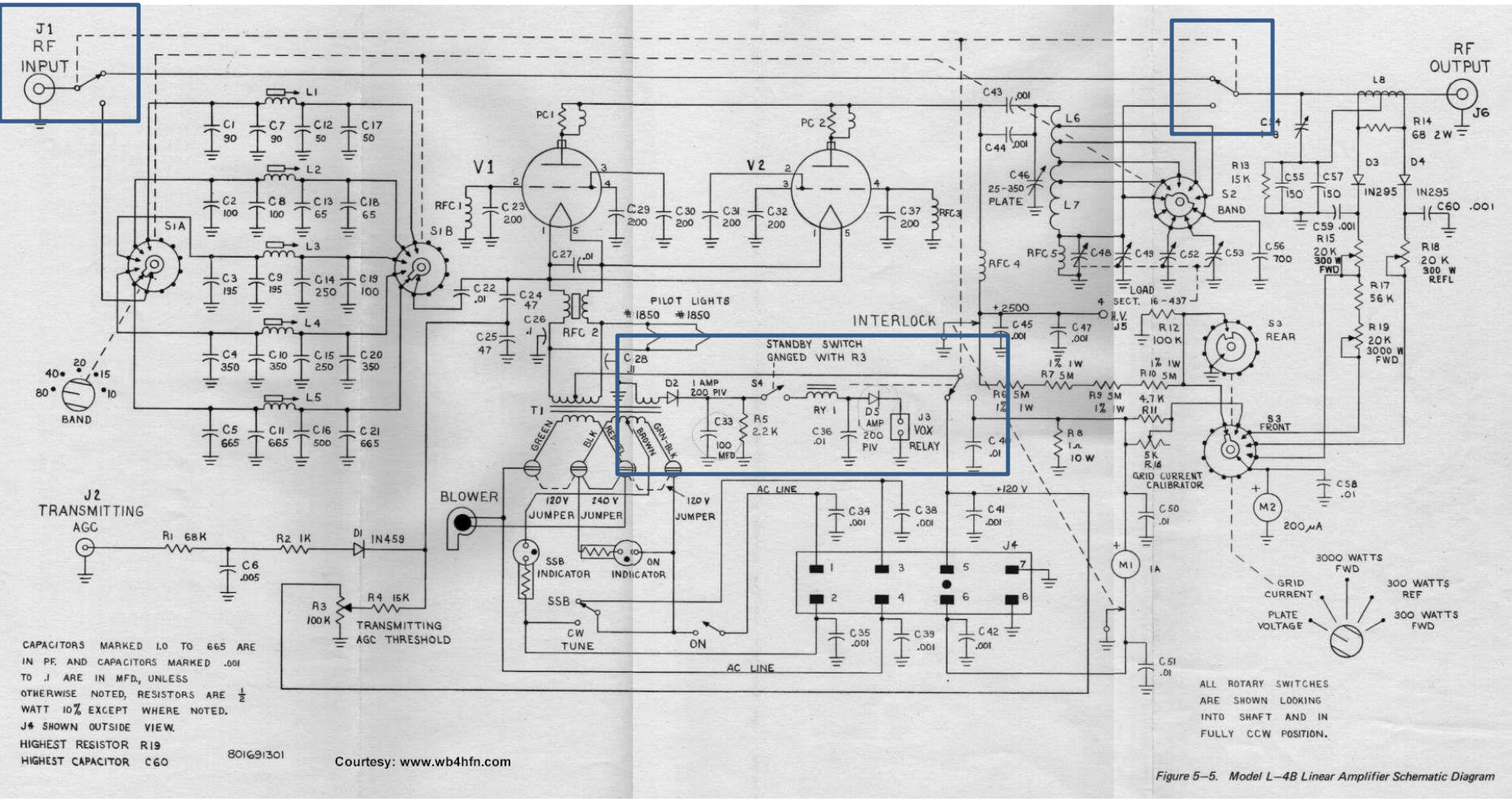
# Overexcite a Relay

- A common way to increase the speed of a relay is to over excite it
  - A higher than normal voltage is applied for a short time to close the relay
  - Close times can be halved
  - Release times are not affected
    - Typically not critical
- A simple circuit is a capacitive input half wave rectifier
  - The capacitor charges to 1.4X the supply voltage
  - The resistance in the ac supply then limits the relay voltage after closed
  - Resistors before the diode can limit steady state voltage

# Modifying the Drake L4b

- The T/R relay was going bad
  - Dirty contacts not going back to receive
  - Arcing sometimes in transmit
- Decided to modify it to full QSK
  - Use vacuum relays even though they are expensive

# Drake L4b




Courtesy: www.wb4hfn.com

*Figure 5–5. Model L–4B Linear Amplifier Schematic Diagram*

# L4b

- Needed a 3 pole double through relay
  - None available
- Used 3 spdt vacuum relays
  - Because of the expense I bought 3 used ones
  - Worked good for a while!
  - Bought a few more swapping out the output relay

# Additional Research

- Input and bias could be switched with small inexpensive relays
  - 100W at 50 ohms:
    - 70 volts
    - 1.4 amps
- Had a supply of Omron G5V-2-H1s in the shack

2 amp contacts

# G5V-2

Low Signal Relay

## General-purpose, Low-cost, Two-pole Relays for Signal Circuits

- General-purpose DIL terminal layout.
- Wide switching power of 10 μA to 2 A.
- Fully-sealed type Relays standardized with bifurcated crossbar contacts. Highly reliable in addition to its high environment resistance.
- Conforms to FCC Part 68 (impulse withstand voltage of 1,500 V for 10 x 160 μs between coil and contacts and between contacts of the same polarity).
- High dielectric strength at 1,000 VAC between coil and contacts, and 750 VAC between contacts of the same polarity.
- UL and CSA standard approved.

**RoHS Compliant**

## ■Model Number Legend

G5V-□-□
1 2

1. **Number of Poles/ Contact form**
   2: 2-pole/DPDT (2c)
2. **Classification**
   None: Standard
   H1: High-sensitivity

## ■Application Examples

- Telecommunication equipment
- Security equipment

## ■Ordering Information

| Classification | Enclosure rating | Contact form | Terminal shape | Model | Rated coil voltage | Minimum packing unit |
|---|---|---|---|---|---|---|
| Standard | Fully sealed | DPDT (2c) | PCB terminals | G5V-2 | 3 VDC | 25 pcs/tube |
| | | | | | 5 VDC | |
| | | | | | 6 VDC | |
| | | | | | 9 VDC | |
| | | | | | 12 VDC | |
| | | | | | 24 VDC | |
| | | | | | 48 VDC | |
| High-sensitivity | | | | G5V-2-H1 | 5 VDC | |
| | | | | | 12 VDC | |
| | | | | | 24 VDC | |
| | | | | | 48 VDC | |

Note: When ordering, add the rated coil voltage to the model number.
Example: G5V-2 DC3.
Rated coil voltage

However, the notation of the coil voltage on the product case as well as on the packing will be marked as □□ VDC.

## ■Characteristics

| Item | Classification | Standard | High-sensitivity |
|---|---|---|---|
| Contact resistance *1 | | 50 mΩ max. | 100 mΩ max. |
| Operate time | | 7 ms max. | |
| Release time | | 3 ms max. | |
| Insulation resistance *2 | | 1,000 MΩ min. (at 500 VDC) | |
| Dielectric strength | Between coil and contacts | 1,000 VAC, 50/60 Hz for 1 min | |
| | Between contacts of the same polarity | 750 VAC, 50/60 Hz for 1 min | 500 VAC, 50/60 Hz for 1 min |
| | Between contacts of different polarity | 1,000 VAC, 50/60 Hz for 1 min | |
| Impulse withstand voltage | Between coil and contacts | 1,500 V (10 x 160 μs) | |
| | Between contacts of the same polarity | 1,500 V (10 x 160 μs) | |
| | Between contacts of different polarity | 1,500 V (10 x 160 μs) | |
| Vibration resistance | Destruction | 10 to 55 to 10 Hz, 0.75 mm single amplitude (1.5 mm double amplitude) | |
| | Malfunction | 10 to 55 to 10 Hz, 0.75 mm single amplitude (1.5 mm double amplitude) | |
| Shock resistance | Destruction | 1,000 m/s² | |
| | Malfunction | 200 m/s² | 100 m/s² |
| Durability | Mechanical | 15,000,000 operations min. (at 36,000 operations/hr) | |
| | Electrical | 100,000 operations min. (at 1,800 operations/hr) | AC: 100,000 operations min., DC: 300,000 operations min. (at 1,800 operations/hr) |
| Failure rate (P level) (reference value) *3 | | 10 μA at 10 m VDC | |
| Ambient operating temperature | | -25°C to 65°C (with no icing or condensation) | -25°C to 70°C (with no icing or condensation) |
| Ambient operating humidity | | 5% to 85% | |
| Weight | | Approx. 5 g | |

Note: The above values are initial values.
*1. The contact resistance was measured with 10 mA at 1 VDC with a voltage drop method.
*2. The insulation resistance was measured with a 500 VDC megohmmeter applied to the same parts as those used for checking the dielectric strength.
*3. This value was measured at a switching frequency of 120 operations/min and the criterion of contact resistance is 50 Ω. This value may vary depending on the switching frequency and operating environment. Always double-check relay suitability under actual operating conditions.

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| | Malfunction | 10 to 55 to 10 Hz, 0.75 mm single amplitude (1.5 mm double amplitude) | |
| Shock resistance | Destruction | 1,000 m/s² | |
| | Malfunction | 200 m/s² | 100 m/s² |
| Durability | Mechanical | 15,000,000 operations min. (at 36,000 operations/hr) | |
| | Electrical | 100,000 operations min. (at 1,800 operations/hr) | AC: 100,000 operations min., DC: 300,000 operations min. (at 1,800 operations/hr) |
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# Vacuum Relays

- Used vacuum relays are typically not a good deal
- GigaVac has a ham radio discount
  - GH1 was about $90
  - Working great in my new amplifier
    - At 2KW:
      - 316 Volts
      - 6.3 amps

GIGAVAC®
ADVANCED SWITCHING SOLUTIONS

# 3.5kV SPDT HV Relay
Single Pole Double Throw | **GH1**

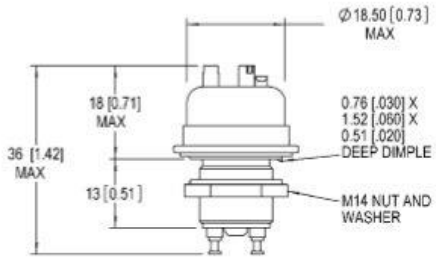
## FEATURES

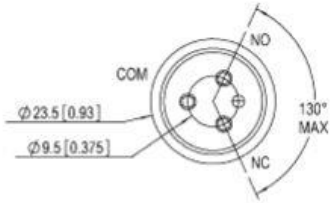
- **Low stable contact resistance for high carry current and low voltage drop**
- **Low loss in RF circuits**
- **Mounting options in any axis**
- **Solder or convenient threaded HV connections**


## PRODUCT SPECIFICATIONS

| Contact & Relay Ratings | Units | GH1 |
|---|---|---|
| **Contact Form** | | C |
| **Contact Arrangement** | | SPDT |
| Contact Material (moveable/stationary) | | molybdenum /copper |
| Dielectric | | Vacuum |
| **Voltage, Test Max., Contacts & to Base (15 µA Leakage Max.)** dc or 60Hz | kV Peak | 5 |
| **Voltage, Operating Max., Contacts & to Base (15 µA Leakage Max.)** | | |
| dc or 60 Hz | kV Peak | 3.5 |
| 2.5 MHz | kV Peak | 2.5 |
| 16 MHz | kV Peak | 2 |
| 32 MHz | kV Peak | 1.5 |
| **Current, Load Switching** | | Contact factory** |
| **Current, Continuous Carry Max** | | |
| dc or 60 Hz | Amps | 25 |
| 2.5 MHz | Amps | 14 |
| 16 MHz | Amps | 9 |
| 32 MHz | Amps | 7 |
| **Coil Hi-Pot (V RMS, 60 Hz)** | V | 500 |
| **Capacitance** | | |
| Across Open Contacts | pF | 2 |
| Contacts to Ground | pF | 2.5 |
| **Resistance, Contact Max @ 1A, 28 Vdc** | ohms | 0.01 |
| **Operate Time** | ms | 6 |
| **Release Time** | ms | 6 |
| **Life, Mechanical** | cycles | 2 million |
| **Weight, Nominal** | g (oz) | 28 (1) |
| **Vibration, Operating, Sine (55-500 Hz Peak)** | G's | 10 |
| **Shock, Operating, 1/2 Sine11ms (Peak)** | G's | 50 |
| **Temperature Ambient Operating** | °C | -55 to +125 |

** Consult factory for load switching applications




## COIL RATINGS

| Nominal, Volts dc | 12 | 26.5 | 115 |
|---|---|---|---|
| Pick-up, Volts dc, Max. | 8 | 16 | 80 |
| Drop-Out, Volts dc | .5 - 5 | 1 - 10 | 5 - 50 |
| Coil Resistance (Ohms ±10%) | 80 | 335 | 6000 |

## PART NUMBER SYSTEM

| GH1 | |
|---|---|
| **High Voltage/Power Terminal Connections** | |
| **Coil Voltage*** | **Blank** = 26.5 Vdc<br>**-12Vdc** = 12Vdc<br>**-115Vdc** = 115Vdc |

* Order the relay with the coil voltage in the part number as shown

# GigaVac detail

| | | |
|---|---|---|
| **Voltage, Test Max., Contacts & to Base (15 µA Leakage Max.)** dc or 60Hz | kV Peak | 5 |
| **Voltage, Operating Max., Contacts & to Base (15 µA Leakage Max.)** | | |
| dc or 60 Hz | kV Peak | 3.5 |
| 2.5 MHz | kV Peak | 2.5 |
| 16 MHz | kV Peak | 2 |
| 32 MHz | kV Peak | 1.5 |
| **Current, Load Switching** | | Contact factory** |
| **Current, Continuous Carry Max** | | |
| dc or 60 Hz | Amps | 25 |
| 2.5 MHz | Amps | 14 |
| 16 MHz | Amps | 9 |
| 32 MHz | Amps | 7 |
| **Coil Hi-Pot (V RMS, 60 Hz)** | V | 500 |
| **Capacitance** | | |
| Across Open Contacts | pF | 2 |
| Contacts to Ground | pF | 2.5 |
| **Resistance, Contact Max @ 1A, 28 Vdc** | ohms | 0.01 |
| **Operate Time** | ms | 6 |
| **Release Time** | ms | 6 |
| **Life, Mechanical** | cycles | 2 million |

Note!

# Life Expectancy

- At 20 wpm and 50 ms on, 50 ms off
  - 2,000,000 operations minimum life
  - Equals 138 days of steady dots!
    - If properly designed you will not wear the relays out

# Next Relay Project

- Single “on” button from the K3
  - Turning on the k3 will
    - Turn on the pan adapter
    - Connect the antenna
      - Turn off and ground the antenna when not in use
    - Turn on the amplifier
- Maximum current on the accessory out is 500ma
  - The plan is to use an automotive relay and power up a fuse block

# Switching Inductive Loads

- All relay coils are inductive
  - Without a diode the relays in the amplifier wiped out the Arduino processor
  - Transient protection is a must in solid state circuits
- Switching DC loads can be difficult
  - DC is more difficult than AC
    - AC has a off time every 1/120 of a second
    - HF becomes more difficult because of the off time and capacitance.

# Miscellaneous Relays

- Automotive
  - 12v coils
  - 30 amp SPDT contacts
  - 40 amp SPST contacts
  - I have used them in RF circuits
- Latching
  - Mechanical
  - Magnetic
    - A positive pulse latches the relay
    - A negative pulse unlatches the relay
- Time delay
  - Time delay on
    - Step start a tube amplifier
  - Time delay off
    - Cooling fan

# Miscellaneous Relays

- Stepper relays
- Solid state optically isolated
  - Typically AC only
- Motor starters
  - Designed for high contact current
  - Designed to break inductive loads
- Mercury wetted contacts
  - Use for signal level switching

# Questions?