INTERFACING YOUR HF RIG

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TOPICS COVERED

What is "interfacing" your HF rig mean?

What type of interface is required?

- K3 Specifics
- Relays versus Switching Transistors

Impetus for this discussion

Open-collector Circuit

- How does this work

Implementation for ORION PTT and Receive LNAs

Simple Relay circuit

WHAT IS "INTERFACING" YOUR HF RIG MEAN?

More than a decade ago, the only "interfaces" were:

- Microphone
- Speaker
- Key jack
- ALC
- PTT

All aspects of operation were largely "manual"

- PTT to control T/R of a linear amplifier
- ALC to prevent clipping due to transmitter overdrive
- Frequency was logged "manually"

Today, literally every aspect of HF transceiver operation is available off the back COM or USB port of a HF transceiver

- Microphone line-in for playback of recorded messages
- Audio line-out for recording of audio from RX
- PTT line for computer and keyer control
- COM port commanding of radio

With all this functionality, the amateur must still interface to the station environment

WHAT TYPE OF INTERFACE IS REQUIRED?

- In the general case one must ask, "What type of signal is being handled?"

  Some cases are quite straight forward:
  - External speaker
  - Key paddle
  - AUX Receiver input

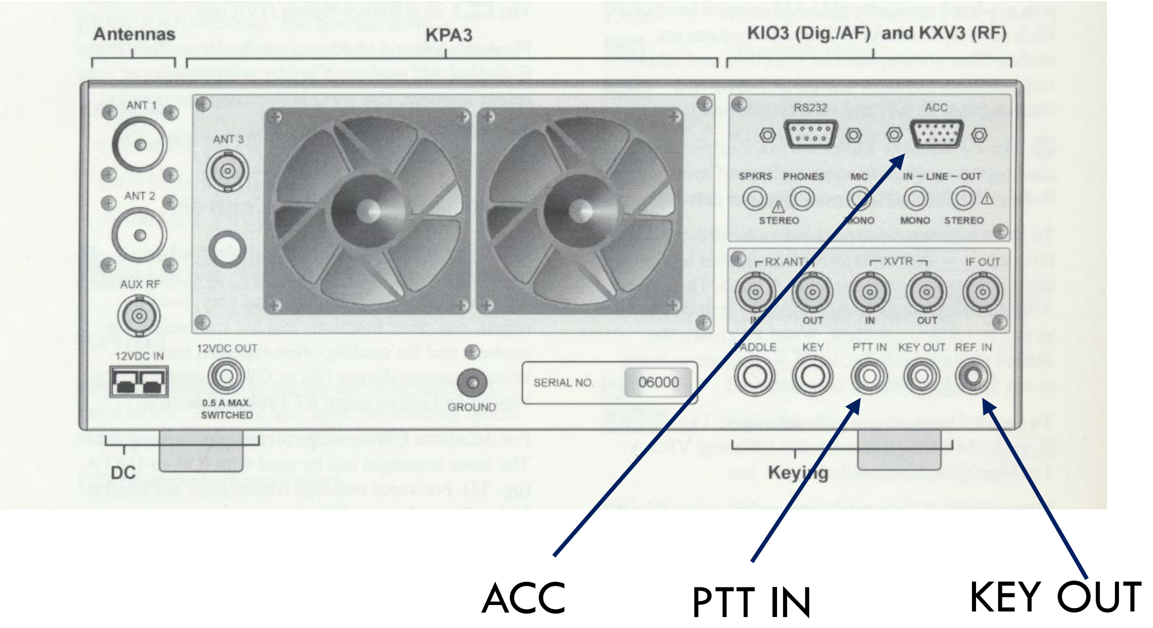
  Others are more complex requiring more investigation
  - Key Out
  - PTT In
  - "Band Outputs" of ACC on K3

- What Options to consider?

  If the signal is simply a voltage at some current level:
  - A relay could be used
  - A switching transistor implementation could be used

  If the signal is RF:
  - A suitable relay is likely required
  - A simple switching transistor is not suitable

Backside of Elecraft K3



SOME K3 SPECIFICS

PTT IN: Use with a footswitch or other external transmit control device

- PTT IN could be a connection to "ground"
  - From a switching transistor
  - A separate relay
  - An external keyer like "Winkeyer"

KEY OUT: the amplifier T-R relay keying output, capable of keying up to +200 VDC at 5 amps

- A relay internal to the K3 is capable of switching at these levels
  - The higher voltage and current requirement is generally found only in older amplifiers such as Collins, Drake, and Heathkit (if no other modifications have been made)

"Band Outputs" of the ACC connector are TTL levels in most cases: 0 or +5V

- In earlier K3s An external "pull-up" resistor to 5 V may be required
  - The "pull-up" will be discussed shortly

**ACC is accessory connector on K3

WHEN TO USE A MECHANICAL VS TRANSISTOR SWITCH?

You may not have a choice in this

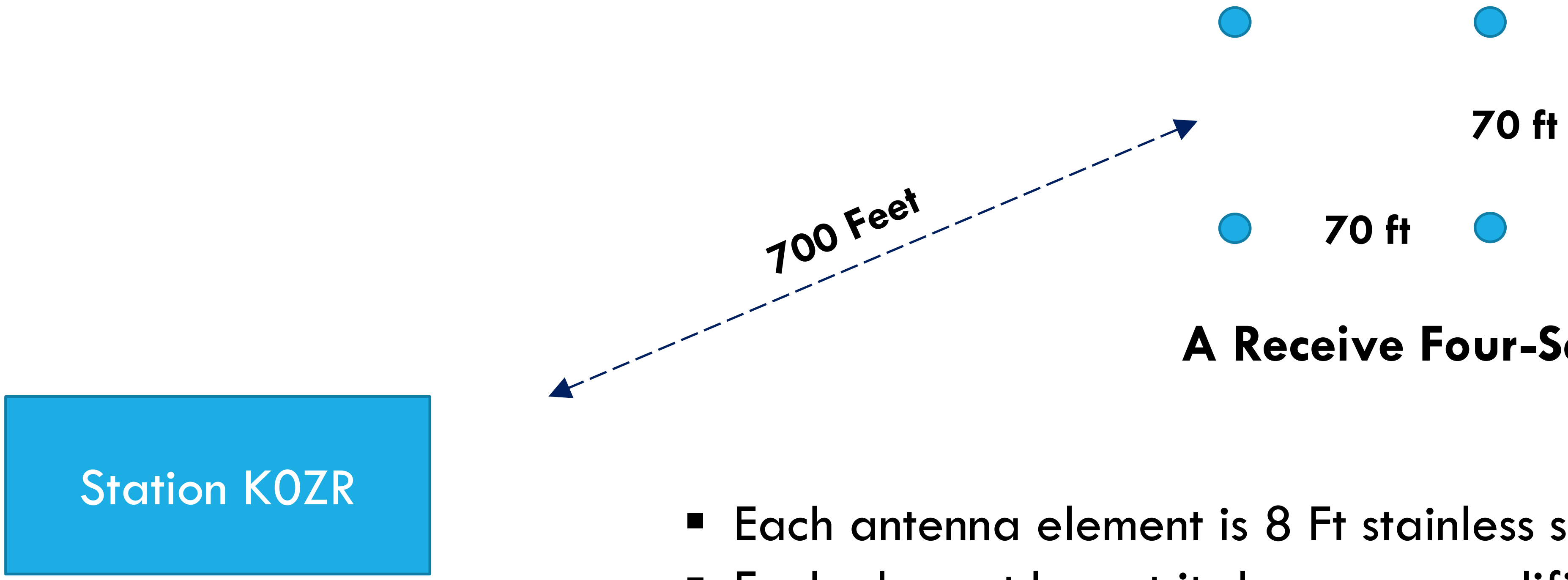
- RF signals need to be switched by a relay suitable for the frequency
  - Switching delays of 10s of milliseconds
  - Reed relays are among the fastest in response time
- Relays require some added circuit attention – to be discussed

- In the case of switching only voltages
  - A transistor switch can respond in 10s of nanoseconds
  - Literally no "wear-out" mechanisms

Terminology associated with a switching transistor, or solid state switch

- The term "Open Collector" is often found
  - In widespread use due to its generality – more to come

IMPETUS FOR THIS DISCUSSION



A Receive Four-Square

- Each antenna element is 8 Ft stainless steel “whip”
- Each element has at its base an amplifier
  that is switched on in “receive” and “off”
  in transmit

IMPETUS FOR THIS DISCUSSION

Approximately six weeks ago, the switching unit used to activate/deactivate my active receive array used on 160m and 80m failed

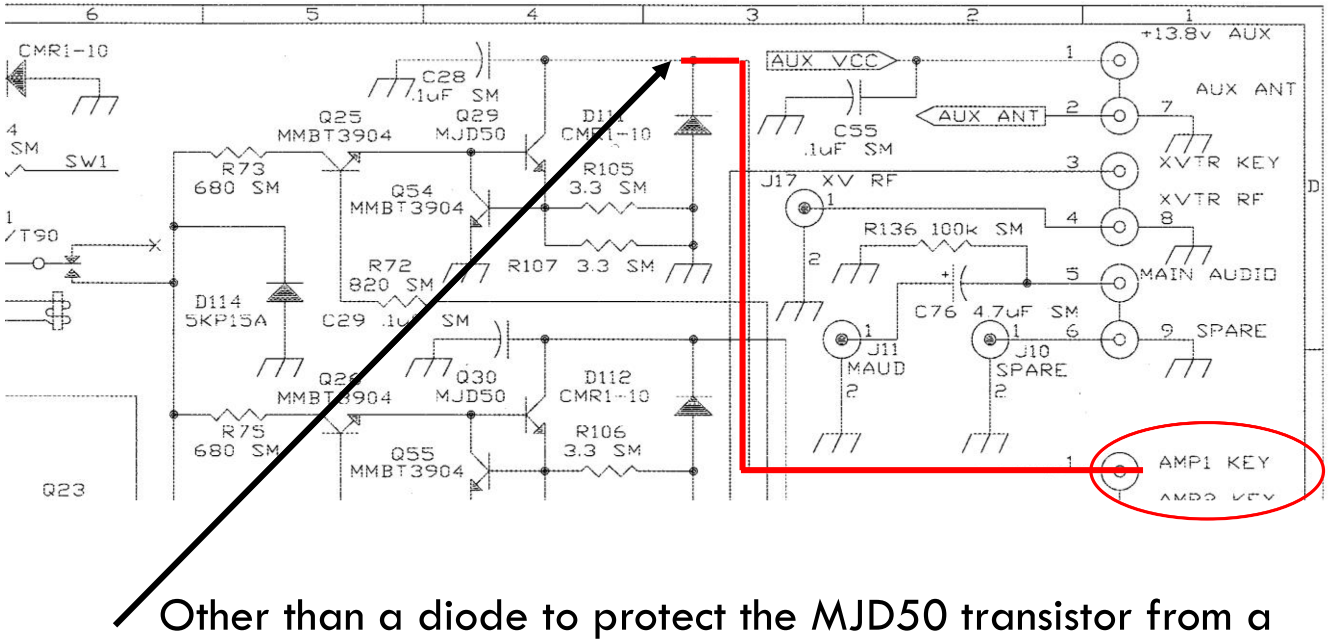
- It is an overly complex unit (DX Engineering Time Sequencer) wherein I used a fraction of its capability
- I chose to simplify this with my own array driver circuit

The active array is toggled on/off by PTT signals from my ORION II transceiver

- Consideration of the “Amp Out” line shows an “open-collector” configuration
- In “transmit” the “Amp Out” jack measures ~ 13 VDC
  - In Transmit, “Amp Out” needs to be ~ 0 V
  - An inverter is needed

PTT OUTPUT OF ORION II

Partial schematic of the ORION II transceiver



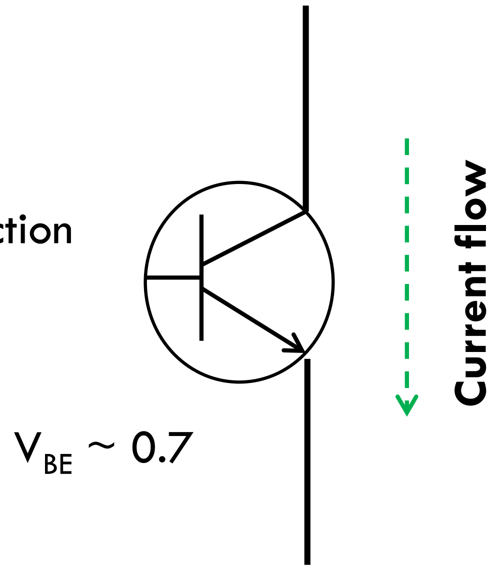
Other than a diode to protect the MJD50 transistor from a negative voltage, there is no collector voltage per say

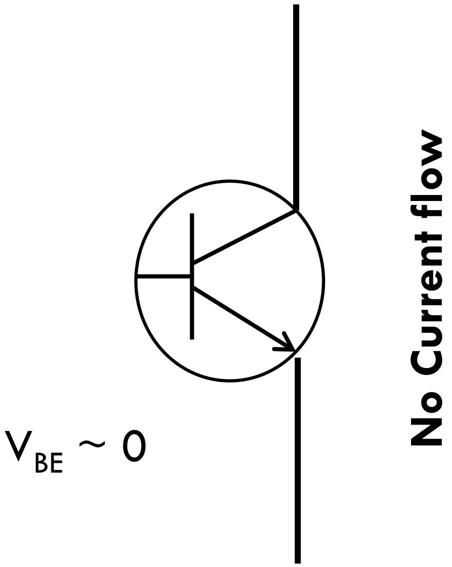
Bottom line: No voltage is being applied to the transistor collector until YOU provide a voltage

SOME TRANSISTOR REVIEW

When base-emitter junction forward biased:

- transistor is "On"
- current flows

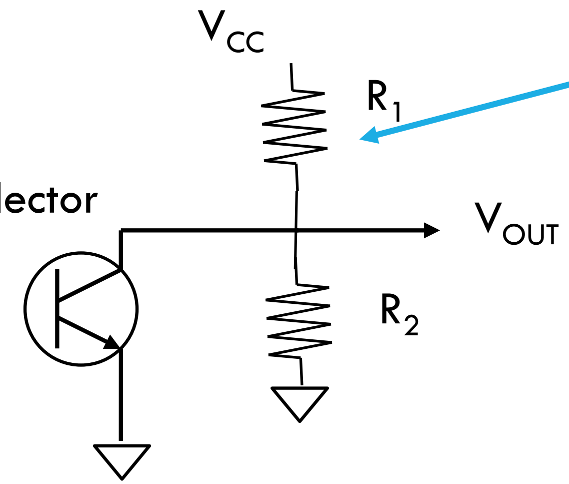




When base-emitter junction not ~ 0.7 V:

- transistor is "Off"
- No current flows

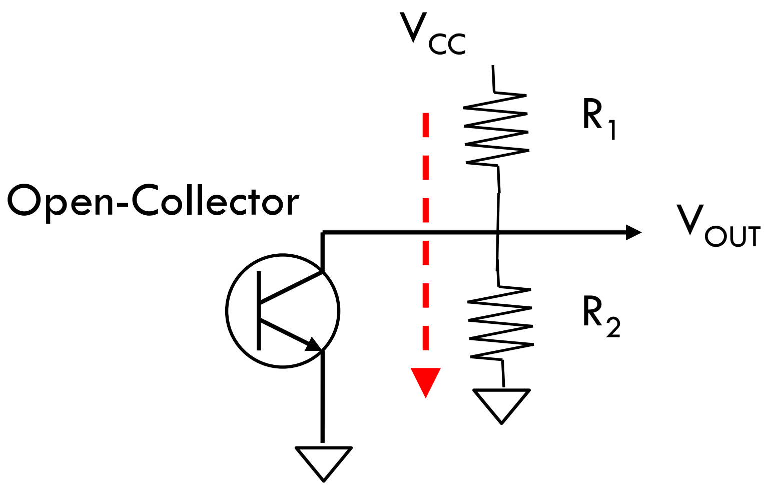
SIMPLIFIED VIEW OF THE OPEN COLLECTOR WITH PULL-UP



Our "pull-up" resistor

R_2 actually represents the input impedance of a subsequent transistor as we will see shortly

A SIMPLIFIED VIEW



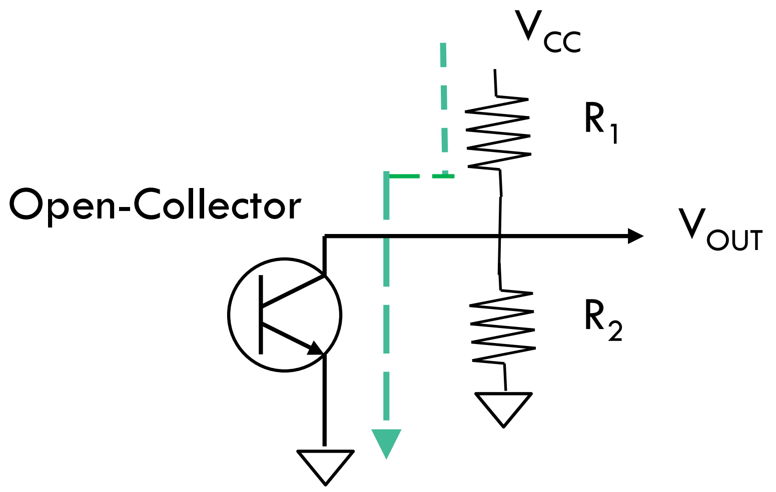
Scenario: NPN transistor is "Off"

- Current flows "only" through R_1 and R_2 with V_{OUT} given by

  $V_{CC} \times R_2/(R_1 + R_2)$

- $i_C = i_E \sim 0$

A SIMPLIFIED VIEW



Scenario: NPN transistor is "On"

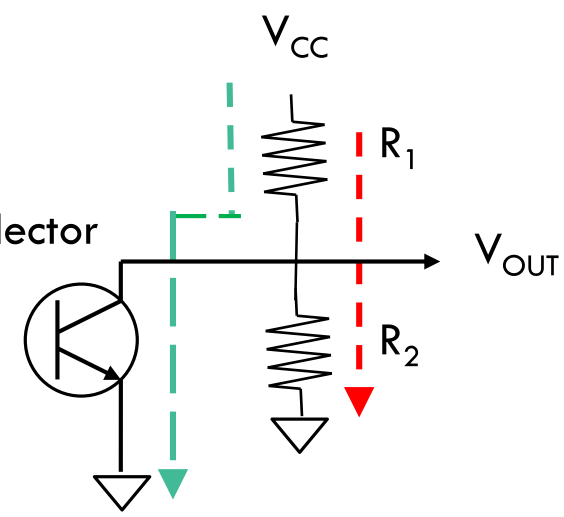
- Current flows "only" through R_1 and the transistor to ground

- The collector voltage is ~ 0.1 V to 0.2 V which, for most circuits, would be interpreted as "ground" or 0

- V_{OUT} is 0

- i_C determined largely by R_1

A SIMPLIFIED VIEW - REVIEW



Scenario: NPN transistor is "Off" (red)

- Current flows "only" through R_1 and R_2 with V_{OUT} given by

$$V_{CC} \times R_2/(R_1 + R_2)$$

Scenario: NPN transistor is "On" (green)

- Current flows "only" through R_1 and the transistor to ground

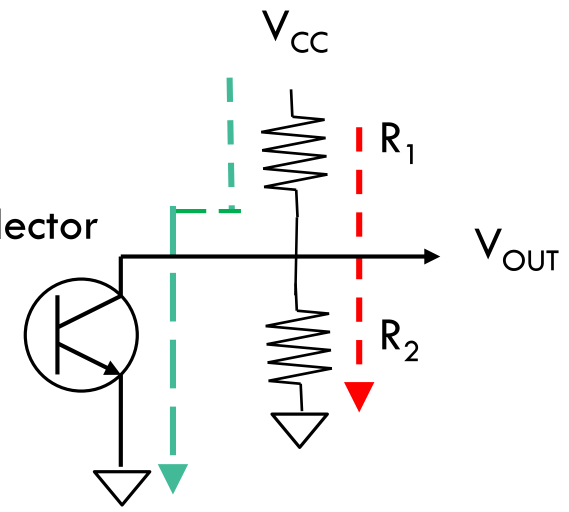
- The collector voltage is ~ 0.1 V to 0.2 V which, for most circuits, would be interpreted as "ground" or 0

R_1, which is tied to an "external" V_{CC}, is our "pull-up" resistor.

R_2 actually represents the input impedance of a subsequent transistor as we will see shortly

Guidelines are generally provided in the documentation for the range of R_1 values to use. In the case of my ORION transceiver, the range is 2.2K to 10 K ohms

A SIMPLIFIED VIEW – THE OUTCOME



The "universal" applicability of the open-collector is seen when one considers the simple formulas just presented

$$ON: \quad V_{OUT} \approx 0.2V$$

$$OFF: \quad V_{OUT} = V_{CC} \times \frac{R_2}{R_1 + R_2}$$

NPN State

On

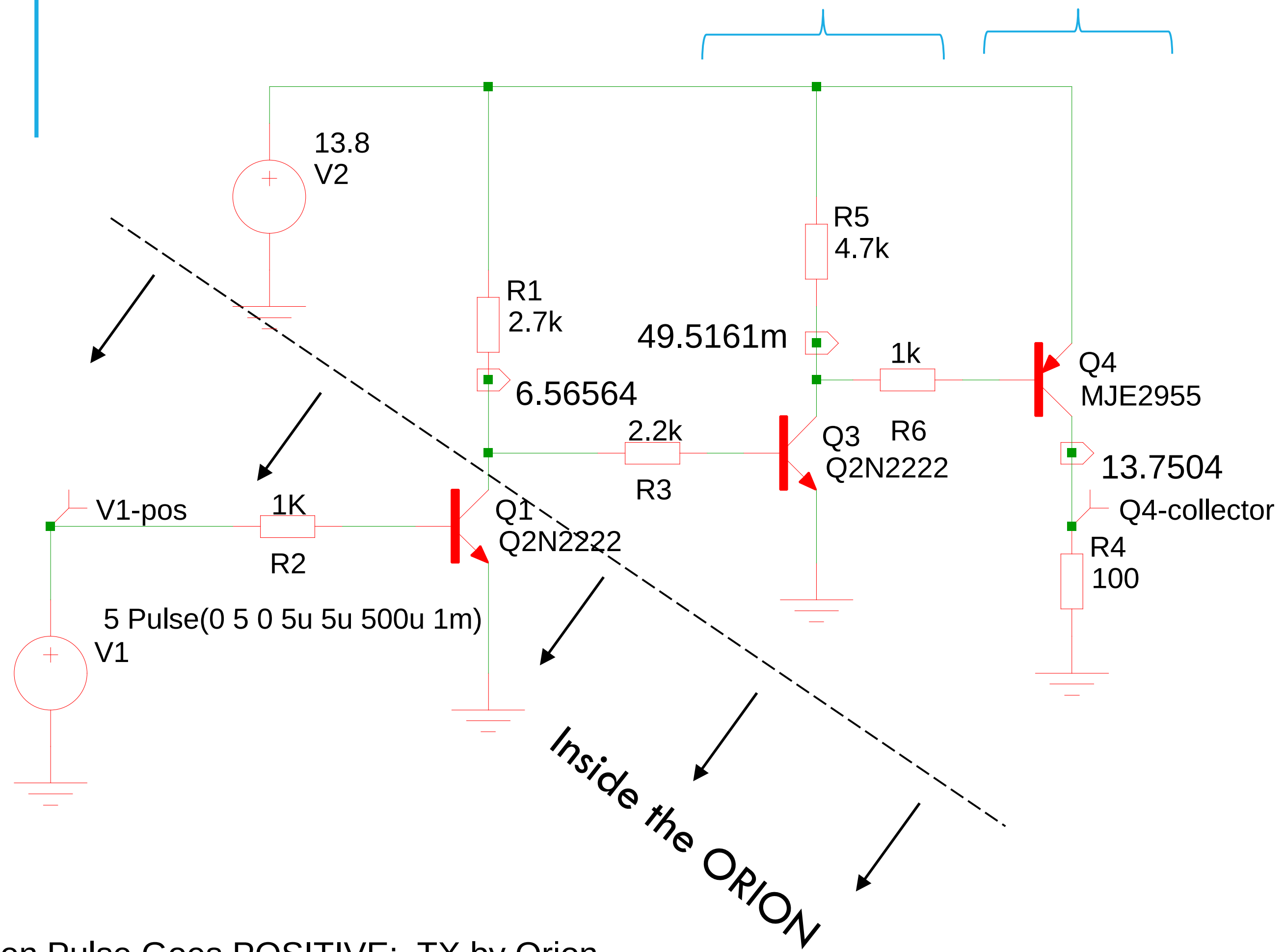
Off

If R_2 large compared to R_1, most of V_{CC} appears at V_{OUT}

If interfacing to **TTL** circuits, choose V_{CC} = 5 V
If directly driving a relay, choose V_{CC} = 13.8 V
If directly driving **CMOS**, choose V_{CC} = 3.3 V

<u>The open-collector configuration allows you to "tailor-make" the necessary voltage interface levels</u>

ACTUAL IMPLEMENTATION



When Pulse Goes POSITIVE: TX by Orion
When Pulse goes ZERO: RX by Orion

R_3 and R_6 chosen to keep base current to reasonable levels

When the ORION NPN (Q1) goes high

- Q_1 is turned "on"
- Q_1 collector goes to its "low" state, here ~ 0.1 V (Q_1 almost short-circuit)
- Q_3 base is now "low", so Q_3 turns "off"
- Q_3 collector current is ~ 0 , so base of Q_4 is near 13.8 V --- Q_4 is "off"
- No current flow through Q_4 so no current to R_4, the "load"

When the ORION NPN (Q1) goes "low"

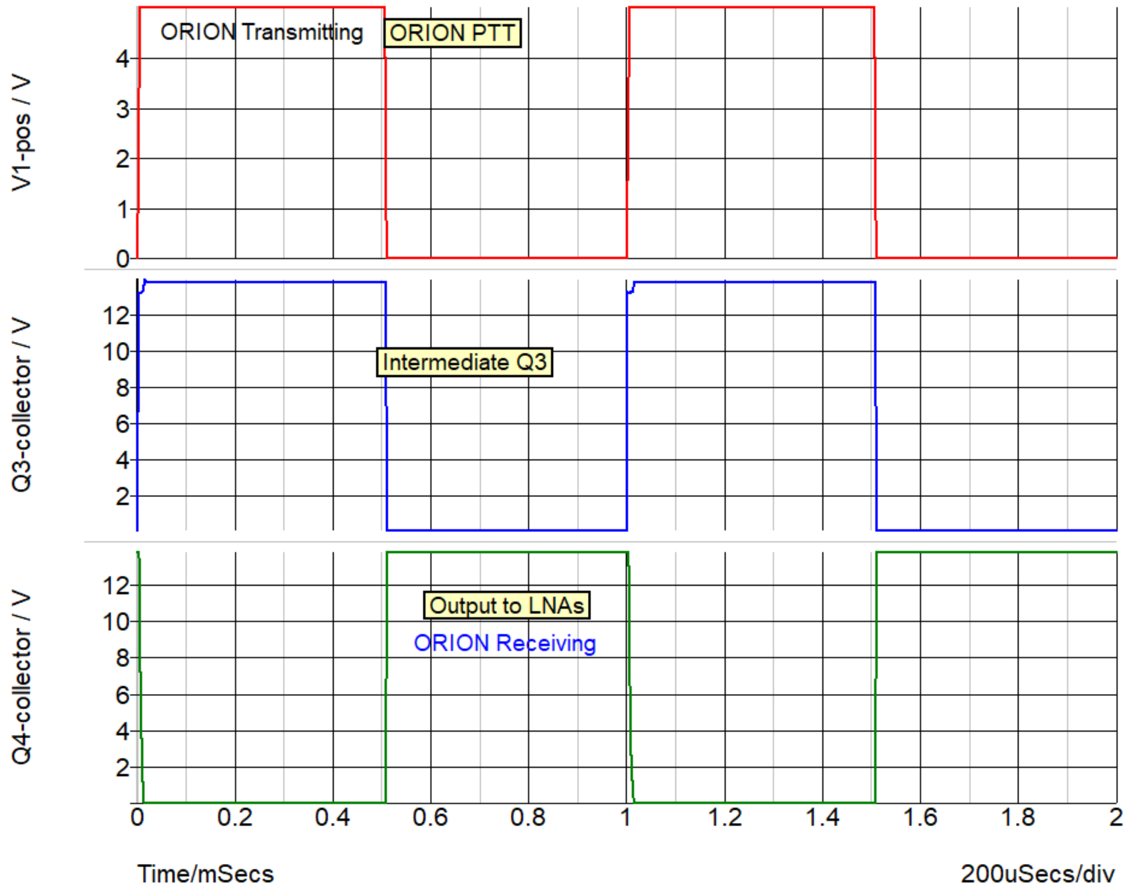
- Q_1 is turned "off"
- Q_1 collector goes to its "high" state, here ~ 6.6 V
- Q_3 base is now "high", so Q_3 turns "on"
- At Q_3 collector, voltage is ~ 0.1 V
- Q_4 emitter-base now forward biased so Q_4 turns "on"
- Current flow through Q_4 delivers power to R_4, the "load"

SIMETRIX SIMULATION WAVEFORMS

When ORION transmits, LNAs “off”
so V_{OUT} needs to be low

When ORION receives, want LNAs “on”
so V_{OUT} needs to be high

As seen, switching is almost “instantaneous” whereas a relay would have 10’s of milliseconds delay

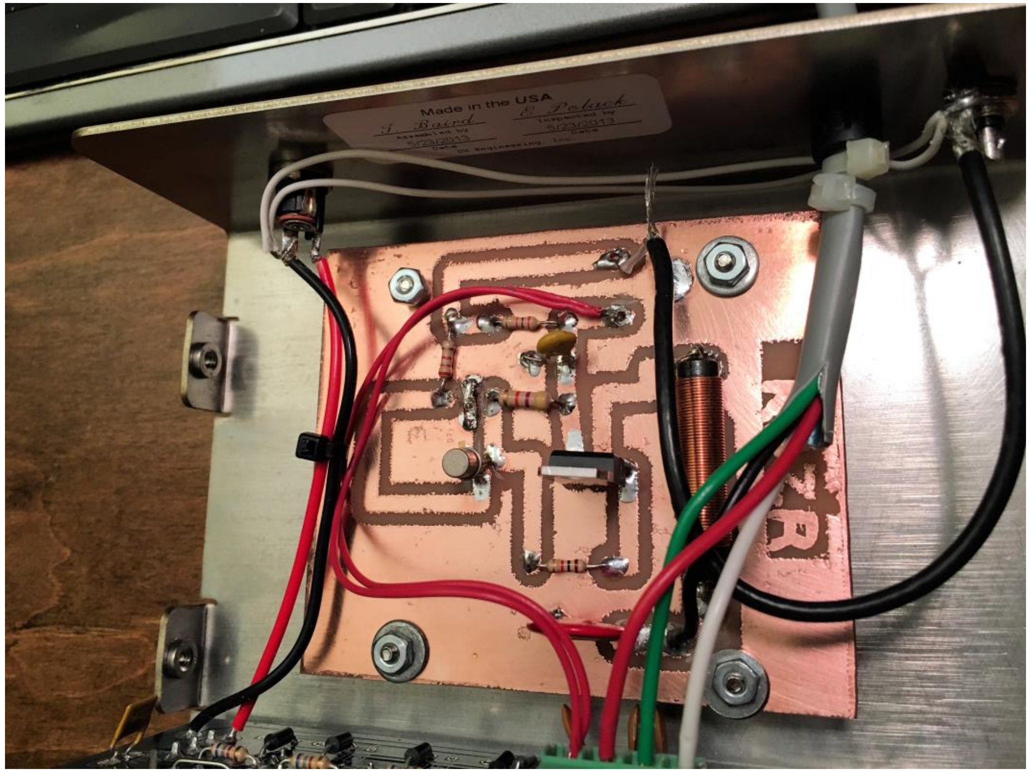


Simetrix is a “SPICE” type program, available “free” over the internet with a node limitation of ~ 50

FOUR-SQUARE DRIVER IMPLEMENTED

A 3” x 3 ½” PCB placed inside the receive array controller does the work

One additional hole for the PTT RCA jack



If anyone is doing their own PCBs and has some suggestions on improving success with narrow line widths, please talk with me ☺

SUMMARIZING

If no PTT polarity change is needed, add pull-up resistor and one transistor to do the switching

If PTT polarity needs changing, add pull-up resistor, transistor to "invert" the PTT signal, and one transistor to do the switching

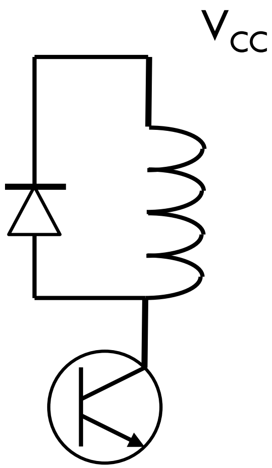
Circuits such as this are the easiest to build

Transistor is either "on" or "off", making resistor selection much simpler

SIMPLE RELAY DRIVER

Situation is simpler if no “inverter” is required for the PTT line

Possible to directly drive a small relay using the open-collector output PTT-Out signal



The inductor represents the relay in use
The diode MUST be positioned as indicated

Inductors react to sudden transitions in their current

A voltage of the reverse polarity occurs when snapped “off” from an “on” state

If the relay were “on” and ‘instantaneously” switched “off”, a voltage of the opposite polarity occurs according to

$$V_L = L\frac{di}{dt}$$

Example: L = 200 uH, I = 50 ma, dt = 50 nsec

$$V_L = 200\,x\,10^{-6}\,x\,\frac{0.05}{50x10^{-9}} = 200\,V$$

More than enough reverse voltage to destroy your transistor