A Hackers guide to NCE's Radio Cab System

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Disclaimer

- This document was not written by or in anyway officially supported by Jim Scorse or NCE incorporated.
- Content accuracy is the sole responsibility of the author.

Wireless Radio
A new way to run a layout!

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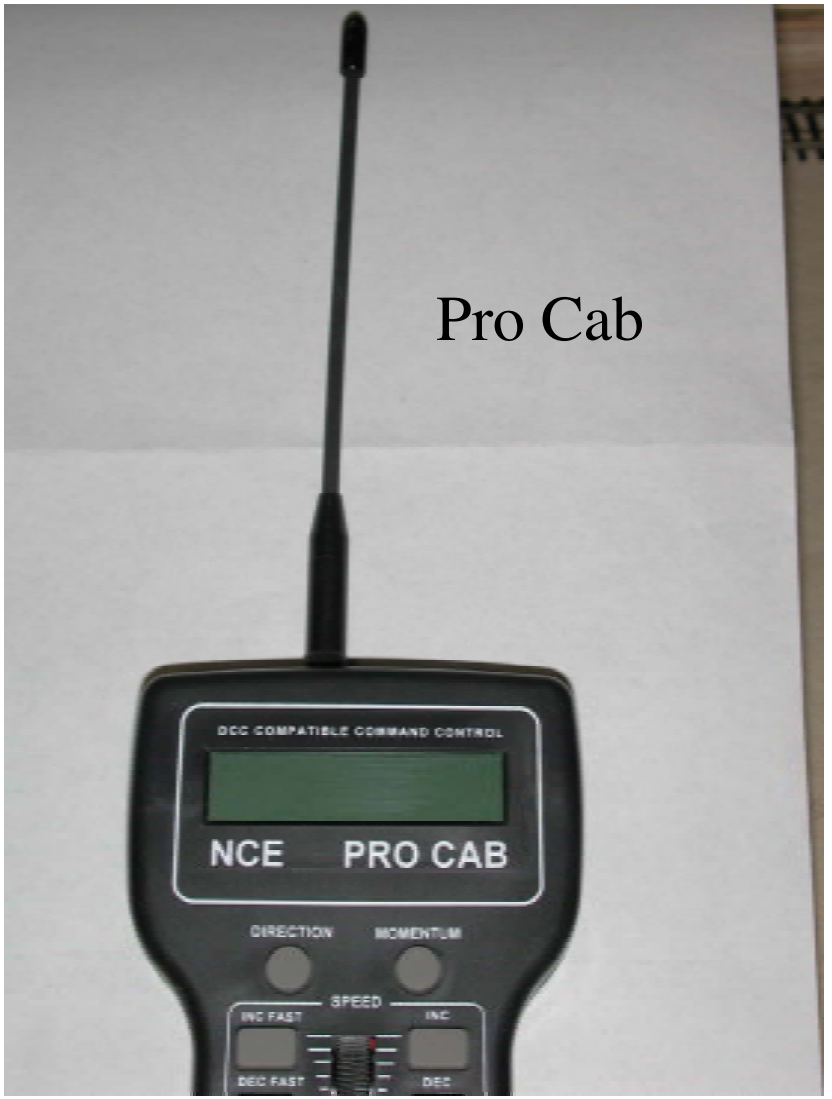
The Radio System

- Consist of two parts:
  - Base Station
  - Cab (Throttle)

Base Station



Pro Cab

Radio “Base Station”

- Connects to cab bus.
  - Looks like a cab to the command station.
  - Draws power from Cab Bus.
  - Load is about 50mA or the same as two Engineer Cabs.
- Polls cabs
  - Keeps track of up to 48 active radio cabs.
  - Prevents (hides) poor radio communication from effecting performance on wired Cab bus.
  - Command station has NO IDEA it is talking to a Radio Cab.
  - Layout ID:
    - Will only respond to cabs with proper ID.
    - Feature **NOT IMPLEMENTED** in V 1.0 of Base Station.

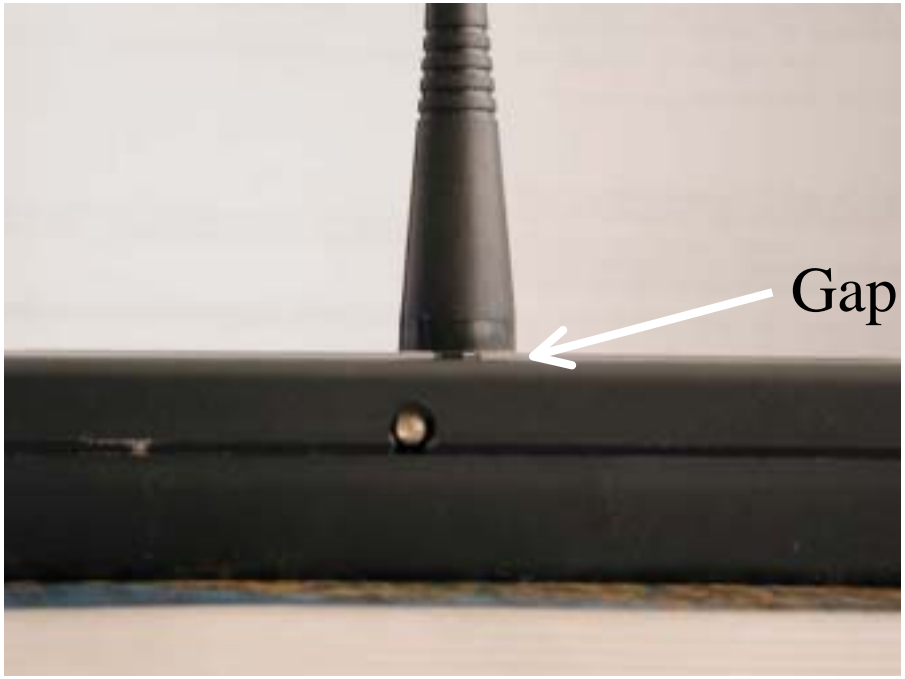
Base Station Notes

- Two types of Antenna can be found)
  - Old base shipped with a off the shelf antenna that is called 1/4 wave.
    - Only good for small layouts.
  - New base shipped (after May 2003) with come with new custom made high performance 1/2 Wave antenna.
    - Good for ANY size Layouts.
- **RECOMMENDATION: Upgrade your 1/4 Wave to 1/2 Wave antenna for all layouts regardless of size.**

Antenna Mounting: Base Station

- MUST screw Antenna ALL THE WAY DOWN.
- #1 cause of poor Radio Performance for Base Station AND Cab.

Bad



Good

Base Station Installation

- Two positions are recommended.
  - Upside Down Ceiling Mount…Best for long range.
  - Right Side up Floor Placement…Small Layouts
- Side mounting (on wall) is not efficient use of radiation pattern.
- Base stations shown with optional “Ground Plane”

Radio Cab

- A Standard Cab with extra Radio Board installed
- Radio Board
  - Adds a battery power supply circuit to run entire cab.
  - Allows seamless switchover from radio to wire operation when plugged into cab panel.
  - Manages communication with the base station.
    - Hides radio system. The cab itself has no idea it is using radio.
    - Translates Radio Signal into standard internal “Local” Cab Bus signals.
    - “Layout ID”: Can talk to a specific base station on a given layout when in the presence of multiple layouts with active base station.
  - Implements Local Radio Setup Menu.
    - Accessed via “EXPN” Key.
    - Radio Shutdown
    - Setup: Auto-shutdown time, Low Bat Alarm, Special Radio modes, ect.

Radio Operation: Usage

- General:
  - Pushing Buttons: Press with slow deliberate (not hard) motion.
  - Best to **avoid programming** and stick to loco operation only.
- Power
  - TURN ON: Press Emergency Stop button leaning (tilting button) on the 3 o'clock side.
  - ProCab Backlight: Keypress turns it on. Stays on for 3 seconds after last key press.
  - Auto Power Off: Turn off delay from last cab action.
    - Range is 1 to 9 Minutes. 0 disables Auto Shutdown.
    - Default is 5 minutes. Adjustable up to 9 minutes on ProCab.
    - **TRICK, Intermediate Cab Adjustment:** Momentarily install intermediate cab radio board into ProCab, set Auto Shutdown time to desired value, then move radio board back to Intermediate Cab.

Radio Operation: Battery Life (1)

- Master (Pro) Cab
  - LED Backlight draws 66% of the cab power.
  - Requires 4 AAA Batteries.
  - 30 to 40 hour life using 2 to 3 hour operating sessions.
- Intermediate Cab
  - No display saves a lot of power.
  - Requires 2 AAA Batteries.
  - 60 hour life using 2 to 3 hour operating sessions.
- Any battery chemistry will work
  - Rechargeable best for very high usage.
  - Alkaline for long life medium to light usage.

Radio Operation: Battery Life (2)

- Radio Kits
  - NCE offered a “kit” for early radio adopters.
  - Problem with Kits: Draw a constant but small amount of power even when power is off.
    - Will drain batteries in about two months!
  - Battery life experience will vary a lot with your usage pattern.
    - People who use the radio cab very little will see battery life issue.
    - People who use the radio cab almost every day will experience good battery life.
  - **Factory** radio cabs have fix at the expense of low battery warning.
  - Bottom Line: Your Mileage will vary!!

Radio Operation: Addresses

- Address is the same on both wire and wireless operation.
  - The command station sees a radio cab address the same as wire cab address.
- Radio Cabs use a sub range of the total cab address range.
  - **Maximum** number of radios that can be used is **48**.
    - Radios are limited to 48 of the 63 total cab addresses.
  - **ProCabs** are limited to addresses 3 to 18. **(16)**
    - ProCabs require memory in the Base Station to cache display data.
    - Display will not work in address range >18.
  - **Intermediate Cabs** limited to addresses 19 to 50 **(32)**
    - You can use ProCab address range but performance will suffer.
- You must manage the ALL addresses accordingly.
  - A Good Address strategy would be to start cab radios at high addresses and work down. Normal Cabs work up.

Radio Operation: Frequency

- NCE uses public domain low power 916.5 MHz Radio Band.
- Compatibility with other railroad radio systems/products
  - 900MHz cordless phones. Spread Spectrum versions are OK.
  - EasyDCC, Not OK.
    - Uses up to 8 different frequencies (in MHz)
      - 903.37, 906.37, 907.87, 909.37, 912.37, **915.37**, 919.87, 921.37
    - Can coexist if you set up the EasyDCC system to avoid this frequency.
  - Digitrax: ~915MHz, Not OK.
  - Train Cam: 916MHz, Not OK.
  - LGB(USA version): 916.5MHz, Not OK
  - Lionel TMCC Wireless: 26.75MHz, OK
  - AristoCraft CREST System 27MHz, OK
  - LocoLink: 75.410MHz, OK

Ordering Information

- Base Station: RB01
- Intermediate Cabs
  - Factory: CAB04PR, CAB04ER, CAB05R
  - Upgrade Kit: RU-4/5
- ProCabs
  - Factory: ProCab-R
  - Upgrade Kit: RU-P
    - Version 1.2 Cab will need to special order a new “battery” replacement back piece.

Antennas: 1/4 Wave vs. 1/2 wave

Antenna Range Comparisons

Test	Base Wave	Cab Wave	Body Distance	Body % Change	Max Distance	Max % Change
1	1/4	1/4	24 Ft	(0% Ref)	60 Ft	(0% Ref)
2	1/4 + Gnd	1/4	26 Ft	8%	84 Ft	40%
3	1/4 + Gnd	1/2	51 Ft	112%	137 Ft	128%
4	1/2	1/4	35 Ft	45%	135 Ft	125%
5	1/2	1/2	61 Ft	154%	164 Ft	173%

- Notes:
  - All test done in an outside using line of site paths.
  - 1/4 + Gnd: 1/4 Wave Antenna + Ground Plane (Tin Plate).
  - Body Distance: Distance with human body between cab and base.
  - Max Distance: Maximum distance with no obstruction.
  - All distance measurements are average values of multiple repeated test.
  - Cab Activity used in test: Changing direction back and forth.
  - Test #1 represents original shipping configuration.
  - Test #4 represents current shipping configuration.
  - Test Performed by Don Fiehmann 5/26/03

1/4 Wave Antenna

- Original Antenna shipped with base station and cabs.
  - Key physical Feature: About 3” tall.
  - Radio Range: Short to Medium
- Due to ergonomic reasons, the antenna implementation is less than optimal on Cab and Base Station.
  - **Efficiency is low**.
  - Radiation pattern is very narrow. OK for small layouts.
- Simple low cost improvement available for base Station.
  - Add a 6” or larger diameter “Ground Plane” using disposable Tin Pie or Cake Plate.
  - Improves radiation pattern, range and Efficiency.
  - Practical for base station only. Plate will not ergonomically work well on a cab.

1/2 Wave Antenna

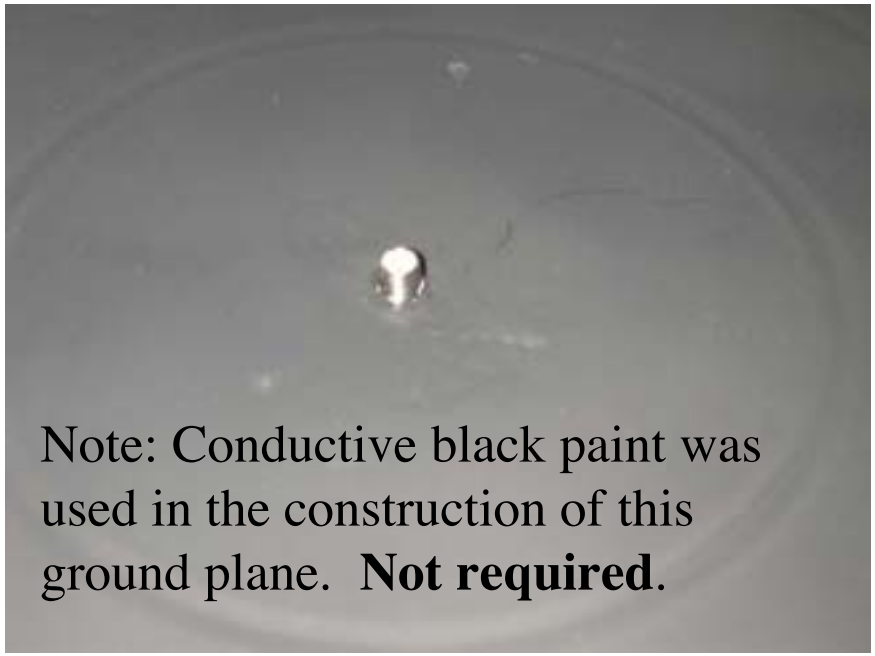
- New standard Antenna for Base station.
  - Key physical feature: About 6” tall.
  - Radio Range: Medium to Large
- Improved performance
  - Reclaims lost RF power relative to 1/4 Wave.
  - RF Power is spread over a larger area.
  - Reception sensitivity improves the same amount.
  - Transmission power feeding the antenna remains the same.
  - **Does not require a ground plane.**
    - **Installing one does not hurt anything.**
- You can upgrade old 1/4 Wave to 1/2Wave
  - Cost $16.95 US
  - Works on both Base Station and Cab.
  - Simply remove old antenna and install new one.

Making A 1/4 Wave Ground Plane

- Definition: A Ground Plane is an electrical conductive surface that provides a ground reference for the antenna.
- It can be round, square or any size as long at the you can achieve a minimum diameter that is 2 times or greater relative to the height of the Antenna.
- A simple plane can be made out of a tin pie cooking plate or pan. The thin-ness of the tin allows good connection.

Making A 1/4 wave Ground Plane

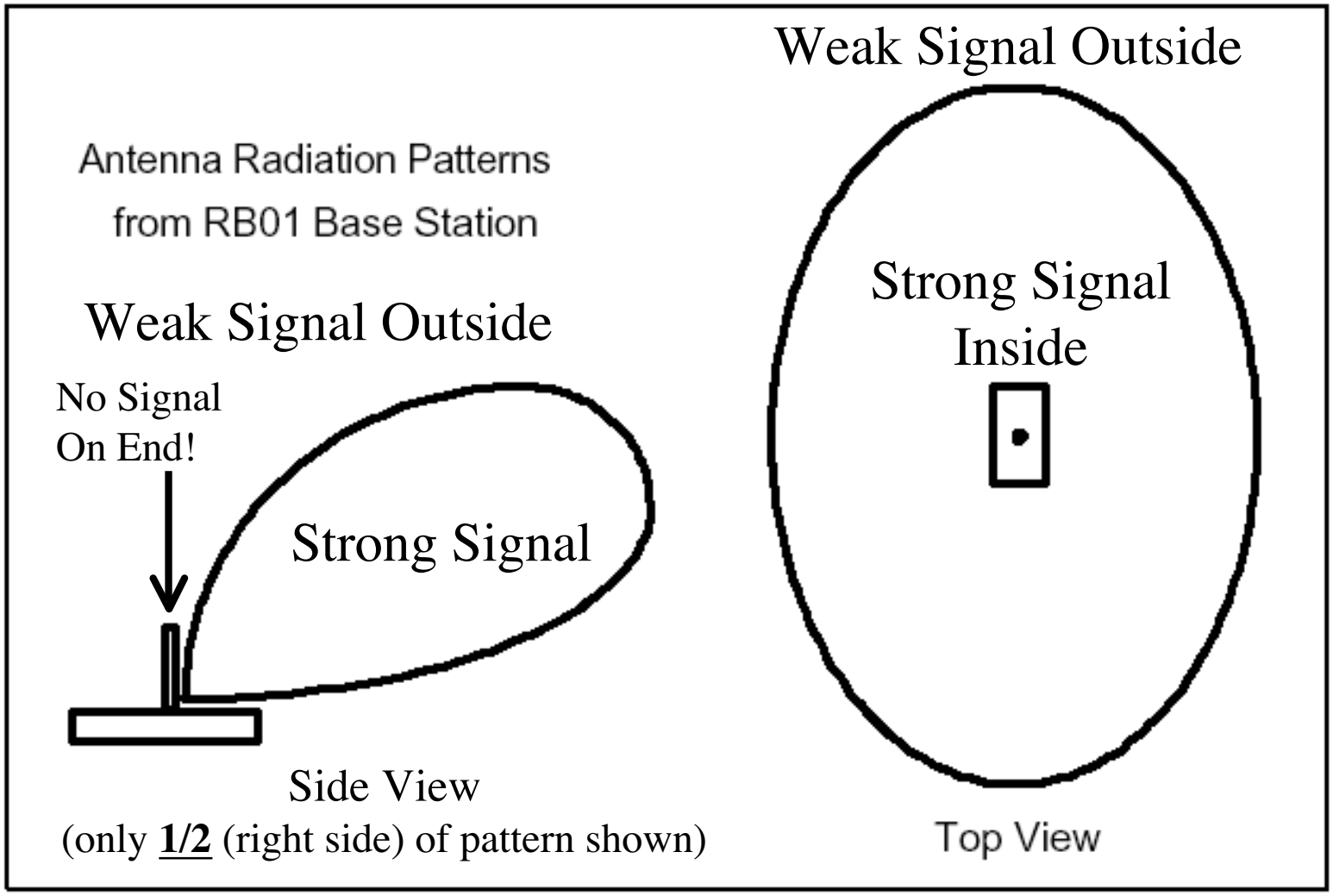
- Drill a hole ~1/4” (0.2455”) Diameter in exact center of ground plane.
- The ground hole MUST have a good connection to the antenna’s coaxial connector “screw” ground.
  - A good fit would need the plane to be “spun” down on the screw threads to get it all the way down.



Note: Conductive black paint was used in the construction of this ground plane. **Not required**.

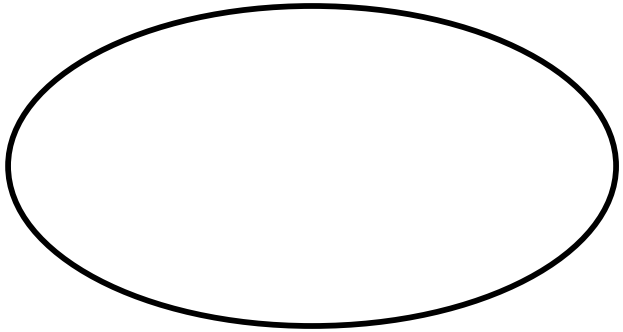
Antenna Radiation Patterns

- Reading Antenna Patterns
  - This works BOTH ways. Receiving and Transmitting.
  - There is no radiation at the end of the antenna, DEAD SPOT, “Cone of silence”.



Antenna Radiation Patterns: 1/4 Wave

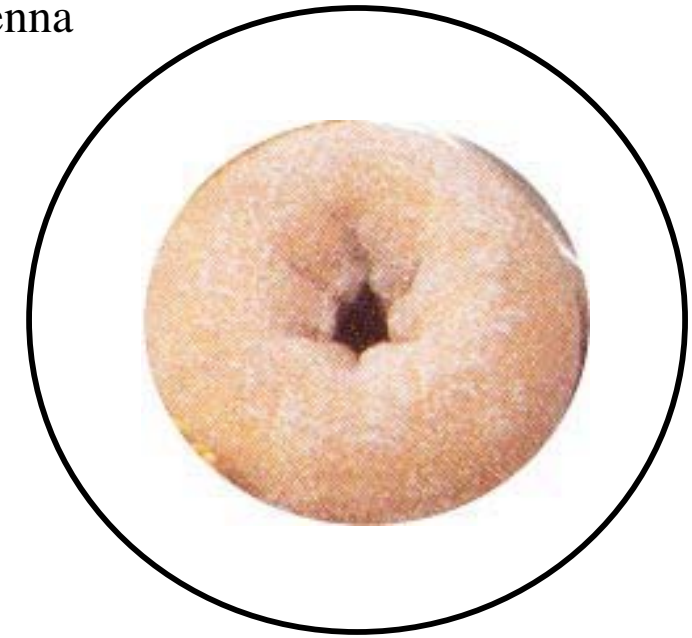
3D Picture: Think of a slightly smashed oval donut cut in half length wise. No radiation comes out of the rear of the Antenna. It all on the front.



Stock 1/4 Wave
Oval "Deformed" Donut

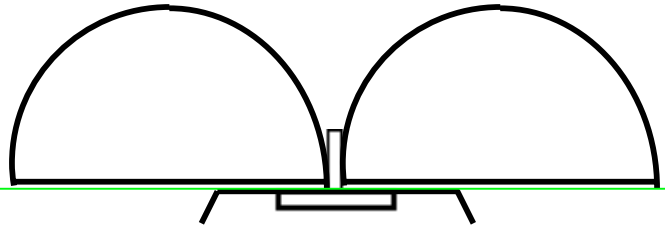
3D Picture: Think of a normal donut cut in half length wise. No radiation comes out of the rear of the Antenna

Top
<--->
View



Front

Rear

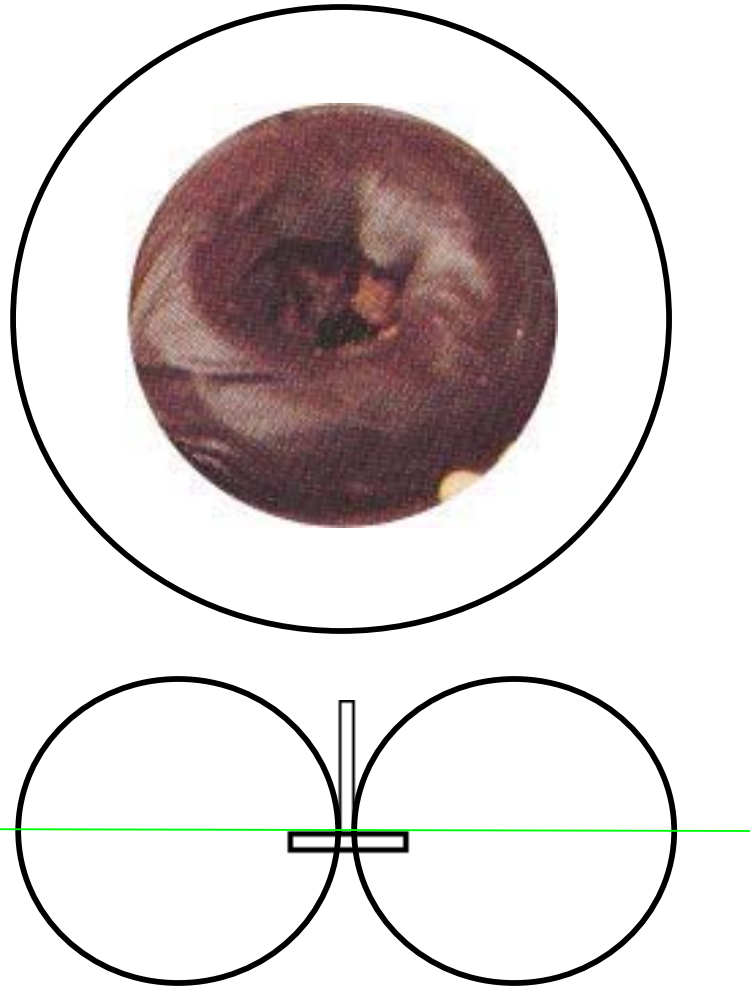


1/4 Wave + Ground Plane
Full 360 Half Donut Radiation

Antenna Radiation Patterns: 1/2 Wave

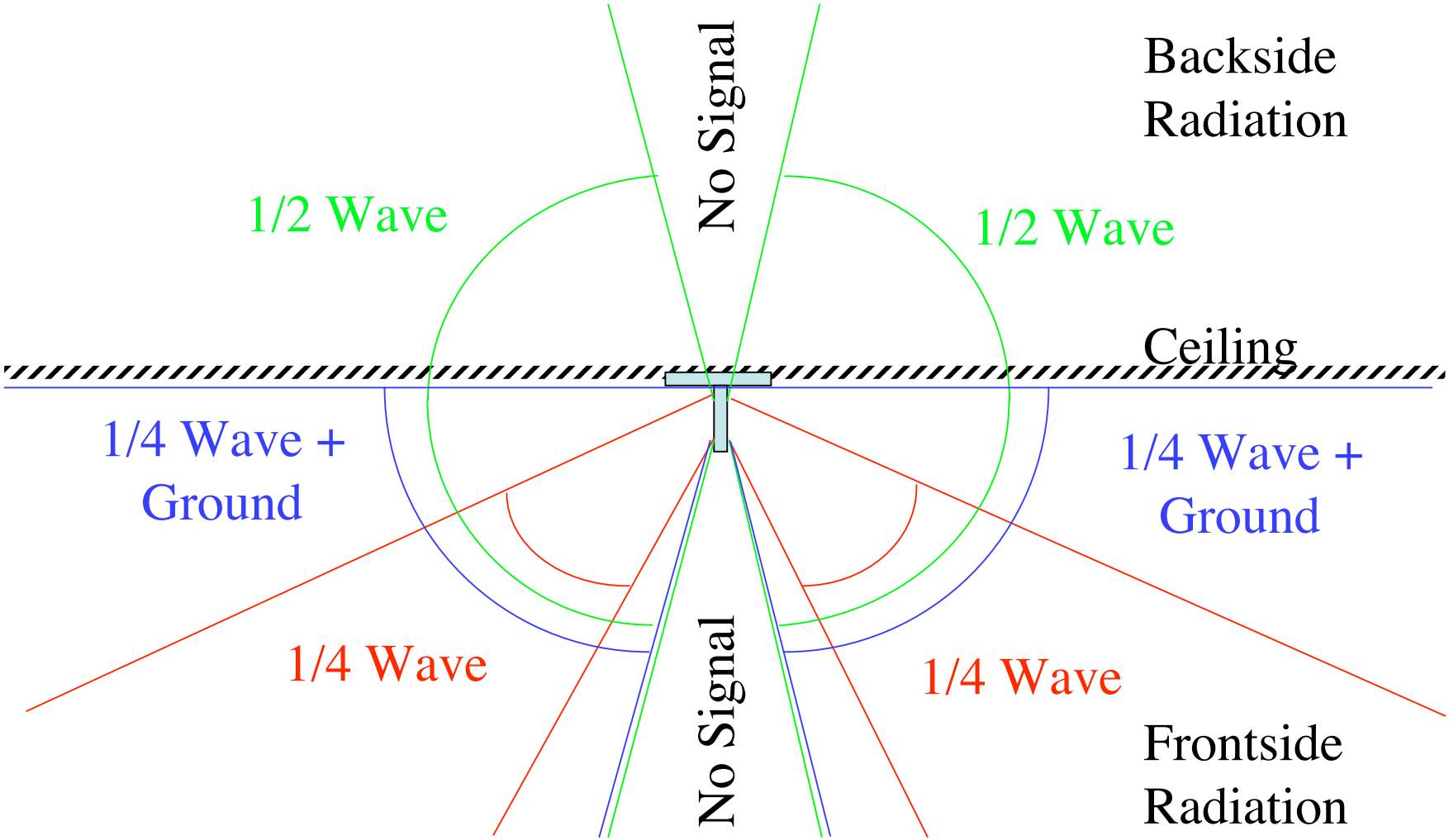
3D Picture: Think of a normal donut. Radiation comes out in BOTH front and rear directions of antenna. No ground plane required.

The 1/2 Wave antenna is more efficient than the 1/4 Wave, however, it must spread the power gain over a larger area. But it is also more sensitive in picking up cab signals.

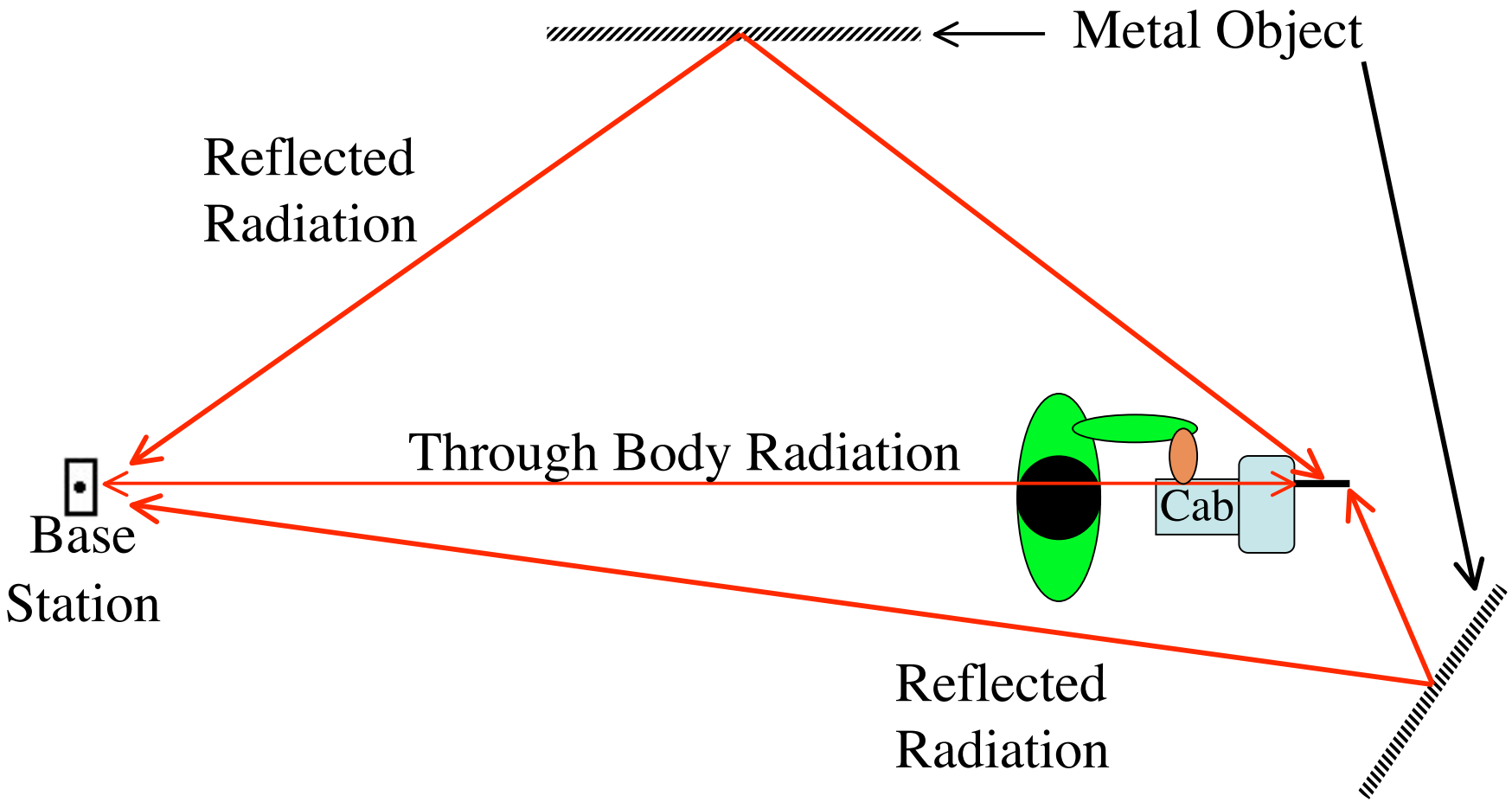


1/2 Wave, No Ground Plane
Full 360 Donut Radiation

Antenna Radiation Patterns: (Side View)



Antenna Radiation Patterns: (Top View)



Conclusions

- Antenna Upgrades
  - When using a 1/4 Wave base Station:
    - **Cheapest Upgrade**: Install a Ground Plane
    - **Value Upgrade** for multiple Radio Cabs (club): Install a 1/2 Wave Antenna on Base Station. Best for ProCabs for faster Display Updates.
    - **Performance Upgrade** with a few Radio Cabs: Install 1/2 Wave on Cabs. Best for Intermediate Cabs for fast button/control response.
    - **Top Performance**: Use 1/2 wave on everything.
  - 1/2 Wave antenna creates "omni-directional" transmission pattern allowing more alternative RF paths to be found.
  - Although most people will experience radio performance improvements with Antenna upgrades, some will not.
    - As antenna efficiency, range and sensitivity improves, so does it's susceptibility to external noise sources.
    - As they say, **Your Mileage Will Vary.**

Conclusions(2)

- Successful Radio Cab Usage
  - Keep your body out of the radio beam line of site back to the base station.
    - The weakest link in the radio system is the cab transmission back to the base station.
    - The human body easily absorbs a lot of the cab transmitted RF power coming from the cab.
    - LED on top of cab will give you a sense of signal strength.
      - Constant flash = Strong Signal. Erratic flash = Weak Signal
  - Do not point antenna at base station.
    - There is no radio signal out the end of the Antenna.
    - Orient you body at right angles (90 Degrees) to the base station.
  - Do not get closer than 3 to 4 feet to the base station.
    - To strong of a signal will kill communications.
    - Led on cab will stop blinking!
  - Avoid doing any function other than train control on the ProCab.
    - Treat it like a intermediate Cab.
    - Ignore the display. A slow display update will make operation frustrating.
  - Turn off the Low Battery Alarm.
    - Get rid of the “LESS 1.0” display.

Conclusions(3)

- Best Base Station Placement
  - Placement would maximize line of sight coverage over operation area.
  - Place it at the geographical center of the room.
  - Keep any metal material such as ventilation duct work or wire mesh away from base station. Plastic or wood will not hurt radio signal.
    - Will block radio signal.
  - 1/4 Base
    - Place upside down above the highest radio cab elevation to be encountered. Typically on the ceiling of the layout room.
  - 1/2 Base
    - 1/4 placement will work.
    - If your layout is multilevel, consider placement at a height from the ground that is 1/2 way between upper and lower levels. Optimize height from a cab held elevation point of view. This technique takes advantage of the forward and backward antenna radiation patterns.
    - You can also try mounting the base station at shoulder level on the layout itself as opposed to the ceiling. Hide it in a tall building or mountain. This places the base station even closer to the user.

Radio Upgrade Kit (ProCab)

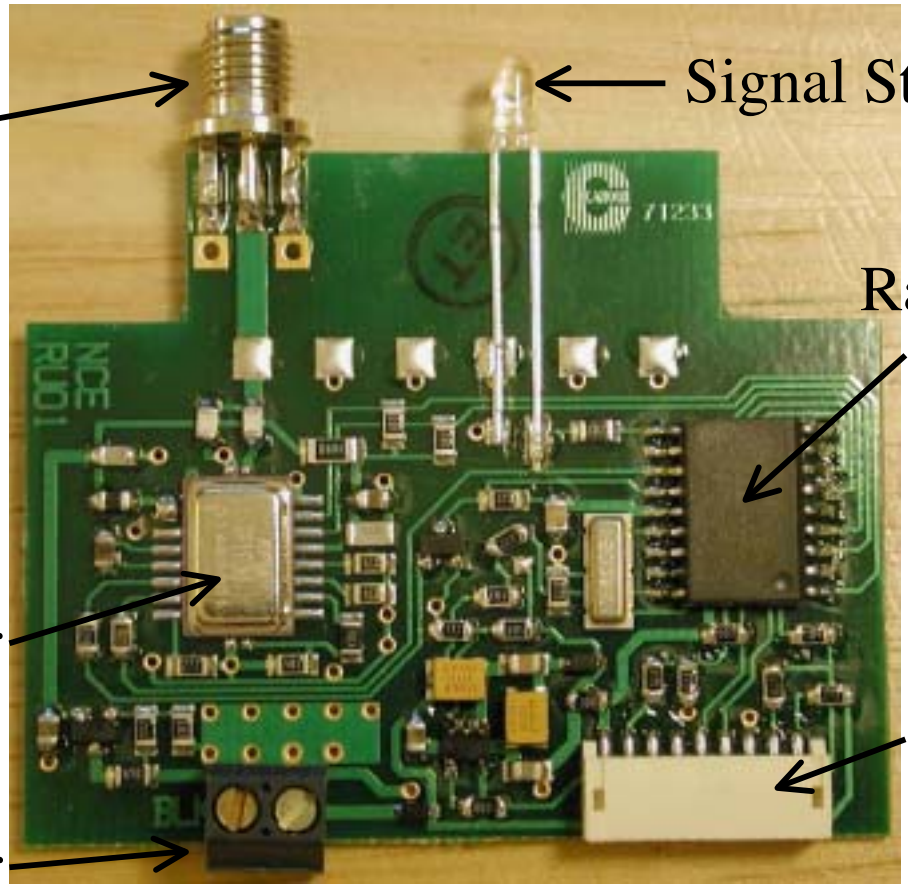
Radio Installed (ProCab)

Radio Kit for Cabs

- Status
  - Radio Upgrade Kits have been officially **discontinued.**
    - You may still find them by checking with various NCE dealers.
- Upgrade Limitations
  - Will only work with NCE "Radio Ready" Cabs.
  - **Intermediate (Engineer) Cab**:
    - Remove battery cover and look inside for white 9 pin connector on back of PCB.
  - **ProCab**: Will only work with V1.2 or V1.3 (current) cabs.
    - V1.3 They have a battery slot on the back.
    - V1.2 Cab: Says V1.2 on startup Display & **No** battery slot on back.
      - Can't read ID? Go to Cab Setup Menu.
      - Must order new replacement cab back with battery slot.
      - **PROBLEM:** NO AUTOMATIC CAB BUS SWITCH OVER TO WIRED CABLE OPERATION.

Radio Upgrade Kit for Cabs(2)

- Kit Notes
  - Two Kits: Engineer and ProCab.
    - Same radio board but different battery wiring. Order correct kit!
  - Requires user to open cab, drill and mount radio board. No soldering needed.



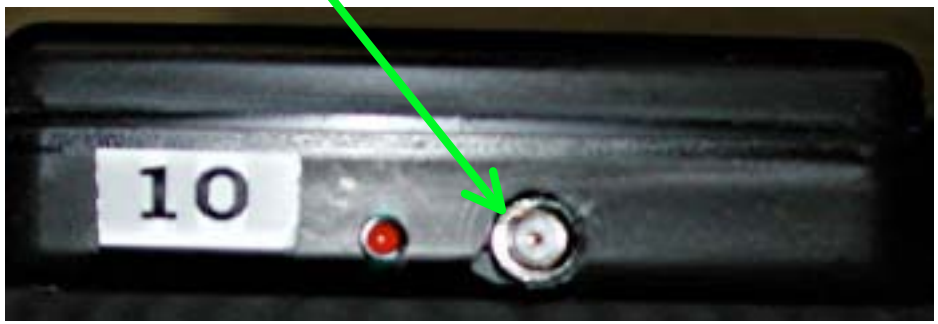
Radio Upgrade Kit: Antenna Mounting

- Problem: Antenna cannot screw all the way down.
  - Does NOT allow proper internal center pin contact.
  - Antenna does NOT get the full signal to transmit and receive.
- Cause: An improperly drilled Antenna hole.
  - **Hole** is **to small** to allow shoulder of the coaxial Antenna connector to pass **through** the plastic wall.

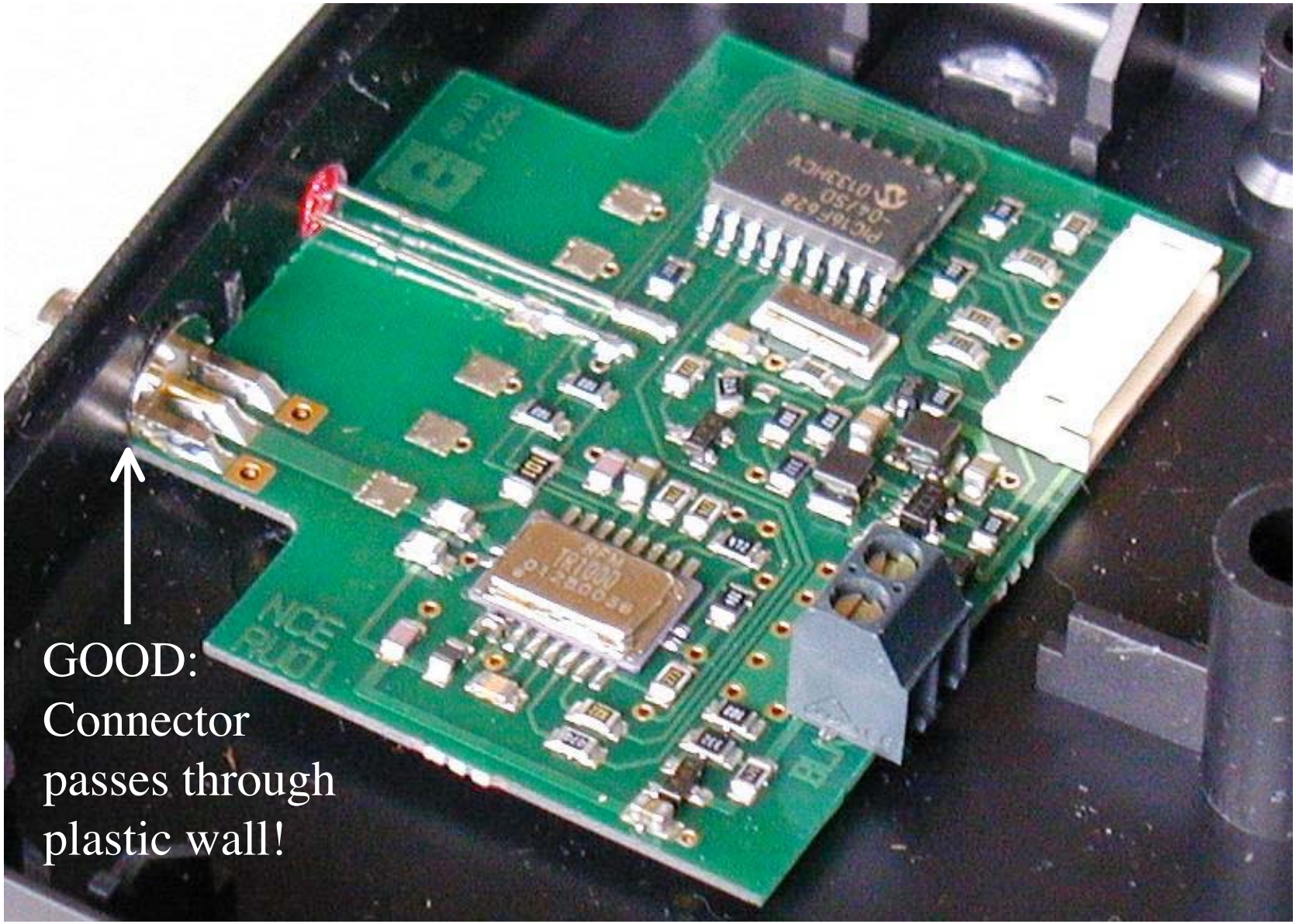
Bad

Exposed Connector Shoulder Ring

Good



Radio Upgrade Kit: Antenna Mounting(2)



Cab Radio Improvements

- Battery Drain
  - **Problem:** The cab radio has a low battery "Low Bat" monitor circuit. However, this circuit also drains the battery (slowly). If you use your radio once a month or less, you will find these changes useful.
  - **Fix #1:** NCE modification of Radio Board Circuit
    - Change two resistors
    - Minimizes battery drain.
    - Permanently disables "Low Battery" detection.
  - **Fix #2:** Add a power switch (SPST) in series with one of the battery leads.
    - Best solution that ELIMINATES battery drain.
    - Your will have to find, drill and install switch yourself.
  - You can do one or the other or both!

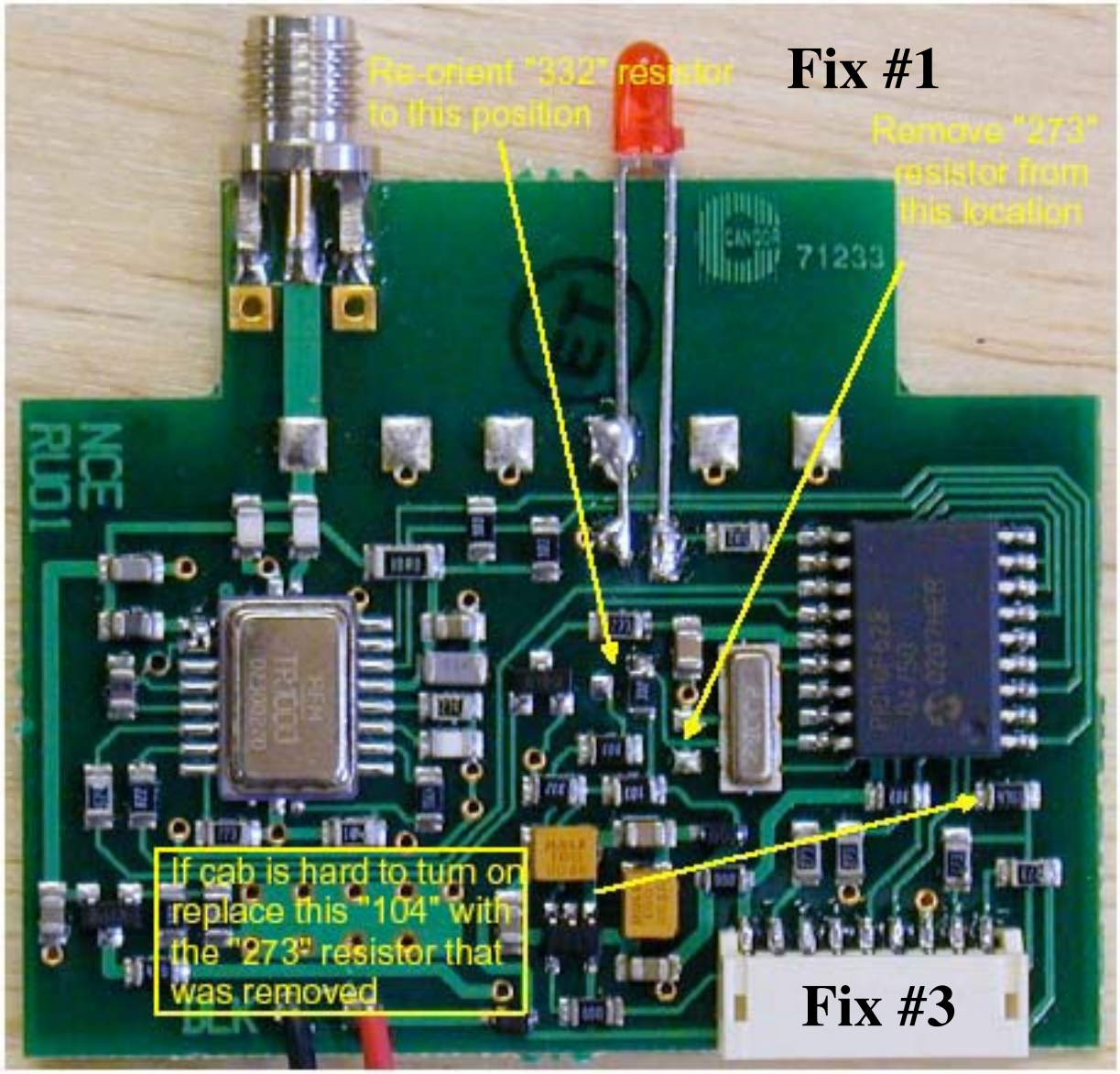
Cab Radio Improvements(2)

- Hard to Power On (even when pressing 3:00 position)
  - **Problem:** Insufficient power up interlock drive.
  - **Fix#3:** One resistor change on Radio Board.
  - **Problem:** LCD Backlight draws to much power.
  - **Fix#4:** One resistor change on Cab Board.
  - **Fix#5:** Check back of LCD Board for Resistors. If exist, remove.
- "LESS 1.0" stuck in Clock Display Area
  - **Problem:** Software "Low Bat" Alarm Mode is On. Radio software **reserves** clock display space to show low battery warning when it occurs.
  - **Fix:** Go to radio menu and turn off Low Bat Mode.

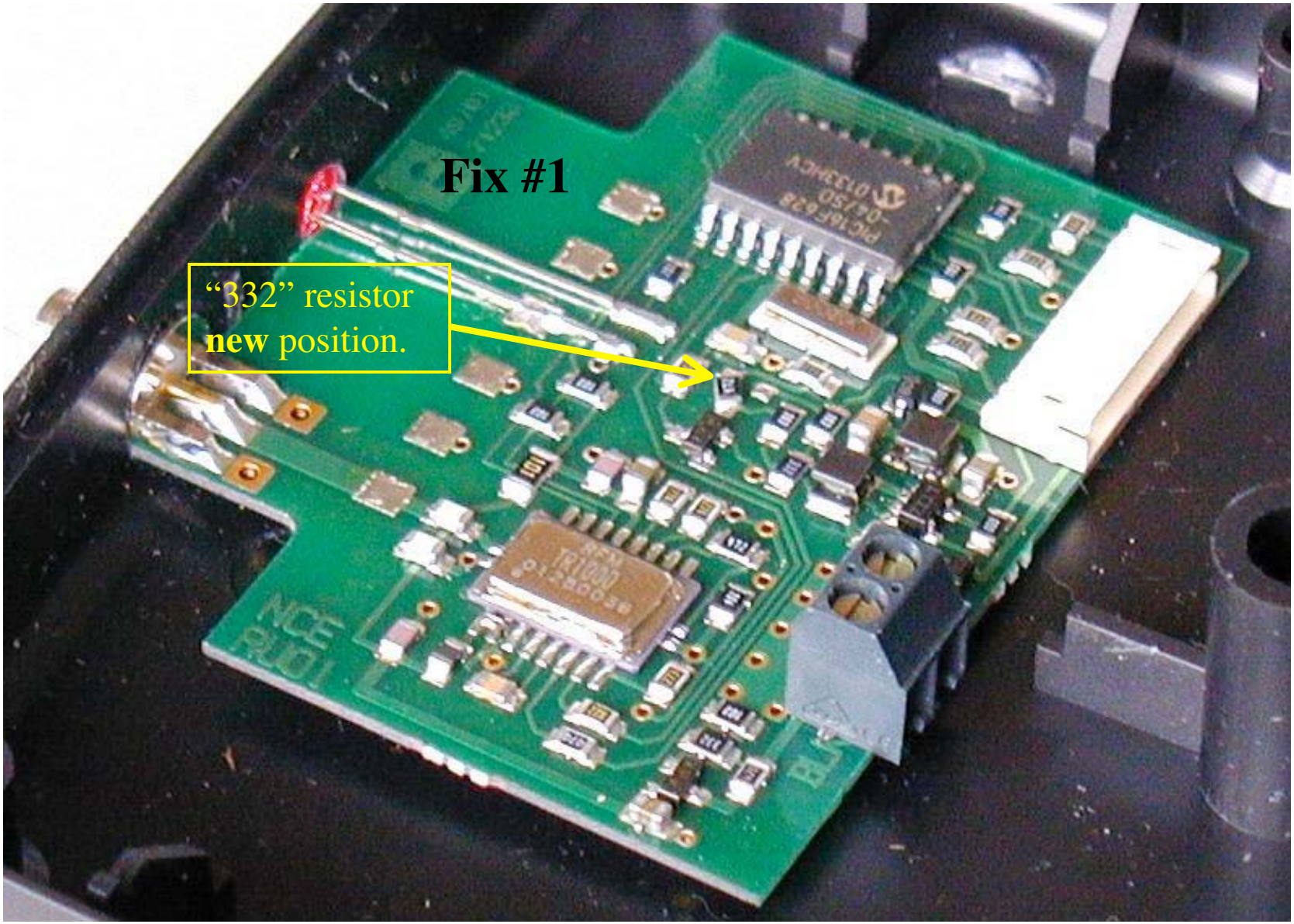
Cab Radio Improvements(3)

Do not use a large high power soldering Iron. These parts are small and delicate. Excessive heat can damage the parts and boards.

If you are unsure about making these changes, find someone else to do the work for you.



Cab Radio Improvements(4)

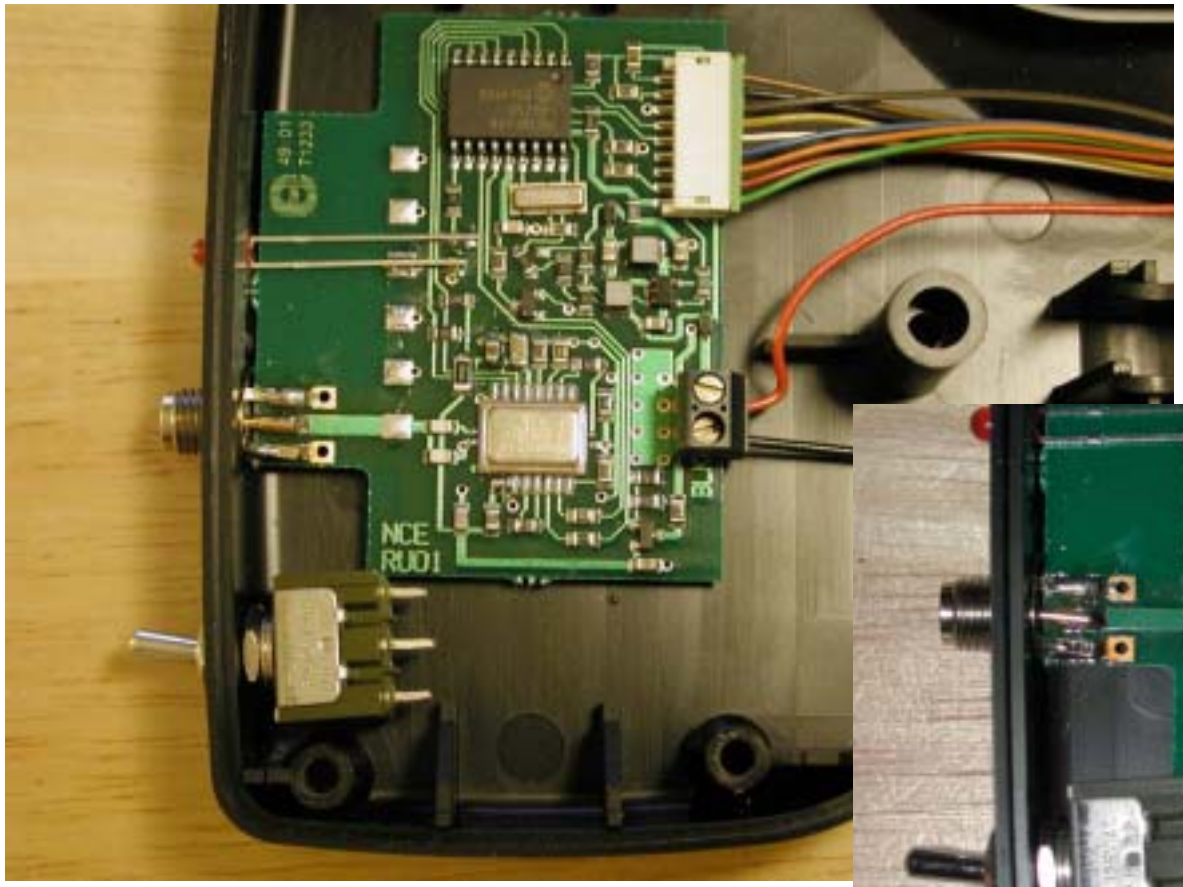


Cab Radio Improvements(5)

Fix #2: Front of Throttle showing switch.

Picture of switch showing Part Number from Digikey. 360-1155-ND

Cab Radio Improvements(6)



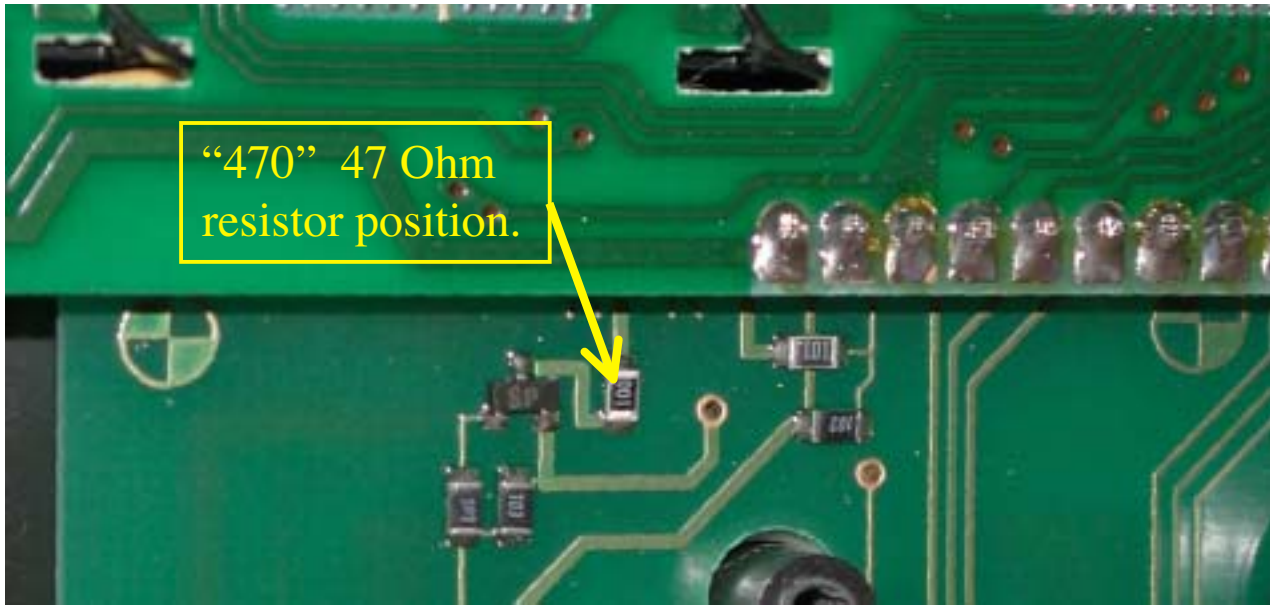
Fix #2: Switch Fix. SPDT or DPDT switch

Switch Installed. Use both nuts. Use one inside to act as spacer.

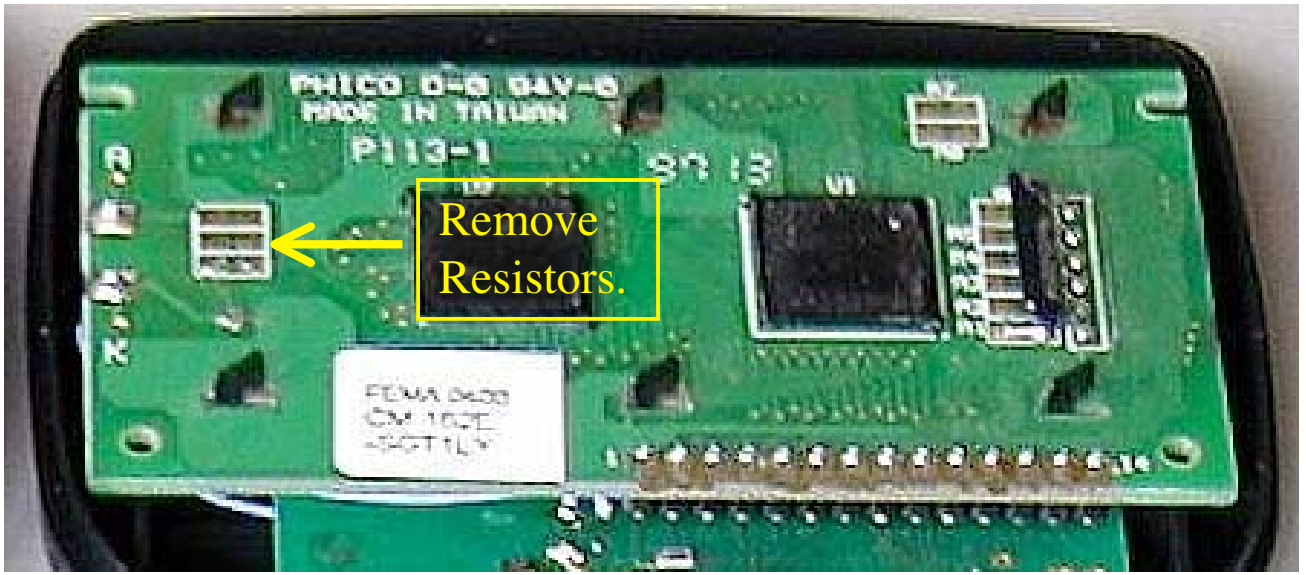
Completed Wiring

Cab Radio Improvements(7)

Fix #4: LED power reduction. Change 10 Ohm (100 marking) resistor to 47 Ohm (470)



Fix #5: LCD Resistors. Remove any found in these 3 locations. **Only** applies to PHICO boards EXCEPT model P113-2A. You must return the cab to NCE if you have a 2A board.



References

- Antenna Information
  - http://www.qsl.net/w4sat/antenna.htm
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