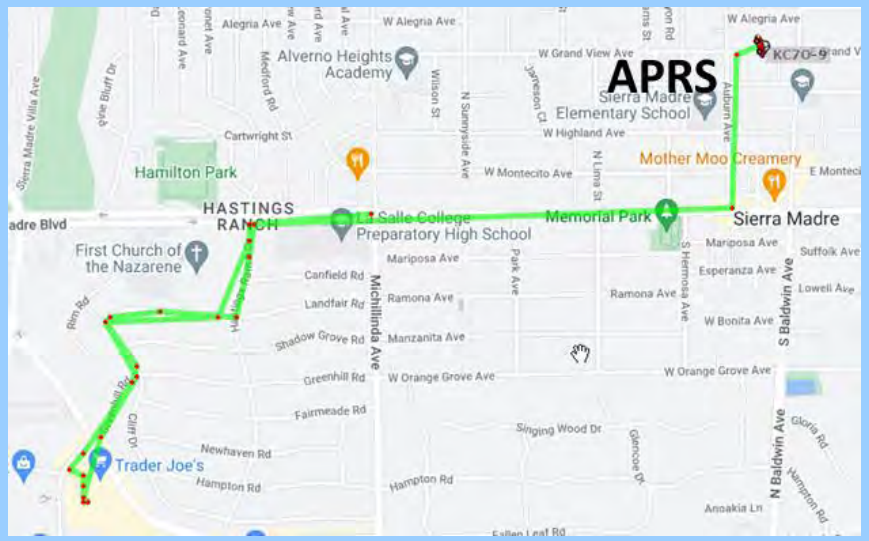
Diplexers, Triplexers & the Low-Profile Mobile



Allen Wolff – kc7o

W6TRW - 14 March 2023

Low-Profile Mobile

- Goal
- Diplexers and Duplexers
- A look back 50 years
- Previous attempts at low-profile
- Have a plan
- Installation
  - Power
  - Coax

- Losses
  - Diplexers & Triplexers
  - Coax

Goal – Low-Profile Operation

- **Operation on three bands + without switching or user input**
  - **2M, 220 & 440**
  - **2M APRS while operation on 2M, 220 or 440**
  - **High band scanner receive**
  - **HF capable**
- **Equipment**
  - **Anytone AT-5888UV III (triband in cabin)**
  - **TM-221A – APRS & TinyTrak3 (in trunk)**
    - **On when the ignition is on**
  - **Scanner (in trunk)**

https://www.qsl.net/n4emp/antenna10.gif


SEP CALIFORNIA 2017
KC70
The Golden State
GS 350
Low-Profile


220, APRS &
Scanner
Or
HF, APRS &
Scanner
GPS
2M & 440
SEP CALIFORNIA 2017
KC70
To achieve goal, diplexers
and triplexers must be used


California
KC70

For the observant

But First!
Diplexers vs. Duplexers

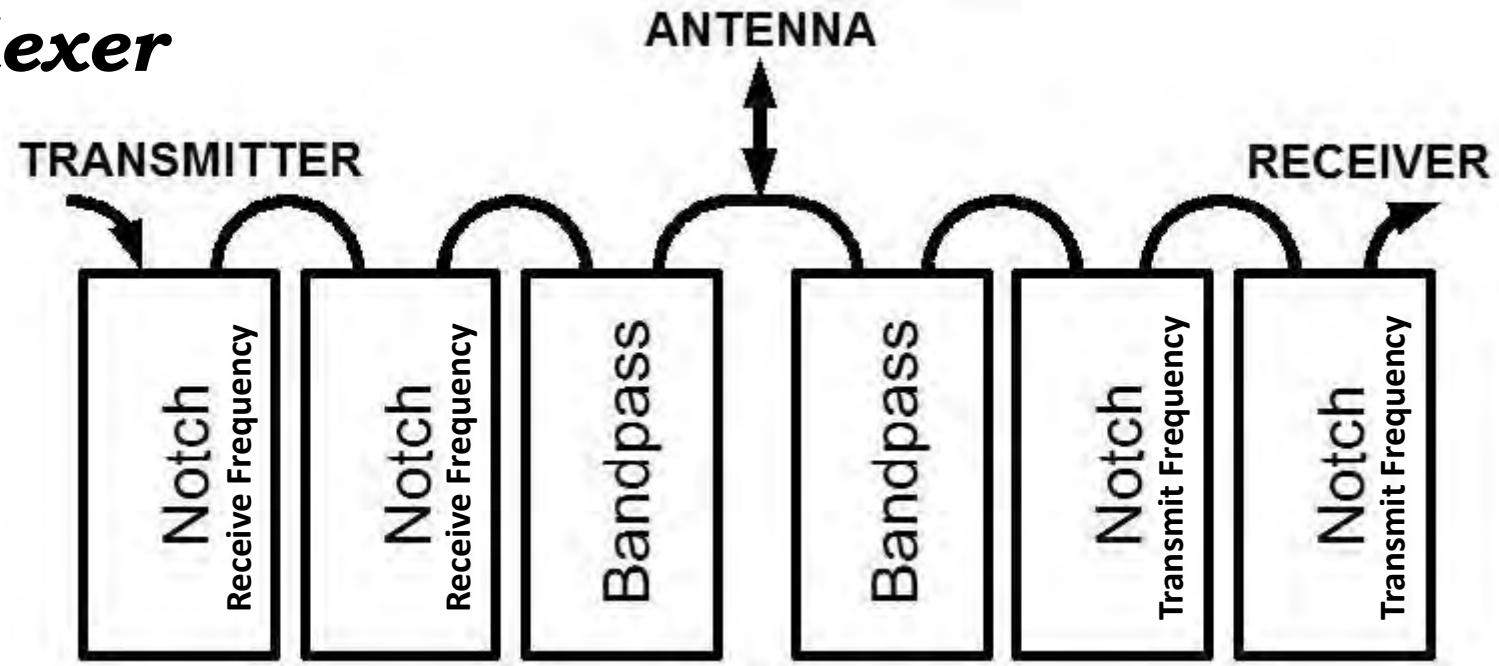
- *The term duplexer is misused by manufactures and Hams*
- *Eliminate confusion*
  - *Difference between Diplexers vs. Duplexers*
- *How do they work?*
- *Why use them?*
- *Efficiency?*

What Is The Difference Between A Diplexer and a Duplexer?

- ***A duplexer separates a transmit and receive path based on signal direction***
  - ***Diplexers and duplexers are not interchangeable, and they cannot be substituted for each other in common circuits***
- ***Duplexers are devices that filter the signals of transmitters and receivers operating at different frequencies*** (simultaneously) ***so that they can share an antenna***
  - ***In a duplexer, two band pass filters are connected in parallel***
  - ***Notch filters are used to block the unwanted frequency***

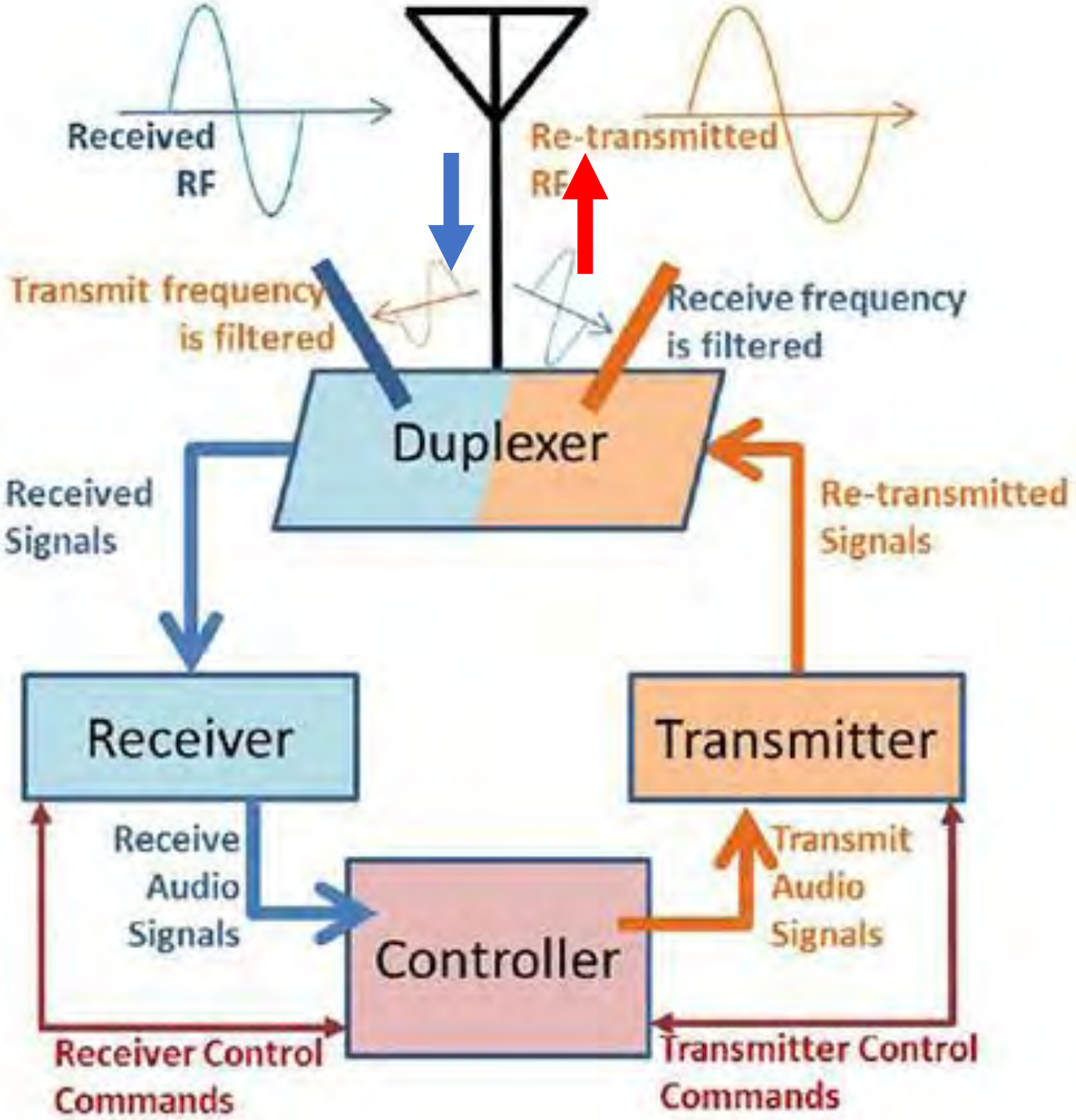
https://www.s-ehrlich.com/how-does-a-ham-radio-duplexer-work/

Duplexer

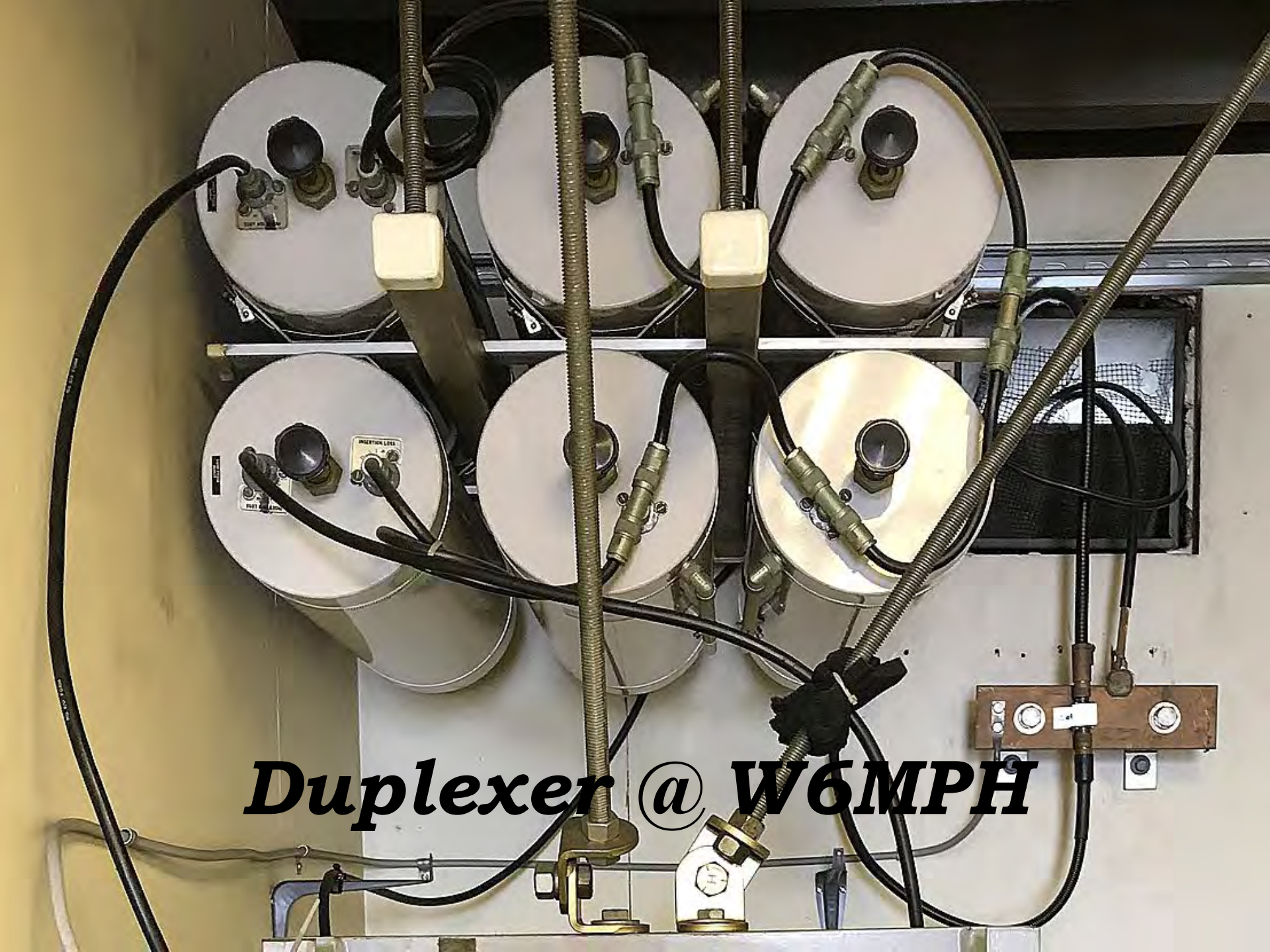


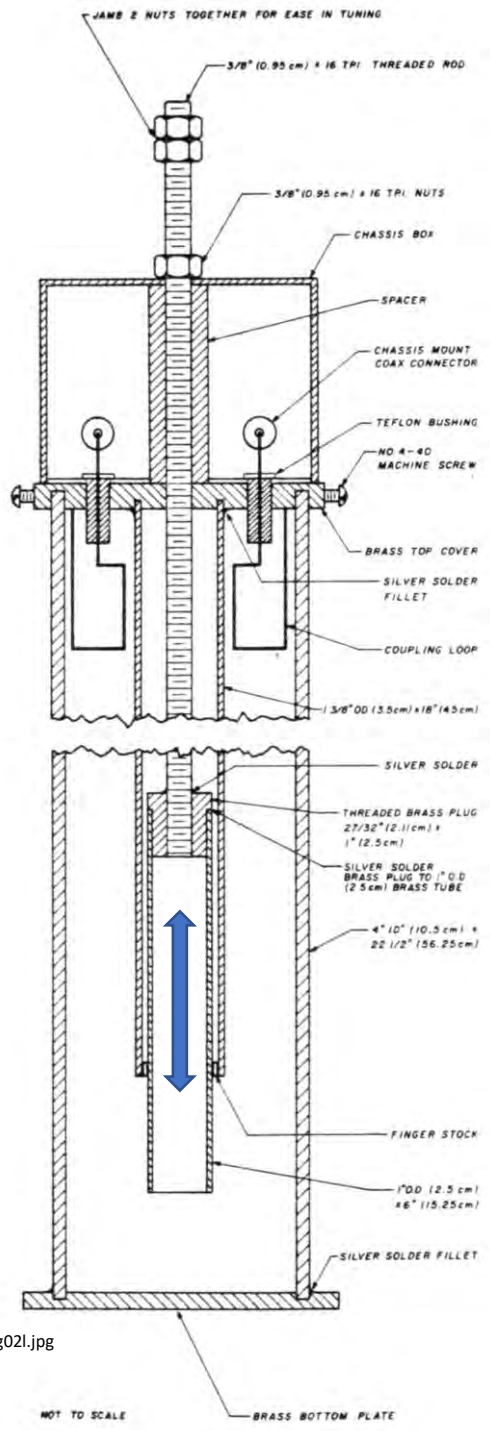
- ***Same band***
  - ***transmit and receive frequency close by***
    - ***2M = T & R frequencies are 600 kHz apart***
- ***Expensive - $$ Thousands***
- ***Complicated, large & difficult to tune correctly***

https://www.repeater-builder.com/antenna/w6nbc-duplexer-book/ch3.html



https://www.hamradioschool.com/post/fm-repeaters-an-introduction


Duplexer @ W6MPH



https://www.robkalmeijer.nl/techniek/electronica/radiotechniek/hambladen/hr/1985/02/page12/fig02l.jpg

- ***A diplexer is a passive (RF) filter component with three ports, which enables the sharing of a common antenna between two distinct frequency bands***
  - ***This technology allows transmitters operating on different frequencies to use the same antenna and each band may both transmit and/or receive*** (simultaneously)
- ***For all multiplexer devices there are two input ports that are multiplexed onto a third port***
  - ***This allows the signals from the two input ports to coexist on the output port without interfering with each other***
- ***Different bands***
- ***Inexpensive less than $100***
- ***Small & easy to use***
- ***Miniscule loss***

https://www.epectec.com/rf-products/diplexers.html

Duplexer
~ $3000

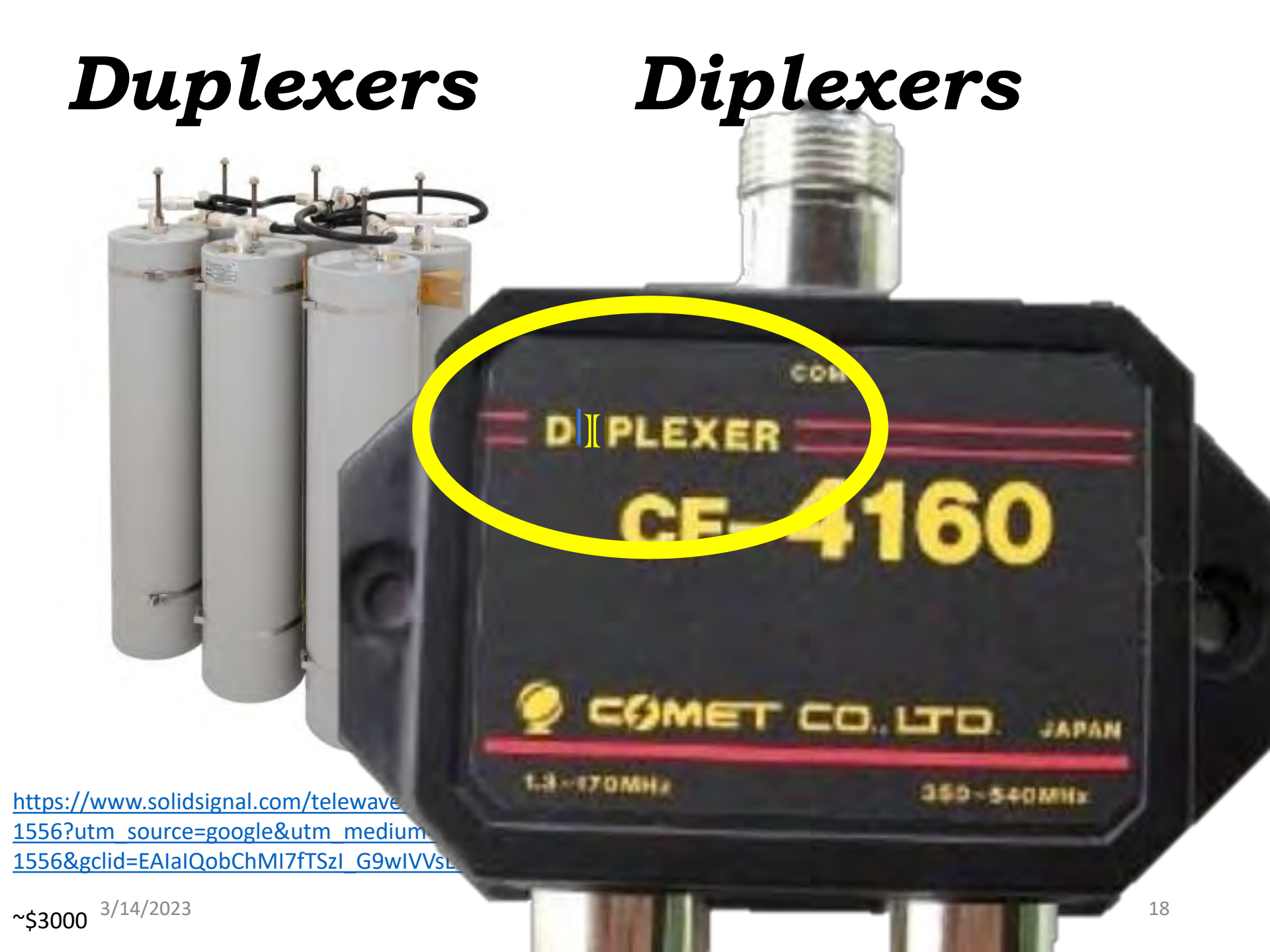
≠

Diplexer
< $100

https://www.solidsignal.com/telewave-144-174-mhz-duplexer-tprd-1556?utm_source=google&utm_medium=cse&utm_term=TPRD-1556&gclid=EAIaIQobChMI7fTSzI_G9wIVVsLCBB0njg0HEAQYBiABEgK4A_D_BwE

Duplexers

Diplexers



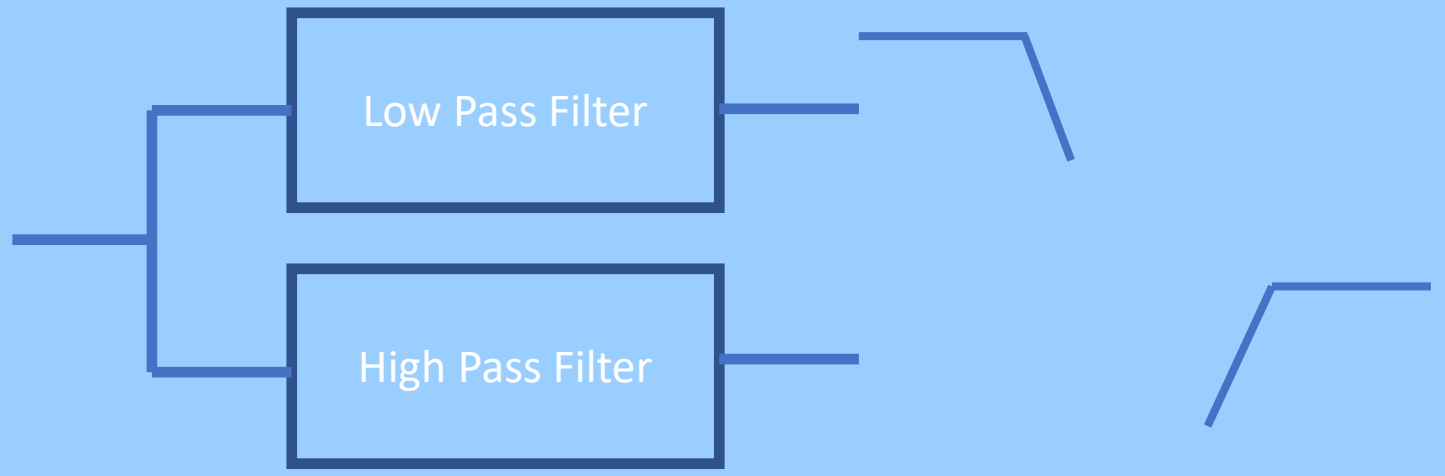
https://www.solidsignal.com/telewave
1556?utm_source=google&utm_medium
1556&gclid=EAIaIQobChMI7fTSzI_G9wIVVsE

~$3000

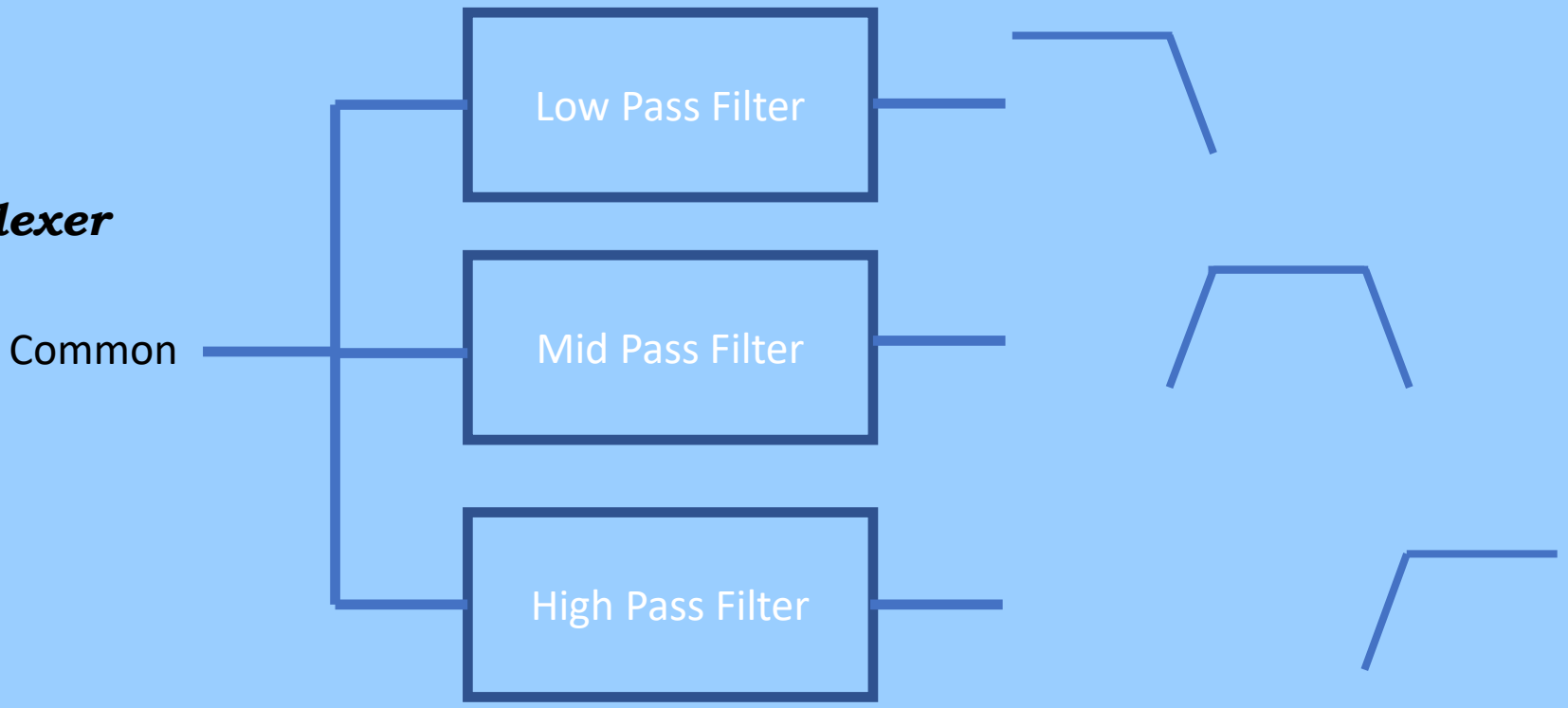
Triplexers are always Triplexers

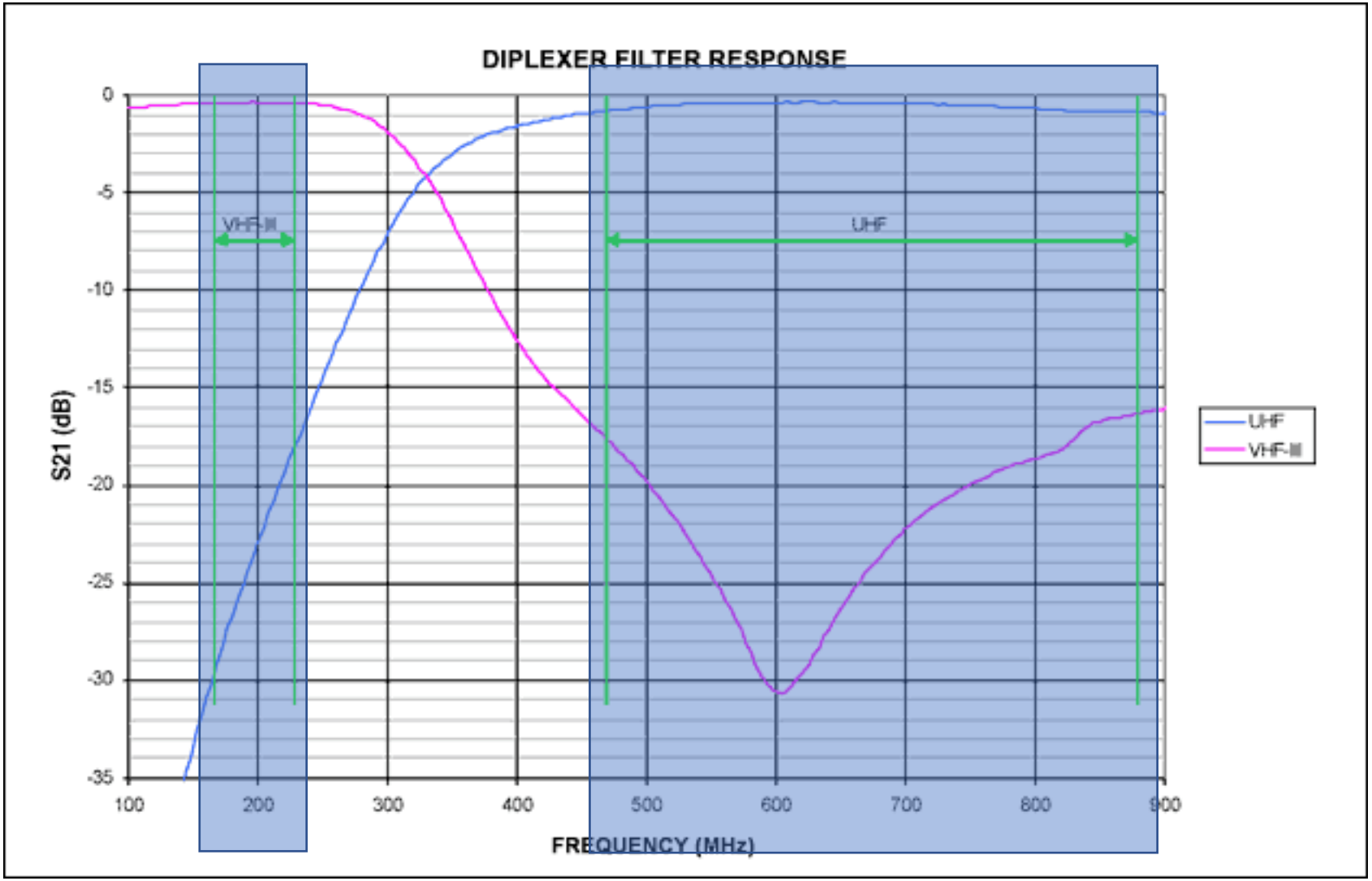
never TrUplexers!

Diplexer



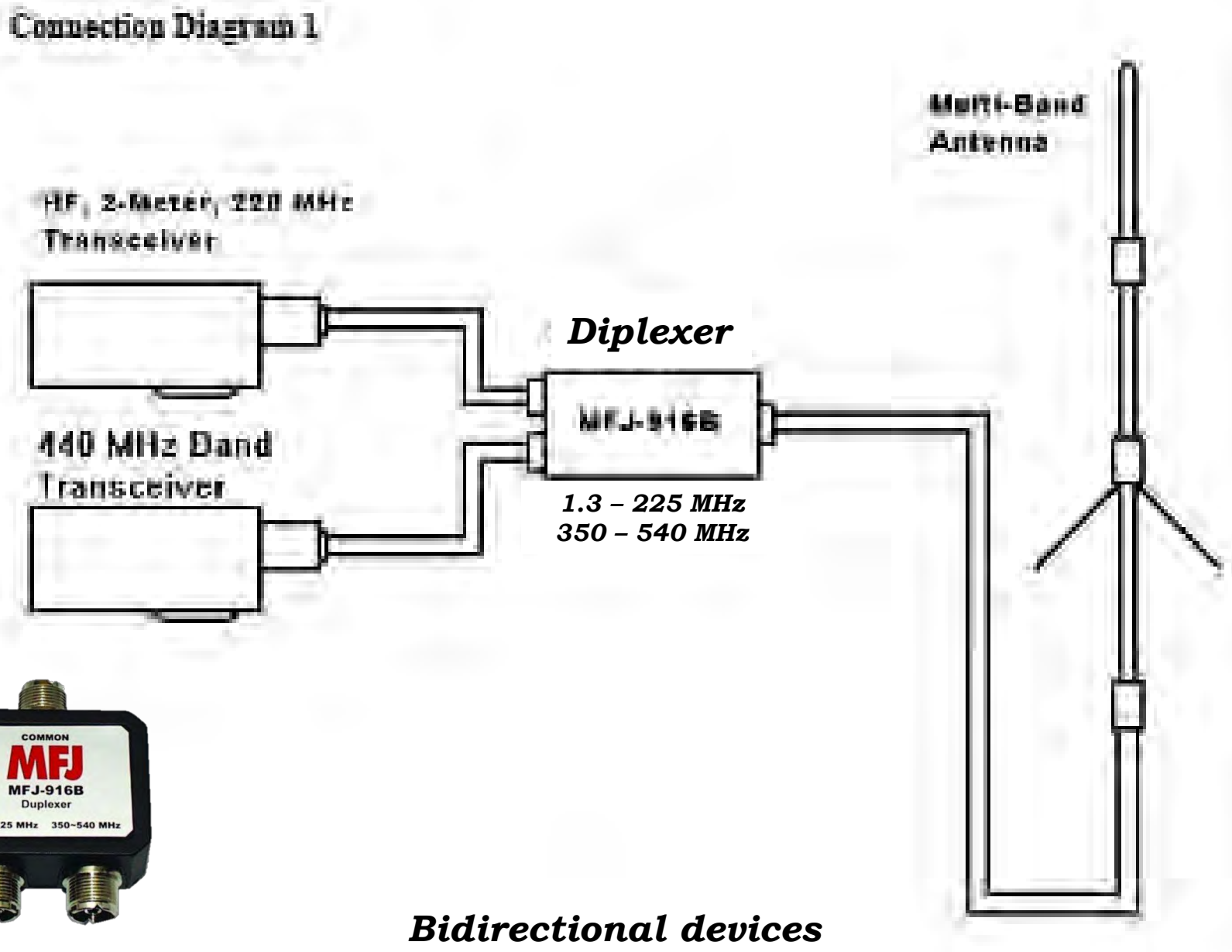
Triplexer





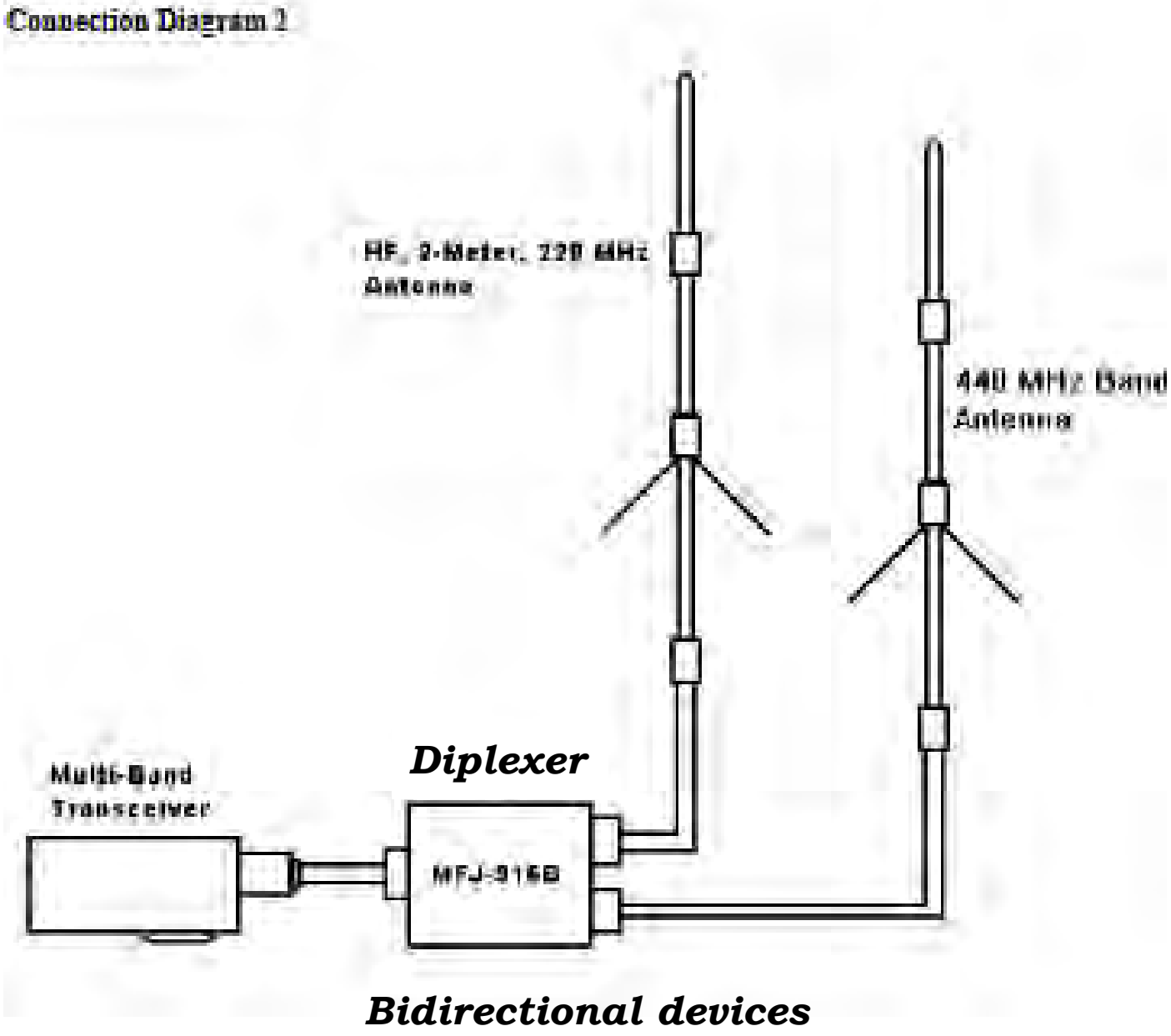
Power transfer between ports

https://www.maximintegrated.com/en/design/technical-documents/app-notes/3/3700.html



Bidirectional devices

MFJ-916B & MFJ-916BN Indoor Duplexer (MFJ manual)

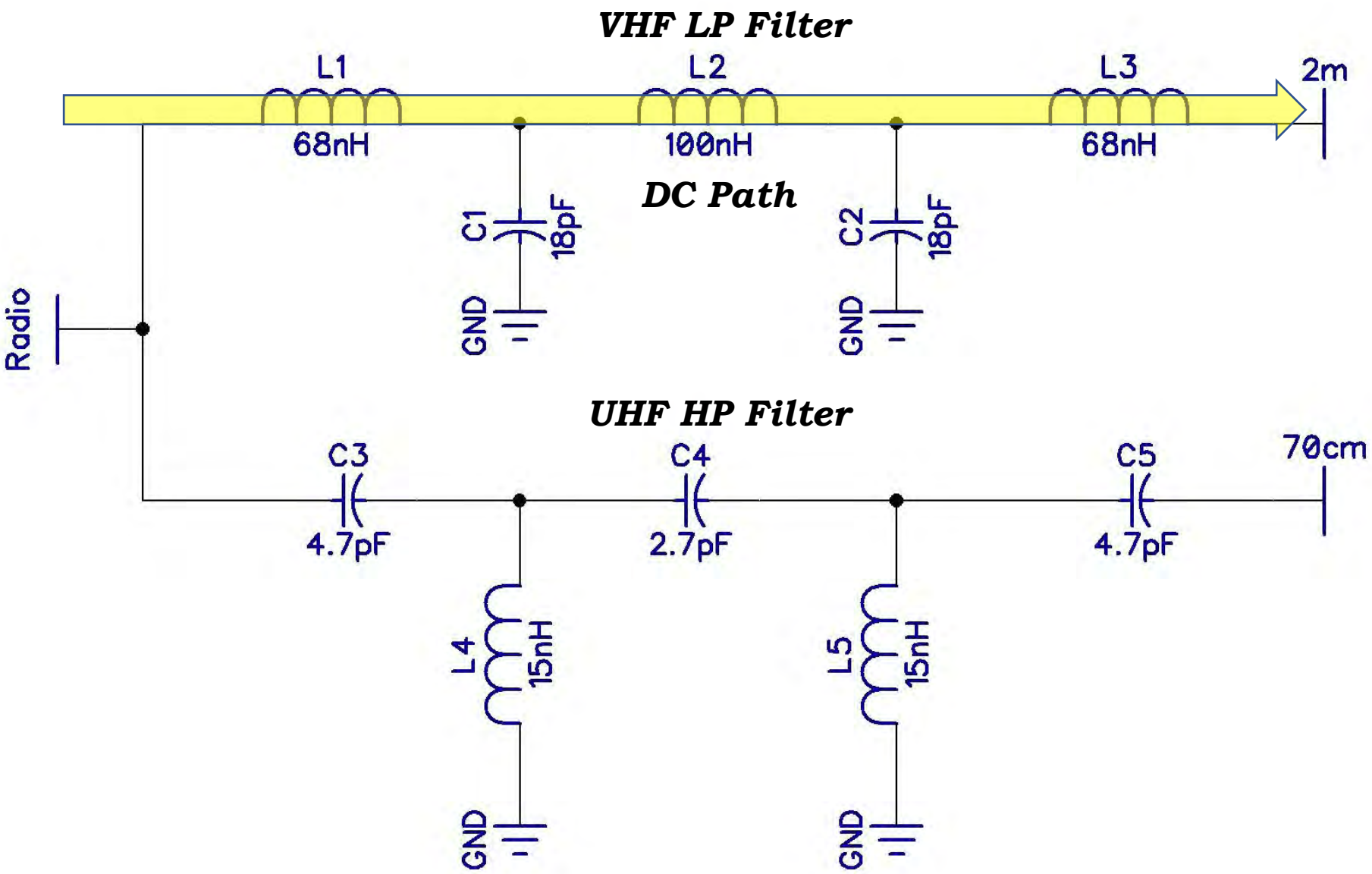


Diplexer

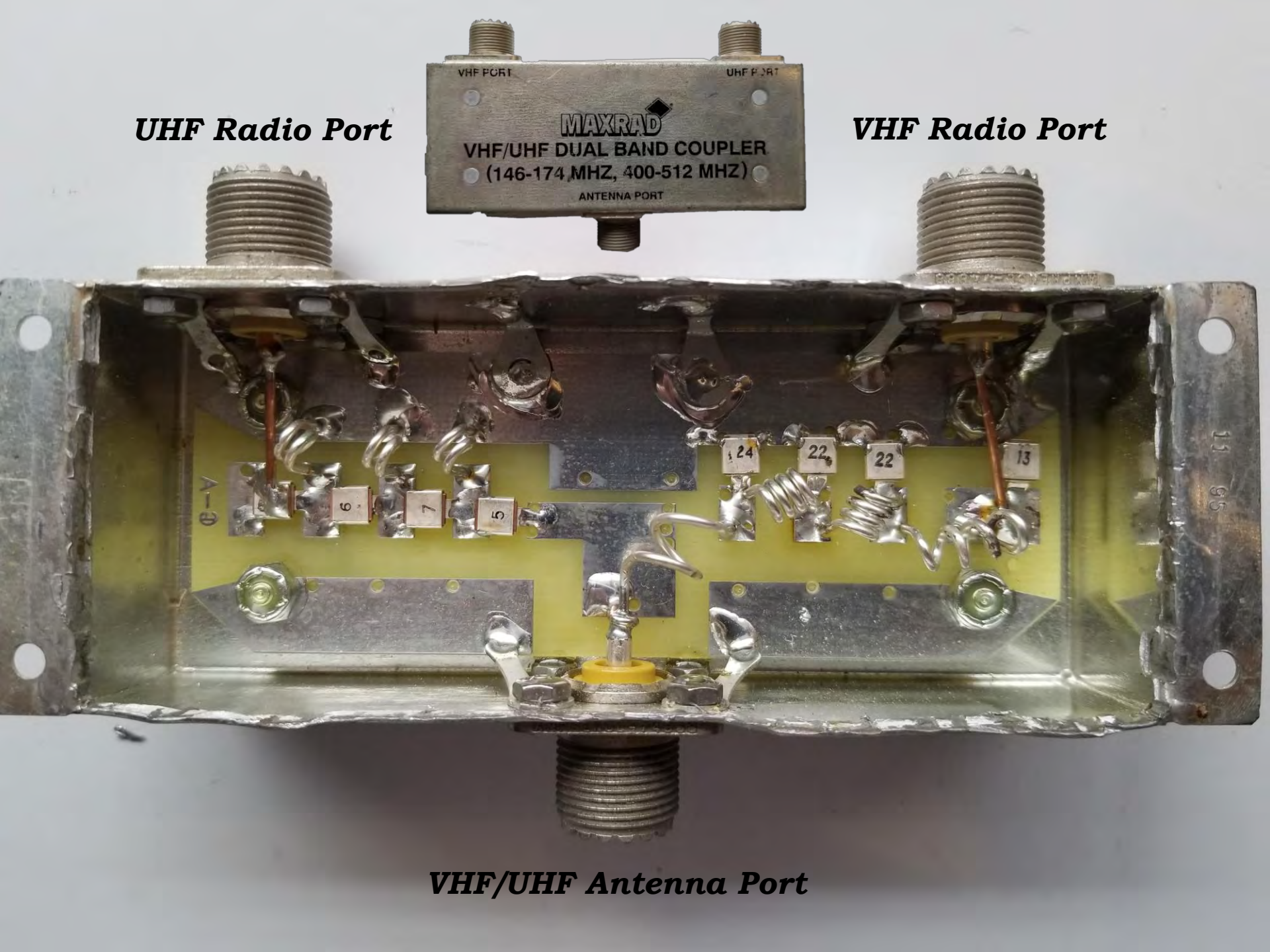
Bidirectional devices

MFJ-916B & MFJ-916BN Indoor Duplexer (MFJ manual)

Typical Diplexer



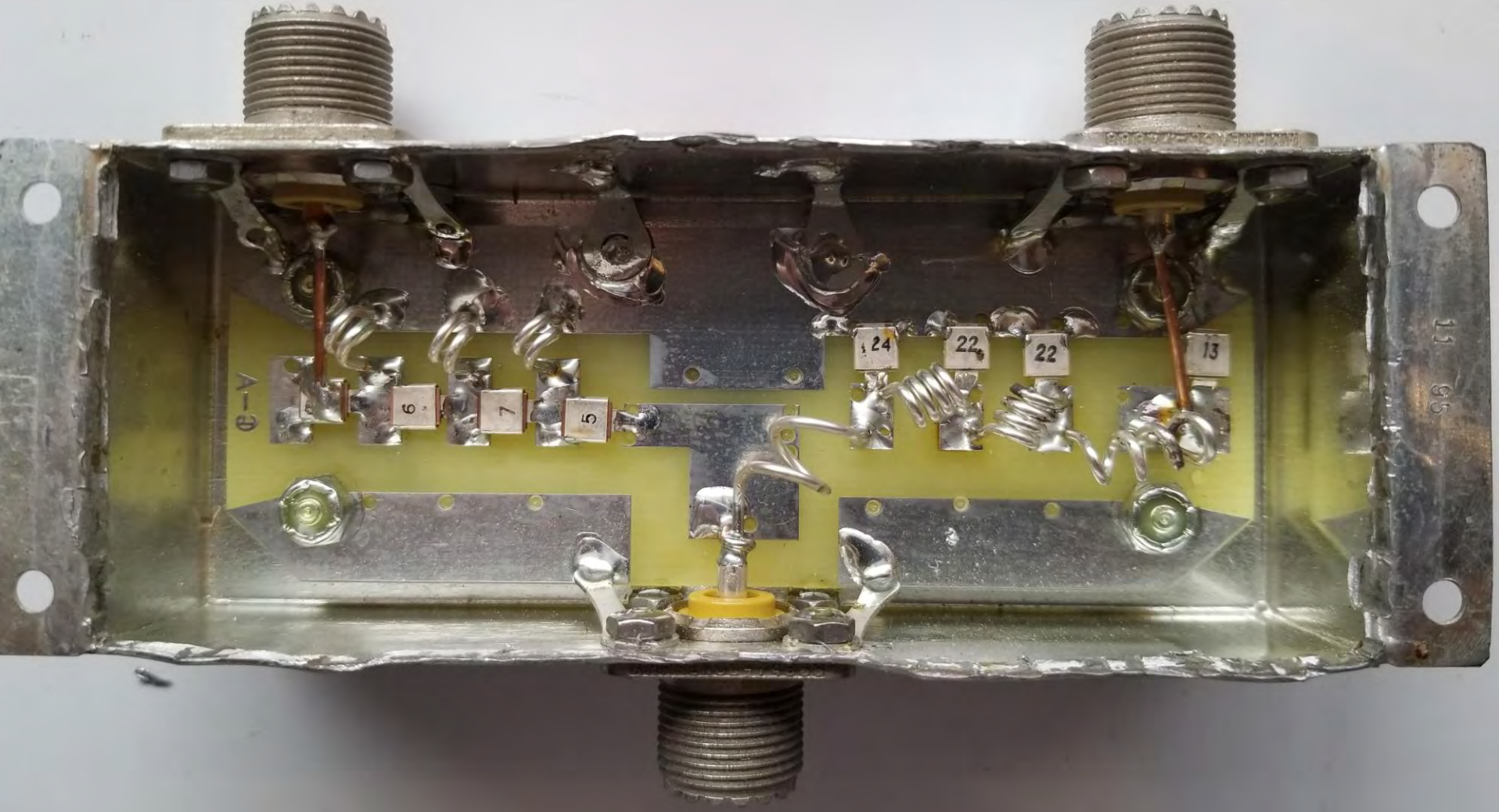
https://kw4fb.com/micro-diplexer/


UHF Radio Port
VHF Radio Port
VHF PORT
UHF PORT
MAXRAD
VHF/UHF DUAL BAND COUPLER
(146-174 MHZ, 400-512 MHZ)
ANTENNA PORT
VHF/UHF Antenna Port

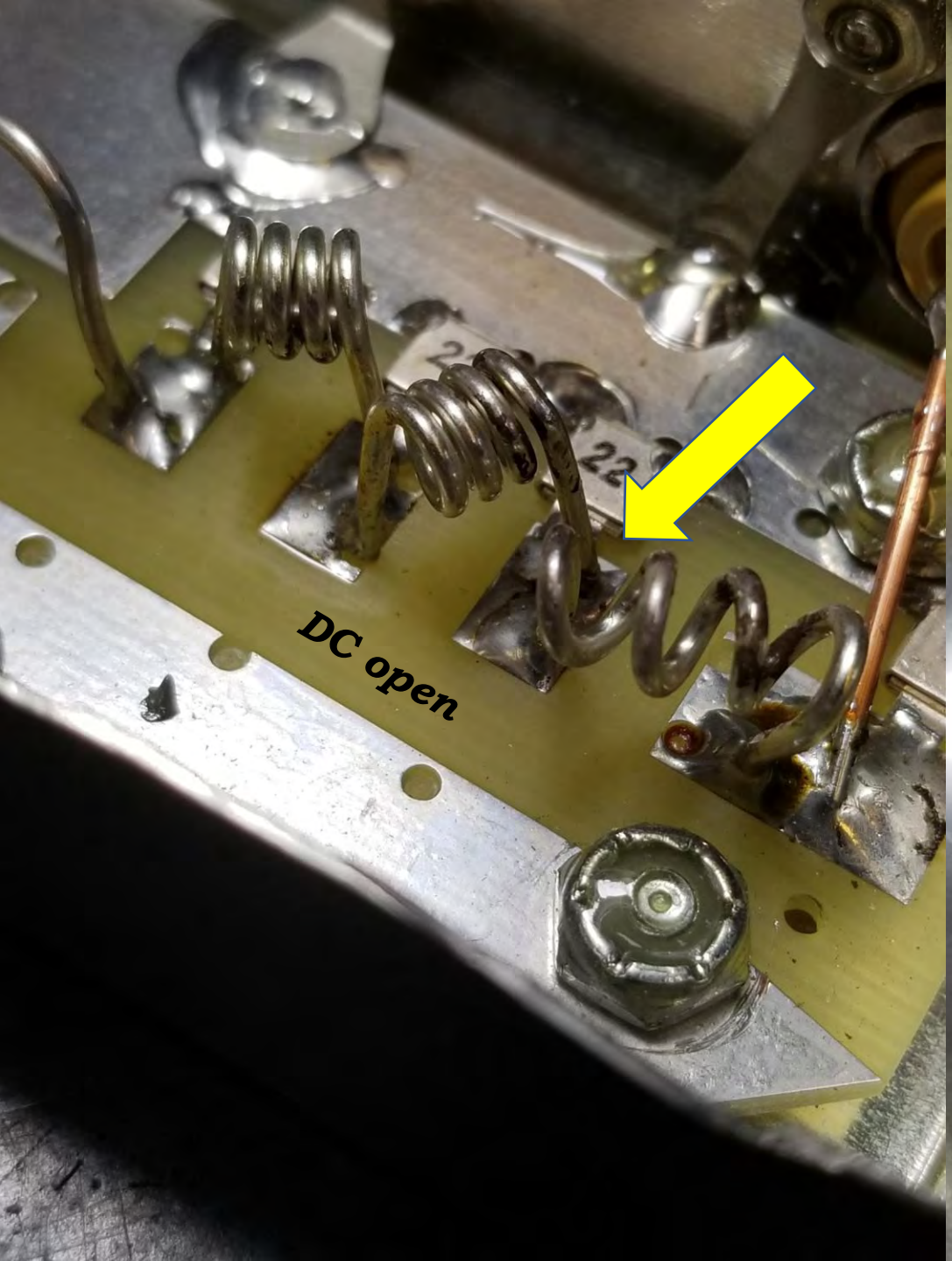
VHF Side Failed

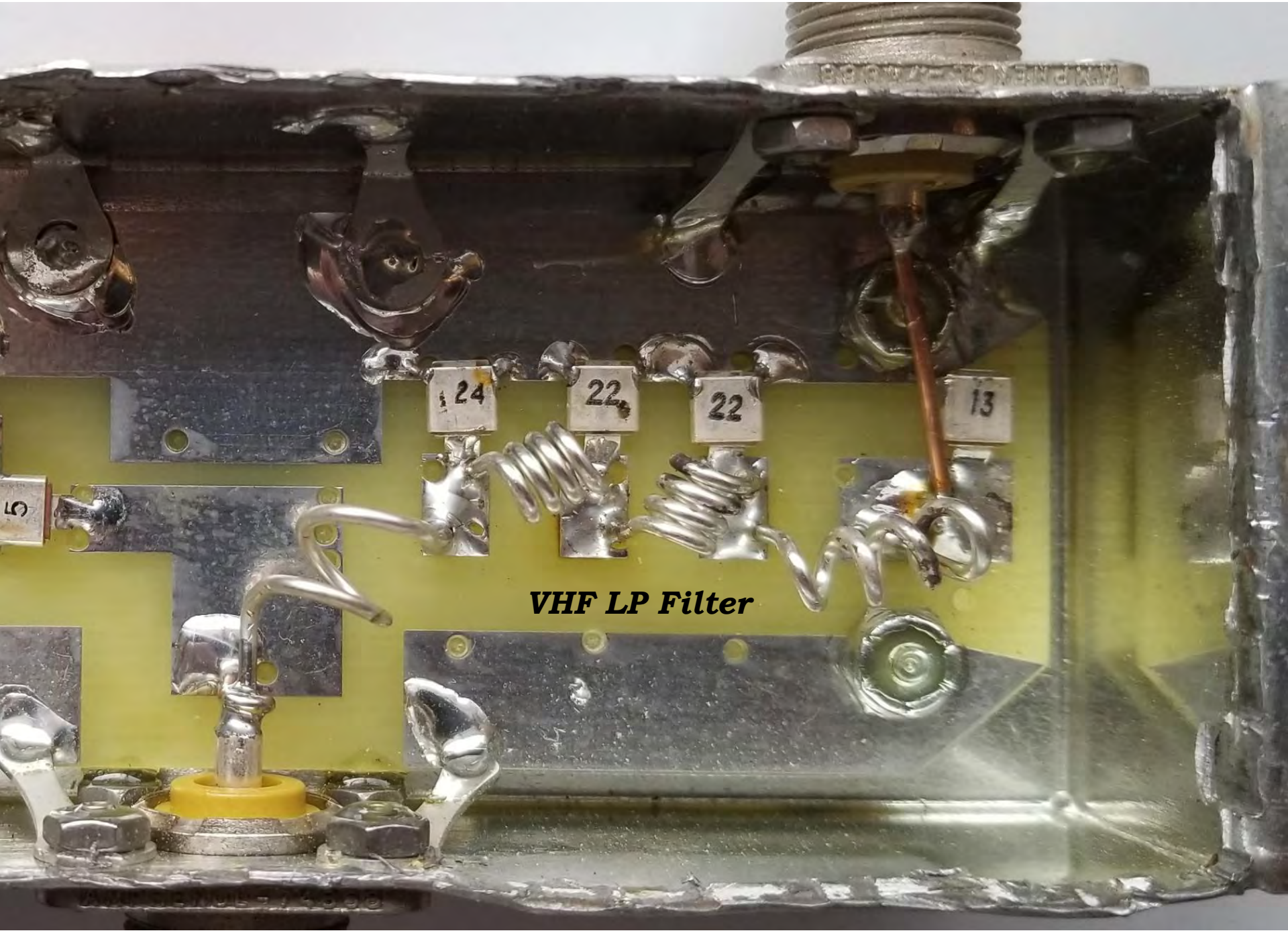
UHF Radio Port

VHF Radio Port

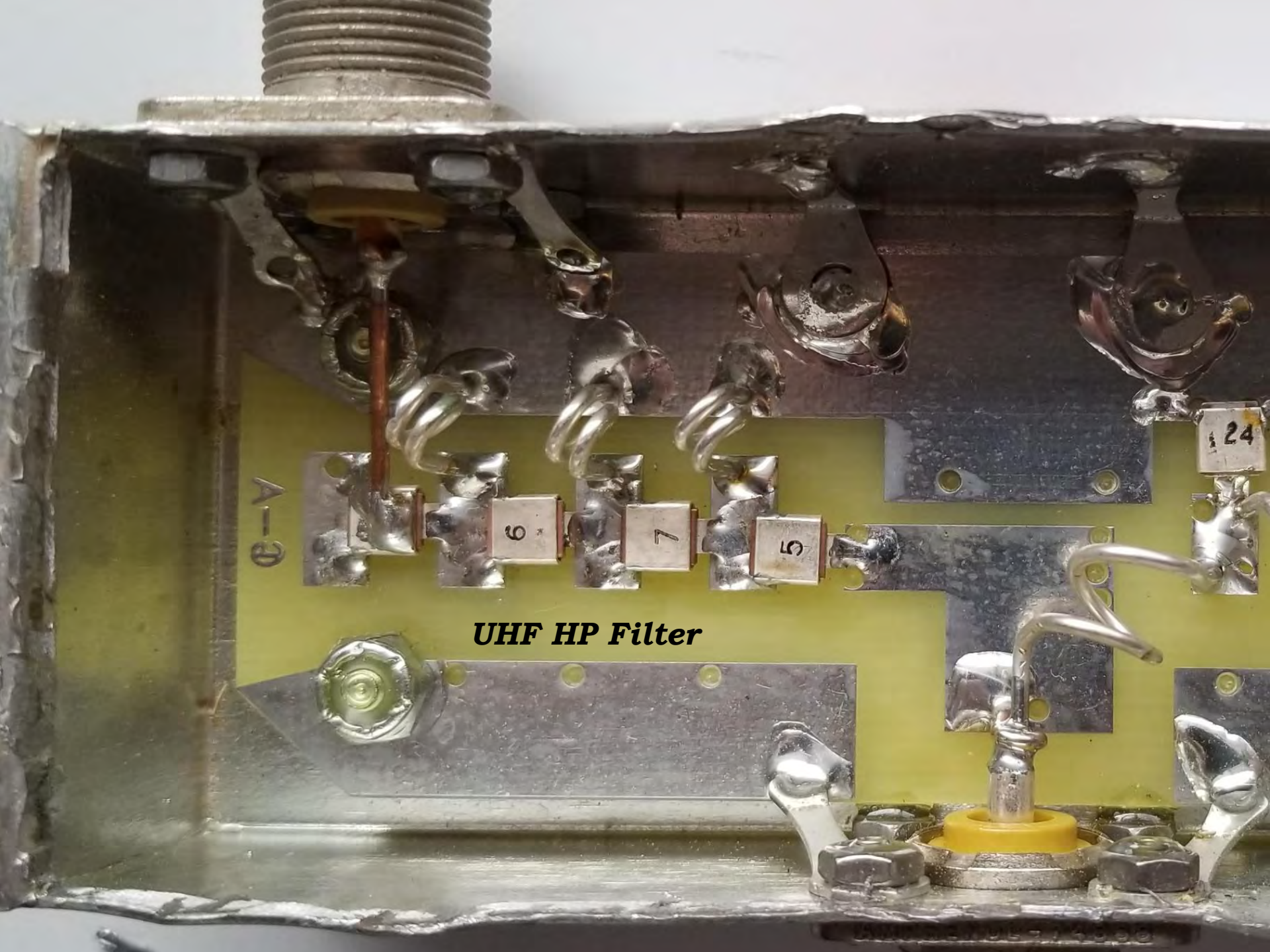


VHF/UHF Antenna Port


DC open

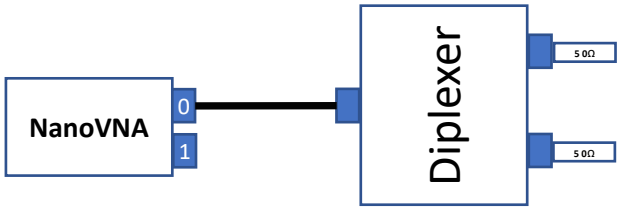


VHF LP Filter

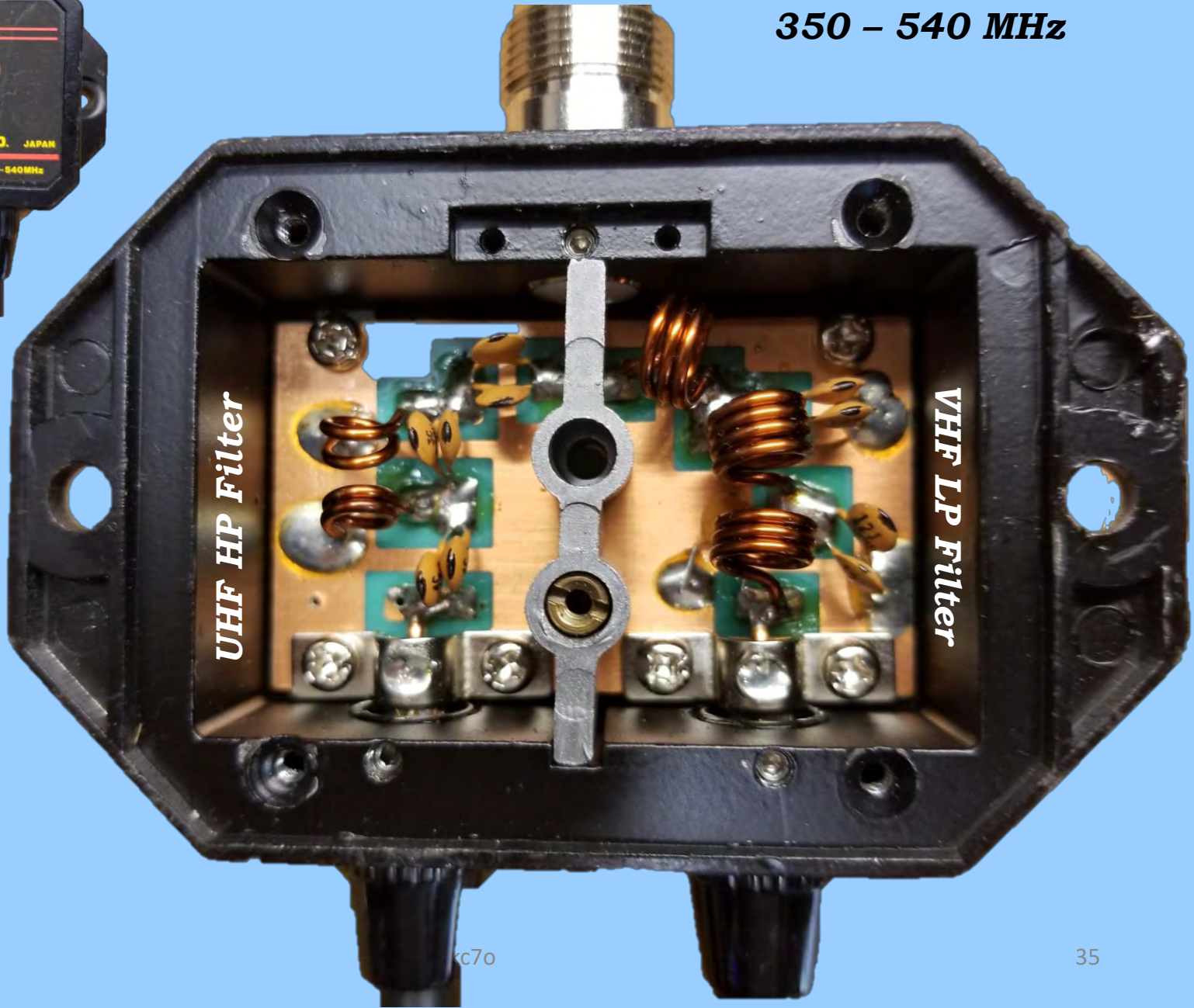


UHF HP Filter

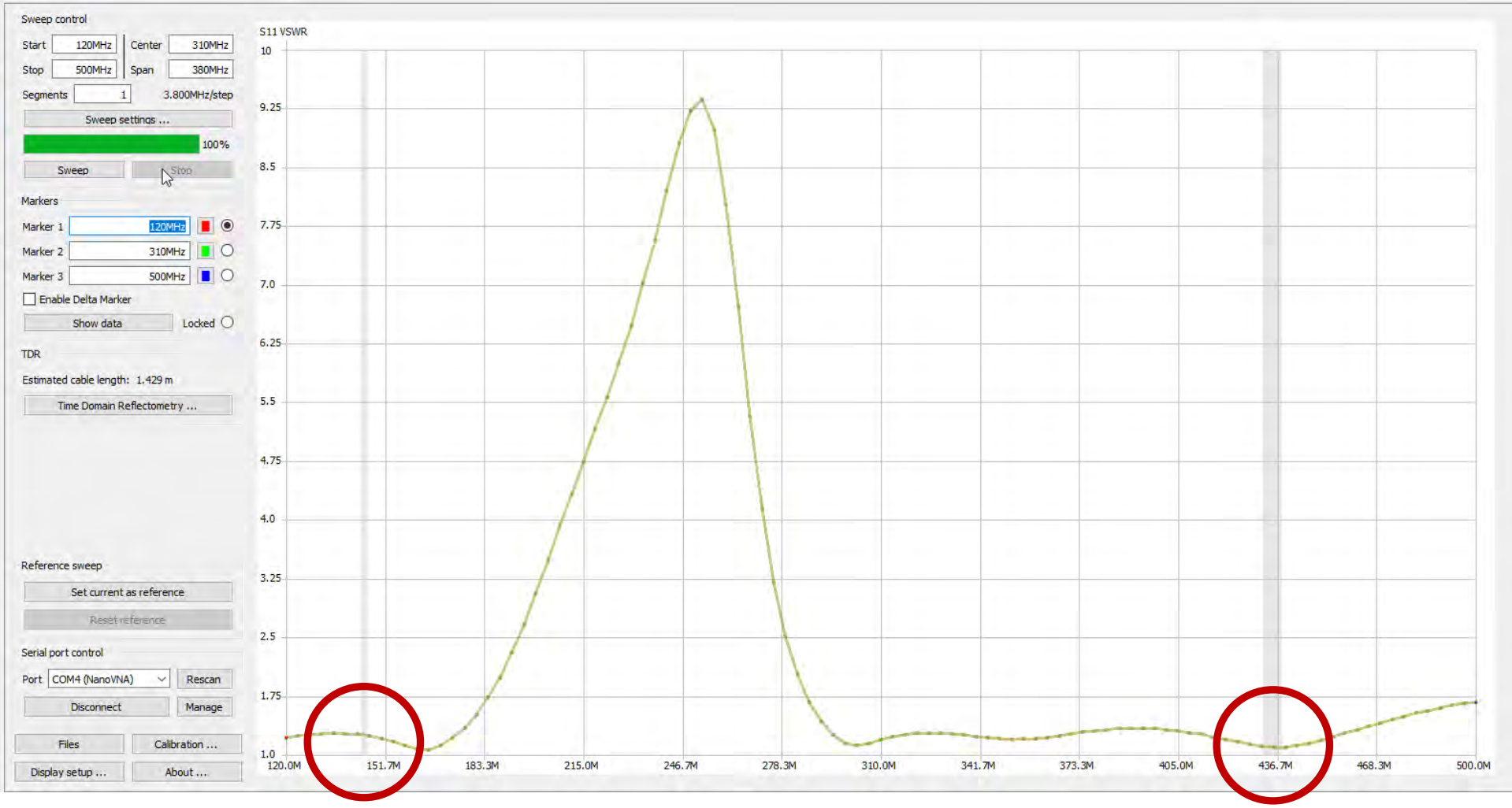
Maxrad – NanoVNA on Common port – 50-ohm termination on other ports

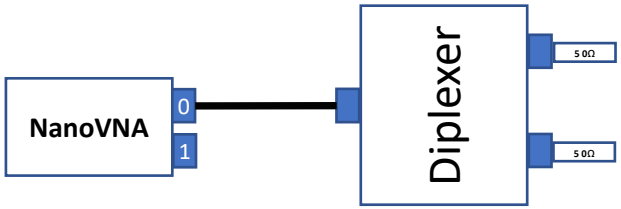


1.3 – 170 MHz
350 – 540 MHz



Comet CF-416 – NanoVNA on Common port – 50-ohm termination on other ports





$55*

CLICK TO ENLARGE IMAGE

Retail Dealer List

CF-416A, CF-416B, CF-416C

	Band Pass	Ins Loss	Max Power
Low Pass:	1.3-170MHz	0.15dB	800W PEP
High Pass:	350-540MHz	0.25dB	500W PEP

Isolation: 60dB minimum

50 watts to 0.00005 watts

Or 50 microwatts

CONNECTORS:

CF-416A

Common: SO-239

Low pass: PL-259

High pass: PL-259

$89*

CLICK TO ENLARGE IMAGE

Retail Dealer List

CFX-324A

2M/220/70cm Triplexer with coax leads

Band Pass	Ins Loss	Max Power
1.3-150MHz	.2dB	600W PEP
200-320MHz	.25dB	600W PEP
390-500MHz	.3dB	600W PEP

Isolation: 40dB minimum

CONNECTORS:

Common: SO-239

Low Pass: PL-259 w/coax lead

Mid Pass: PL-259 w/coax lead

High Pass: PL-259 w/coax lead

****DX Engineering price June 2022***

$79*

CLICK TO ENLARGE IMAGE

Retail Dealer List

CF-706A

HF-6M/2M-440MHz duplexer for the IC-706/MKII/G, FT-1 [No Title]

To match the RX freq range of the IC-706MKII/G the CF-706A was engineered to pass the commercial FM band of 88-108MHz

	Band Pass	Ins. Loss	Max Power
Low Pass:	1.3-57MHz	0.4dB	350w PEP
High Pass:	75-550MHz	0.4dB	350w PEP

Isolation: 40dB minimum

50 watts to 0.005 watts

Or 50 milliwatts

CONNECTORS:

Common: SO-239

Low pass: PL-259

High Pass: PL-259

https://cometantenna.com/amateur-radio/duplexers/

https://cometantenna.com/amateur-radio/triplexers/

Way Back When

- *When cars had room for radios*
- *When cars were made of metal &*
- *When bumpers were metal too!*

A look back

https://attorneyatlawmagazine.com/a-writers-look-back-at-2021

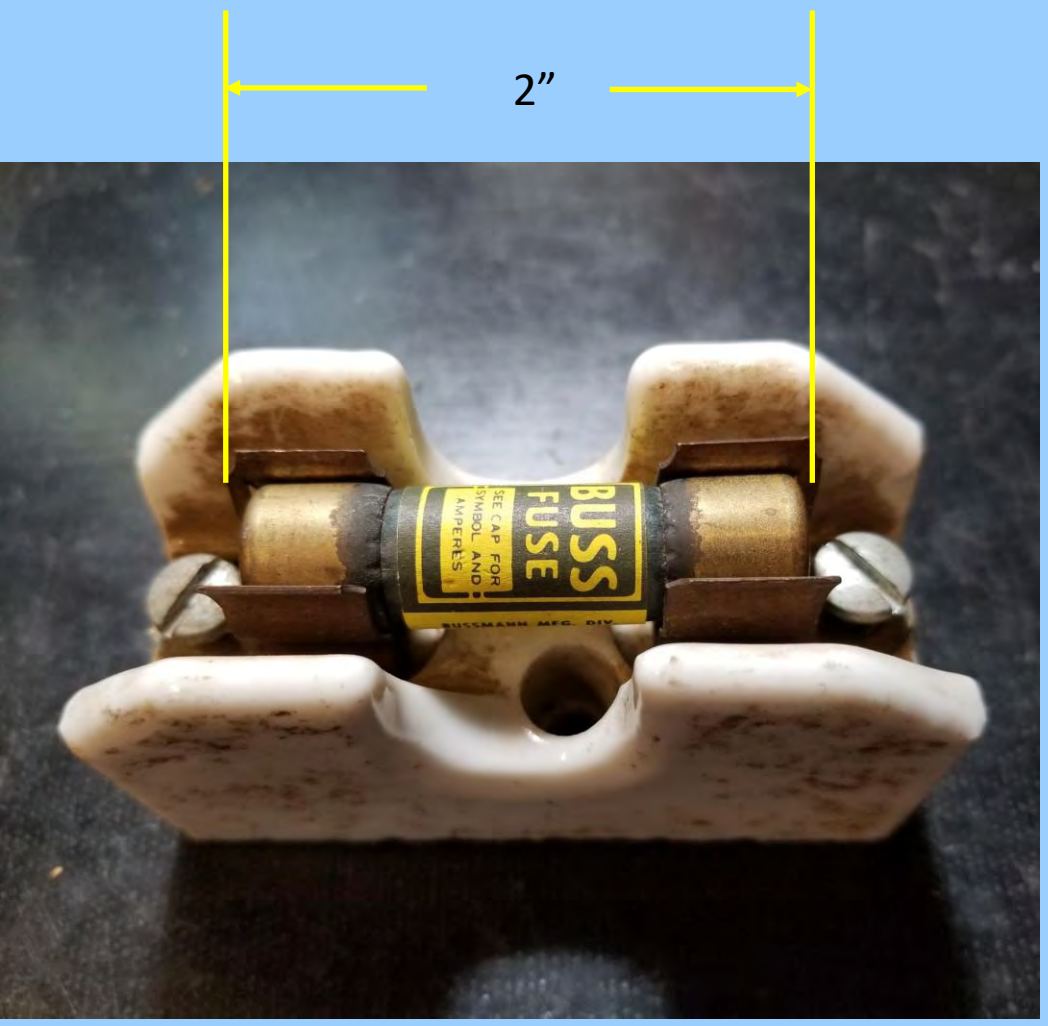

1964 Chevelle in 1970
ex WB2NTL

80, 40 & 20 Meters

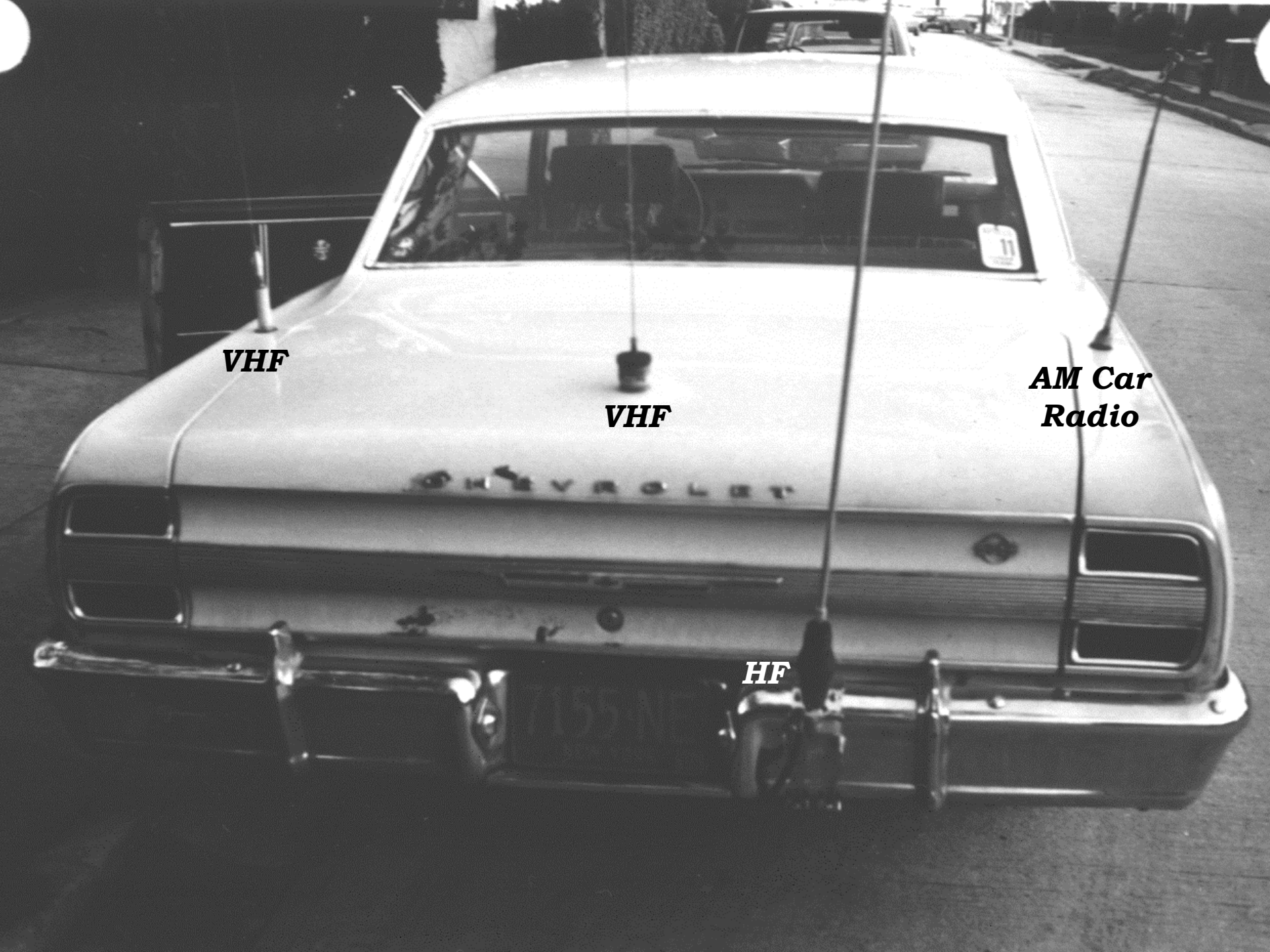
http://www.kc7o.net/articles/1974QST.pdf

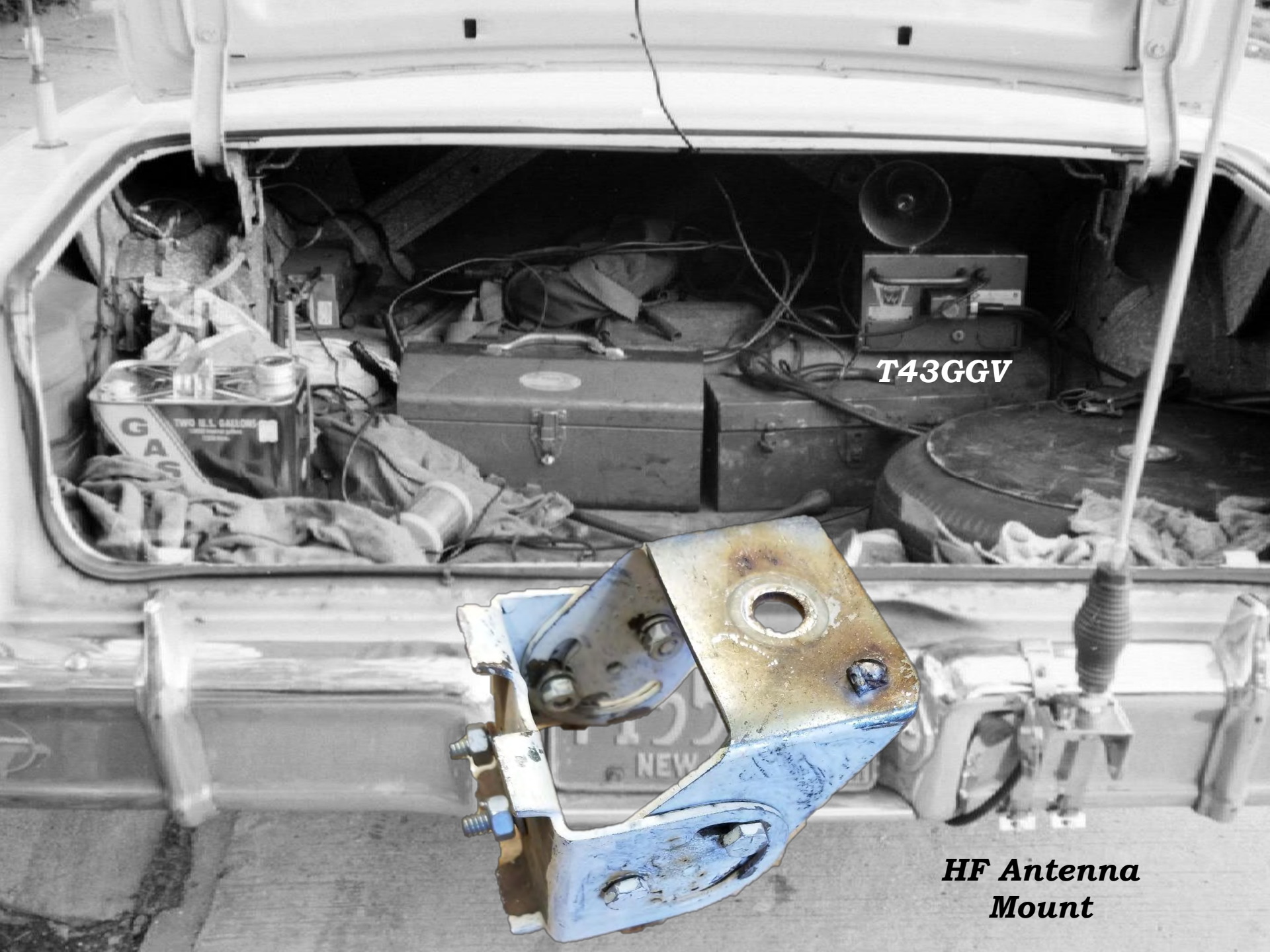
The Eico 753 Rides Again!

Eico 753 & Motorola T43GGV

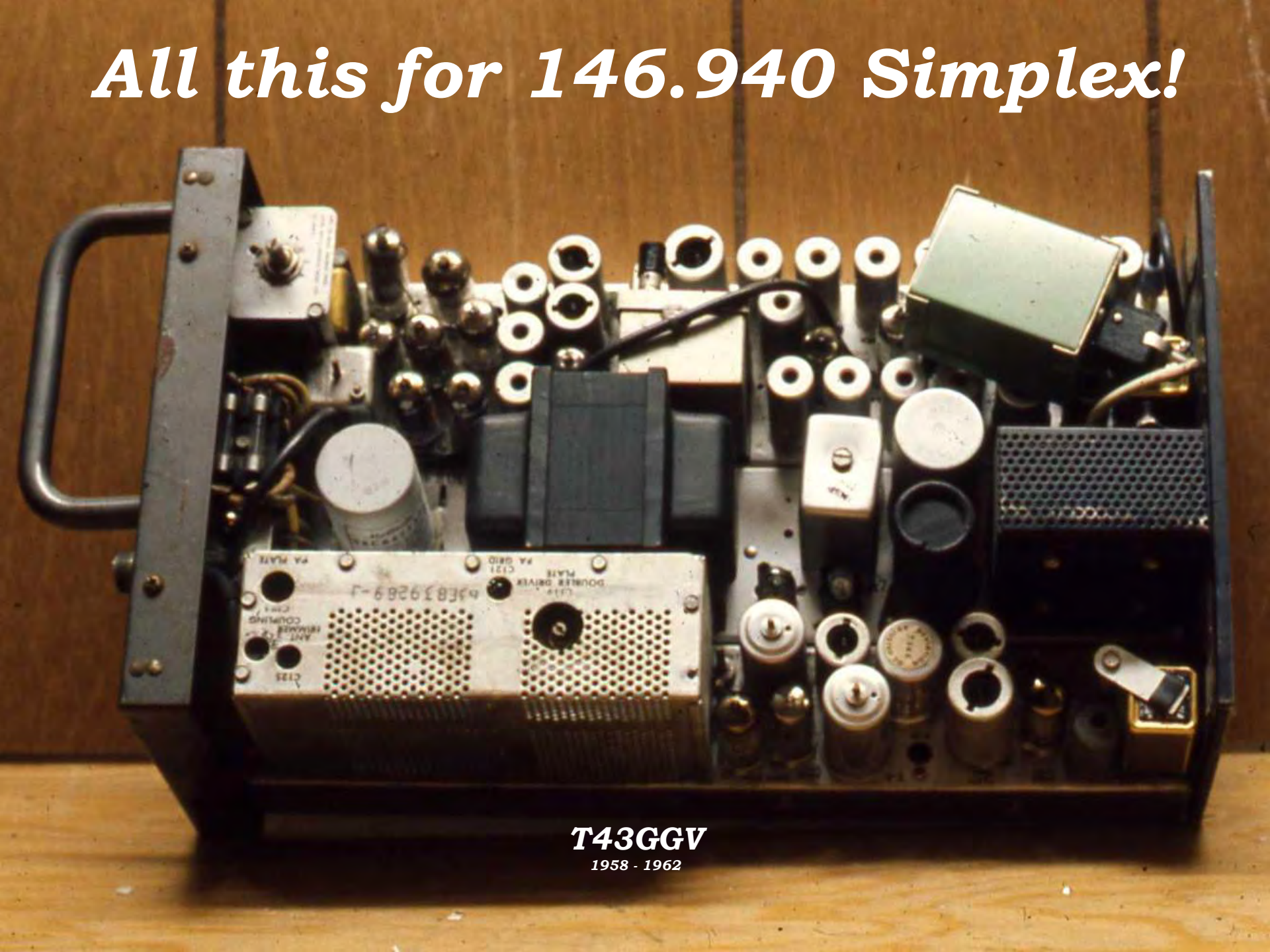

2”
BUSS
FUSE
SEE CAP FOR
SYMBOL AND
AMPERES


SNA 35
BUSSMANN MFG.
McGRAW-EDISON
St. Louis, Mo.


VHF
VHF
AM Car
Radio
HF

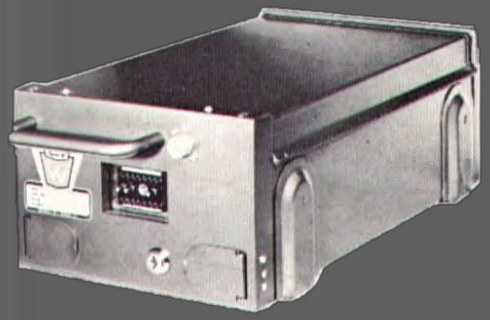

T43GGV
HF Antenna
Mount

All this for 146.940 Simplex!



T43GGV

1958 - 1962



https://www.wb6nvh.com/Moto42/M42Page2.htm

2E26

+

6146

= 30 Watts RF

The National Valve Museum
http://www.r-type.org/

6.3 V filaments 0.8A 1.125A = 12.13 Watts to heat!

= 50 Watts RF


MOTOROLA
Cast aluminum

1lb 3.3oz

10.4oz

(4000 memory channels)

The purist – one antenna for each radio

https://www.hammacho.com/2016/12/the-fabled-red-porcupine-car.html

https://www.hammacho.com/2016/12/the-fabled-red-porcupine-car.html

Or


SEP CALIFORNIA 2017
KC70
The Golden State
GS 350

Previous Attempt at Low-Profile

- ***Not to make holes in metal***
- ***Antennas***
  - ***2M/440 & 2M/220***
  - ***Magnetic whip for APRS***
  - ***Magnetic whip for scanner***
  - ***GPS hockey puck***
- ***Equipment not hidden away in cabin***

Previous Car


Kenwood TM-742A


Kenwood TM-742A
OPTION
ANT
OPTION
EXT.SP
144
ANT
144
EXT.SP
DC
13.8V
440
ANT
440
EXT.SP
34840
220
144
440

2001 GS 430 Radio Installation

Cabin Dashboard

Kenwood TM-742A

2M

440

CF-416 Diplexer

Common

220

Scanner

Trunk Driver Side

GPS Ant

TinyTrack

TM-221A APRS

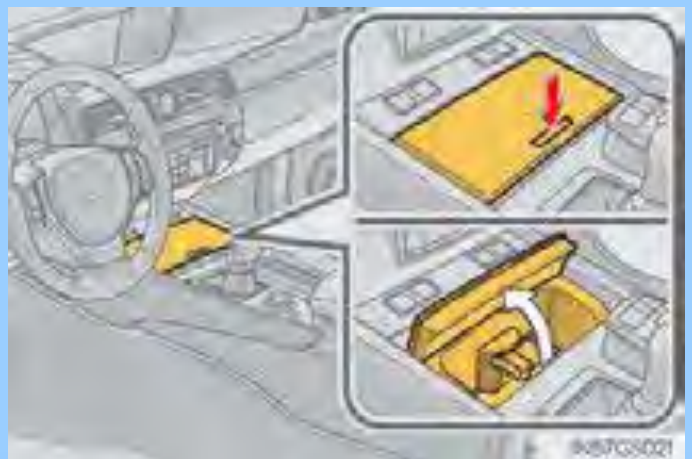
2M/220 - Diamond CR214S

Trunk Passenger Side

2M/440 - Comet B-20M

Next Attempt at Low-Profile

- *2014 Lexus GS350*
- *Not to make holes in metal*
  - *Only two holes in plastic*
    - *One in the bottom of the armrest – replaceable part*
    - *The other in the under-floor storage bin in trunk*
- *Minimum number of antennas*
  - *Two dual band*
    - *2M/440 & 2M/220*
  - *GPS hockey puck*
- *Equipment hidden away in cabin – Stealth!*
  - *Totally contained in center console*
    - *Radio, speaker & microphone in armrest*
    - *Radio remote head where cupholders were*
      - *Under a hinged lid*



Have a Plan!

- What do you need now & in the future?
  - Radios

  - Power

    - Current needed
      - Switched & not switched
    - Coax to the trunk – number

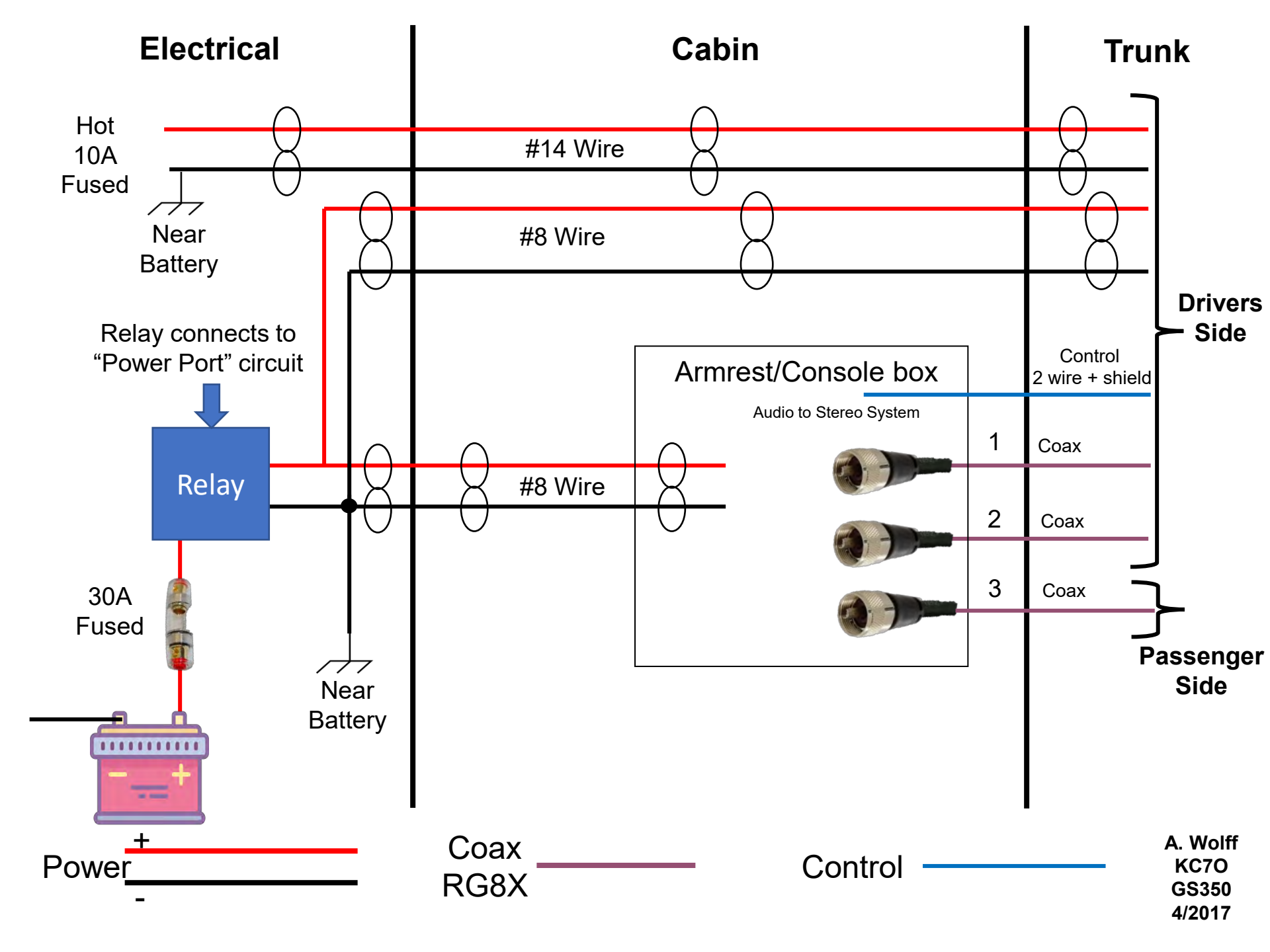
    - Control lines to the trunk
  - Who will do the wiring?
    - You or a commercial company?
      - Get a written estimate
  - Create a wiring plan

My Plan

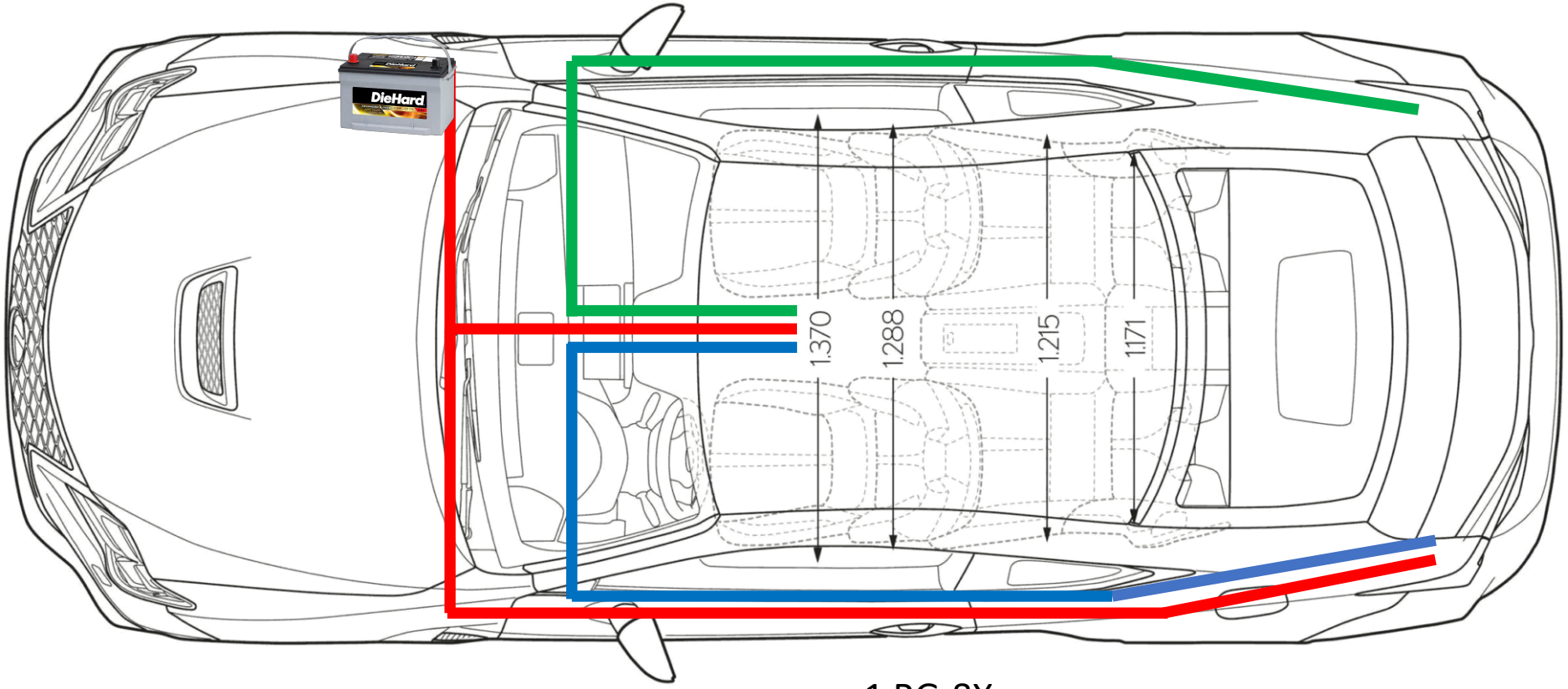
- 2M, 220, 440 & APRS
  - HF ability in future
- Radios
  - Started with a Kenwood TM-742A Triband
  - Changed to Anytone AT-5888UV III Triband in 2021
- Power
  - Accessory switched 30-Amp to the armrest
  - Accessory switched 30-Amp to the trunk
  - 3 RG-8X cables from armrest to the trunk
  - Control wires from armrest to the trunk
  - Un-switched 10-Amp to trunk*

- ***Un-switched 10-Amp to trunk***
  - ***To have 12V available when car is off***
  - ***The hood of my car is under a shelf in my garage***
    - ***When the battery died, I was able to jump it with a 2-Amp charger for a few hours to get car started***
    - ***After not running for a long time, toping off the battery with a 2-Amp charger prevented over stressing the battery***

- ***Have a commercial company do the wiring*** (Car Electronics Installer)
  - ***It cost $350 in 2017***
    - ***As I told a friend: "do you know how much wooden panels costs to replace if I mess up?"***
- ***Prepare***
  - ***3 RG-8X cables from armrest to the trunk***
    - ***Prepare the three 25+ foot cables with PL-259's in advance (armrest end)***
    - ***Color code each cable***
    - ***Put the trunk connectors on after installation***
  - ***2 wires + shield from armrest to the trunk***


Electrical
Cabin
Trunk
Hot
10A
Fused
#14 Wire
Near
Battery
#8 Wire
Drivers
Side
Relay connects to
“Power Port” circuit
Armrest/Console box
Control
2 wire + shield
Audio to Stereo System
Relay
1
Coax
#8 Wire
2
Coax
30A
Fused
3
Coax
Passenger
Side
Near
Battery
+
Power
-
Coax
RG8X
Control
A. Wolff
KC7O
GS350
4/2017

Coax & Power Runs

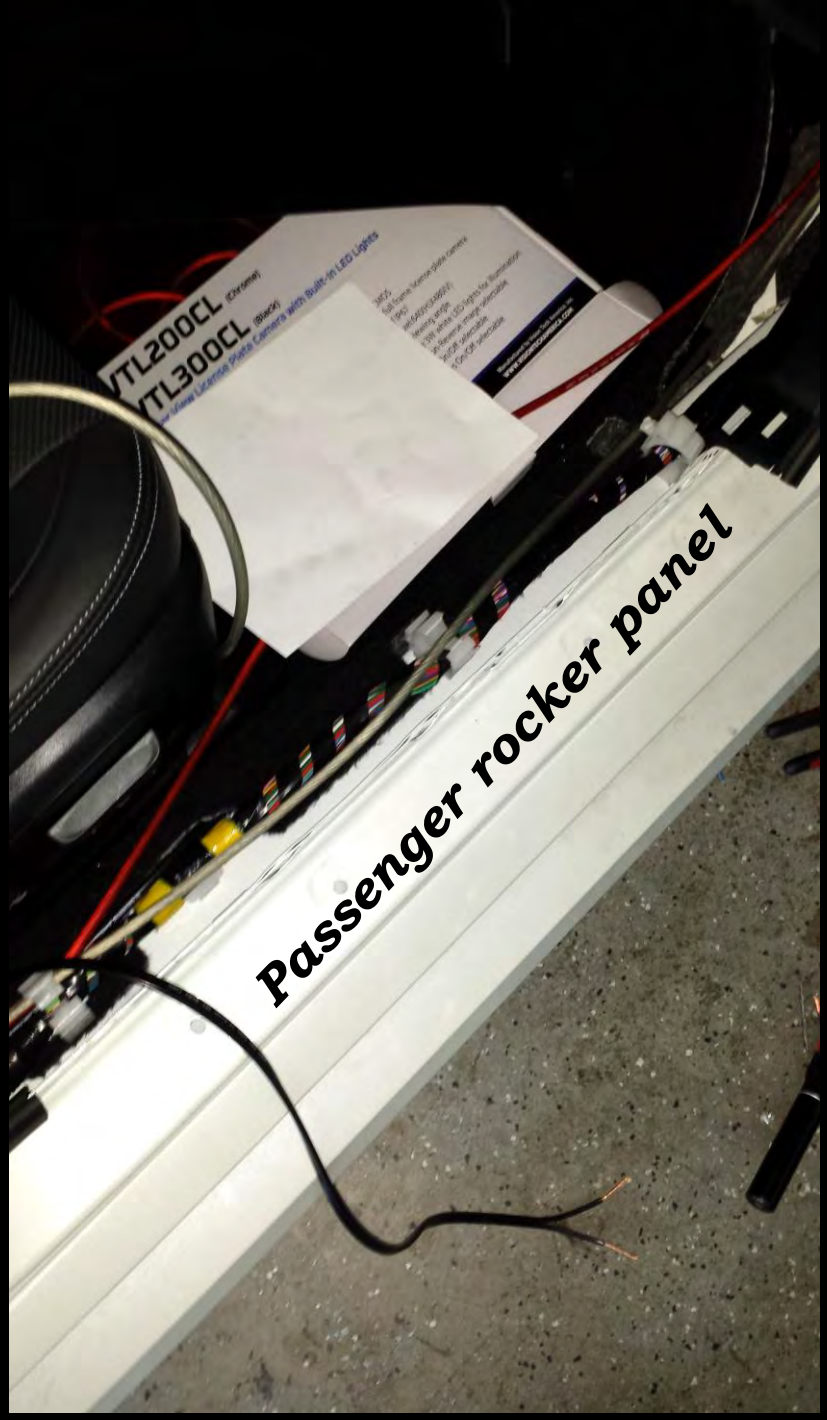


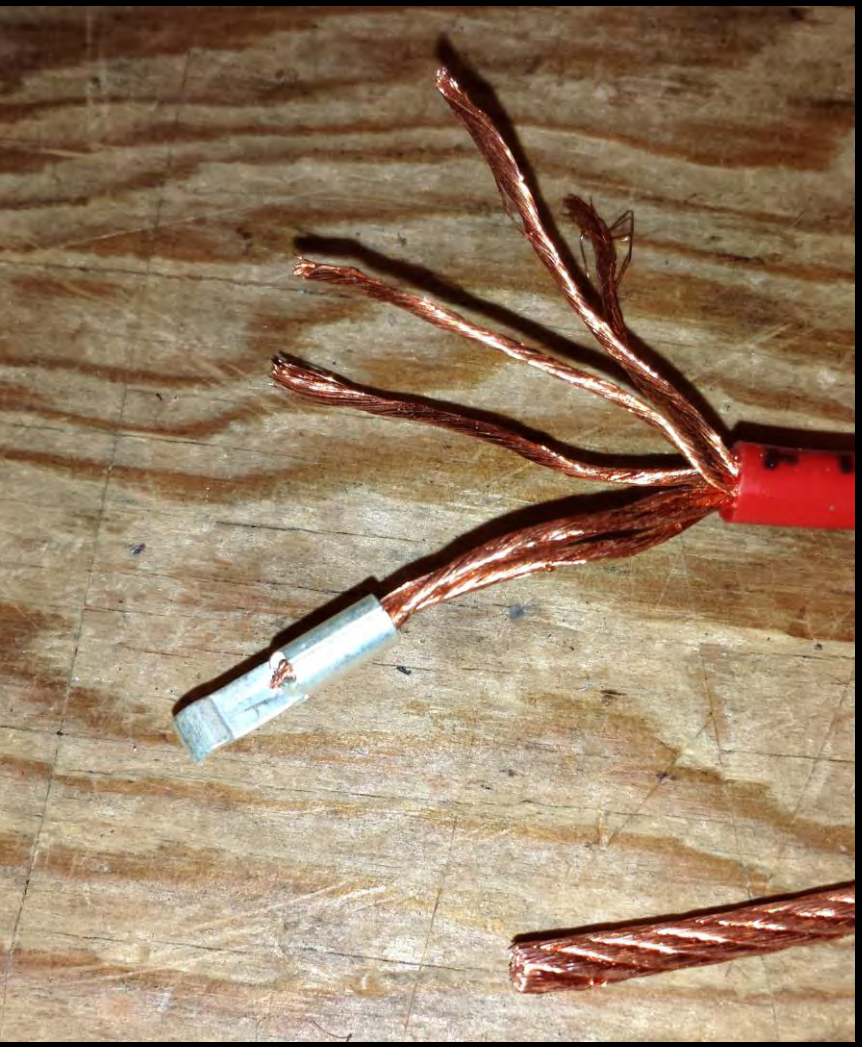
1 RG-8X coax

2 RG-8X coax & control lines

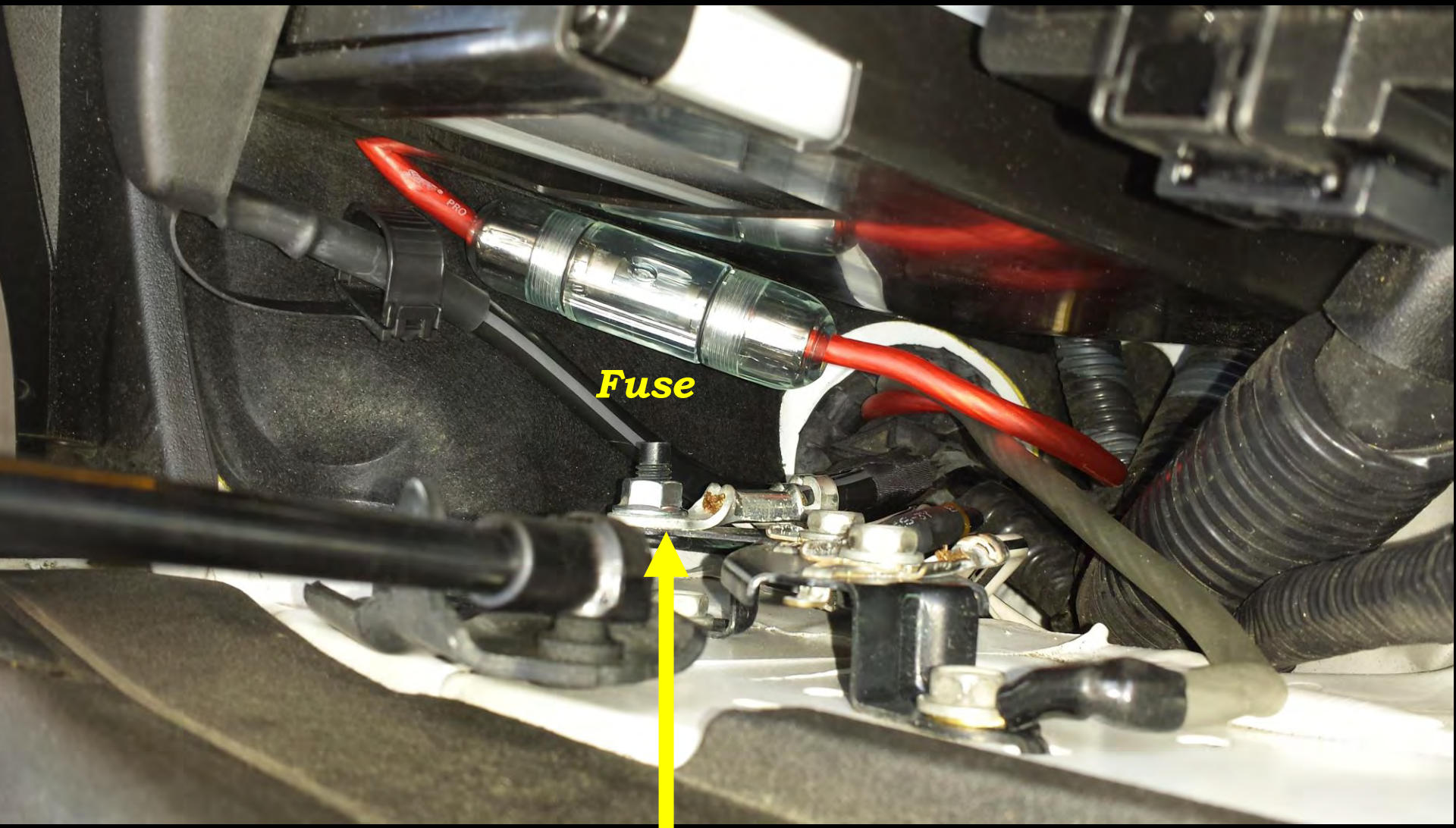
Power

https://drawingdatabase.com/lexus-rcf-2019/


VTL200CL (Chrome)
VTL300CL (Black)
Passenger rocker panel

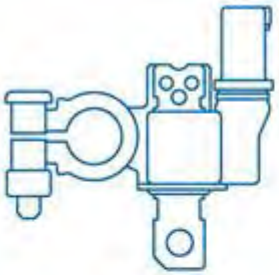


Unwind the #8 wire to fit PowerPoles



Negative wire tied to chassis not negative battery terminal (some cars have an Electronic Battery Sensor (EBS) between (-) battery terminal and chassis)


Battery Monitoring System
Electronic Battery Sensor
2018 ARRL Handbook
Pg 24.14
©Samarins.com



Battery state detection (BSD)

BSD functions

- **Charge prediction (SOC)**
  Adaptable prediction of deliverable charge/energy
- **Voltage prediction (SOF)**
  Adaptable prediction of voltage drop
- **Battery ageing (SOH)**
  Determination of battery ageing

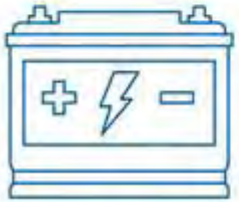
U, I, T

SOX

Electronic energy management (EEM)

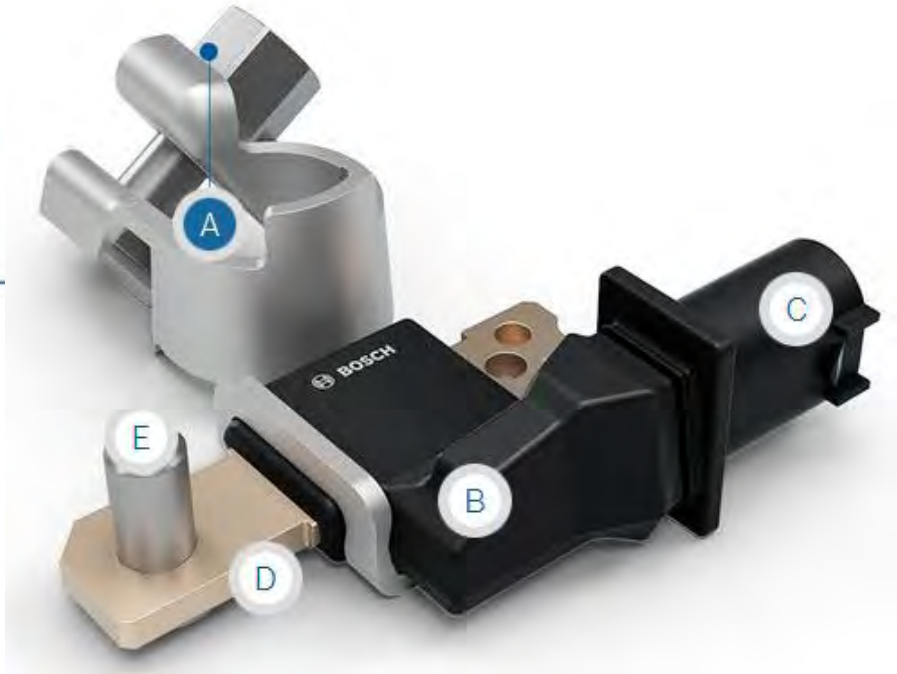
- EEM coordination
- Battery management

U, I, (T)



Battery features

- **State of charge (SOC)**
- **State of function (SOF)**
- **State of health (SOH)**



https://www.bosch-mobility-solutions.com/en/solutions/sensors/electronic-battery-sensor/

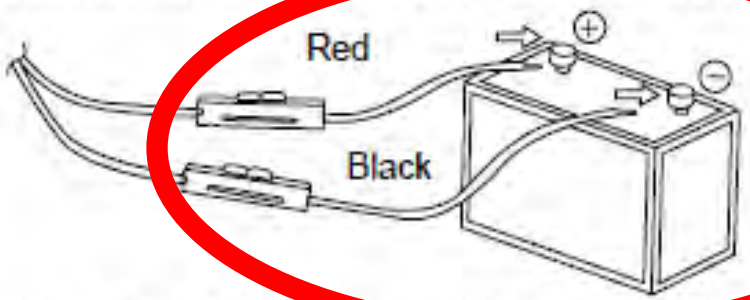
AnyTone®

AT-5888UV III

TRI-BAND
FM TRANSCEIVER

USER'S MANUAL

5. Reconnect any wiring re[illegible] from the negative terminal.



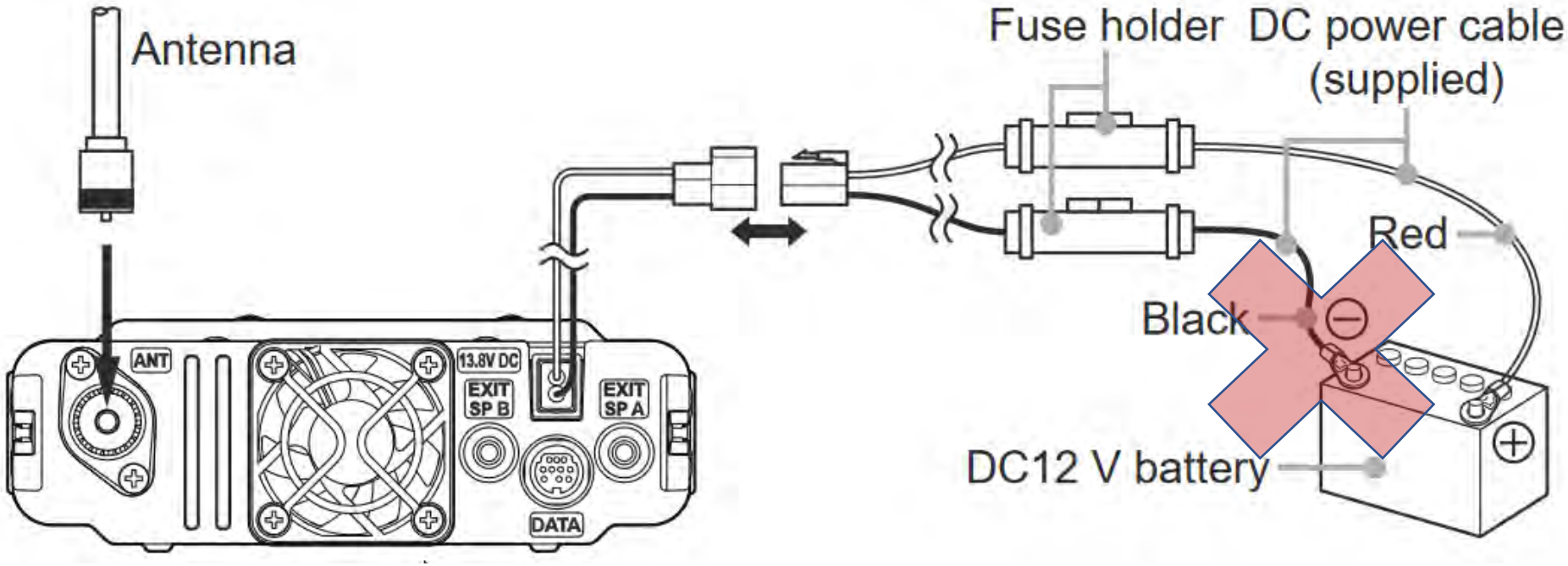
6. Connect the DC power [illegible] transceiver's power supplyconnector.

YAESU
The radio

C4FM/FM 144/430MHz
DUAL BAND DIGITAL TRANSCEIVER

FTM-200DR
FTM-200DE

Operating Manual



PROFESSIONAL DIGITAL TWO-WAY RADIO SYSTEM
MOTOTRBO™ MOBILE Installation Guide

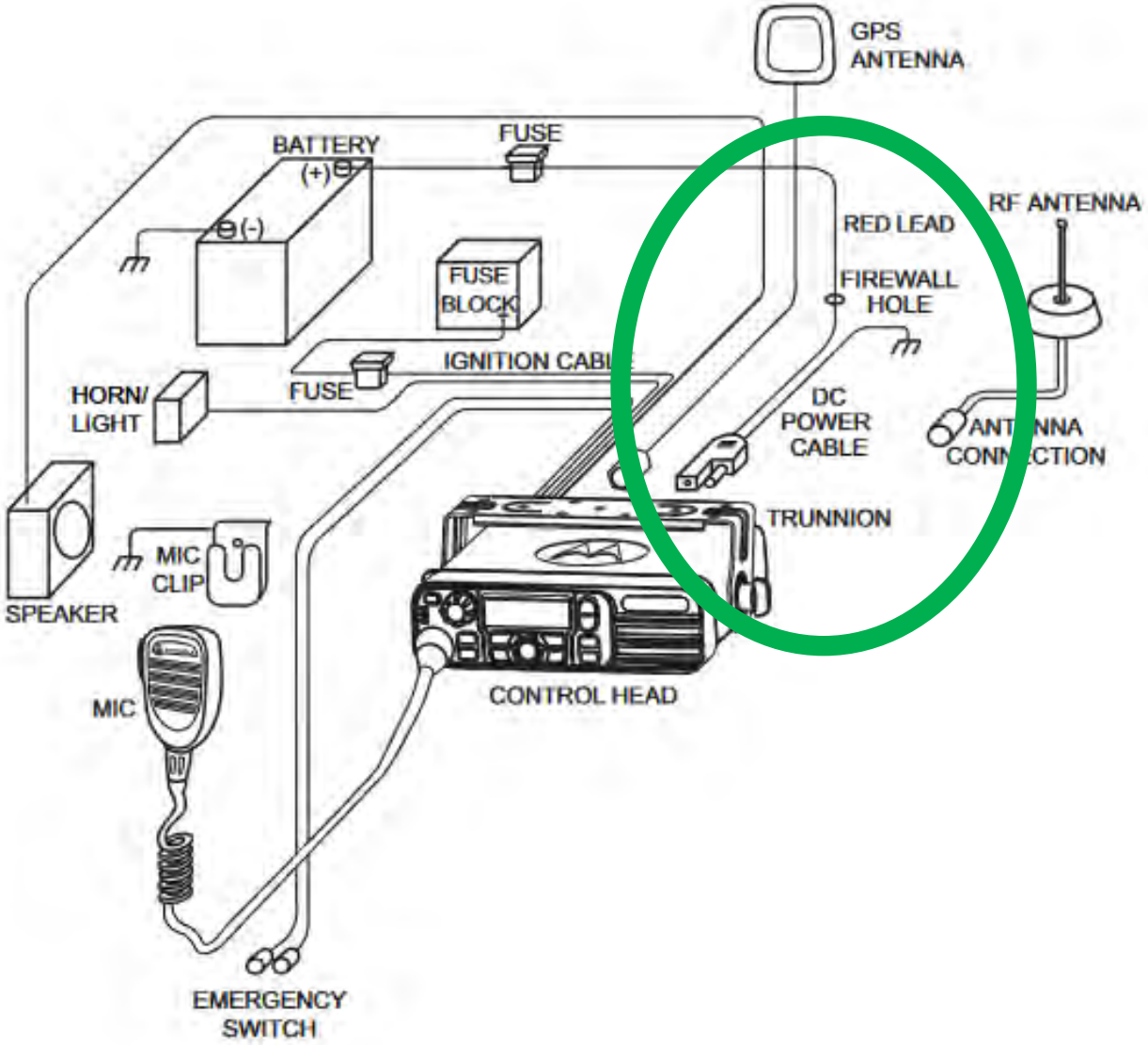


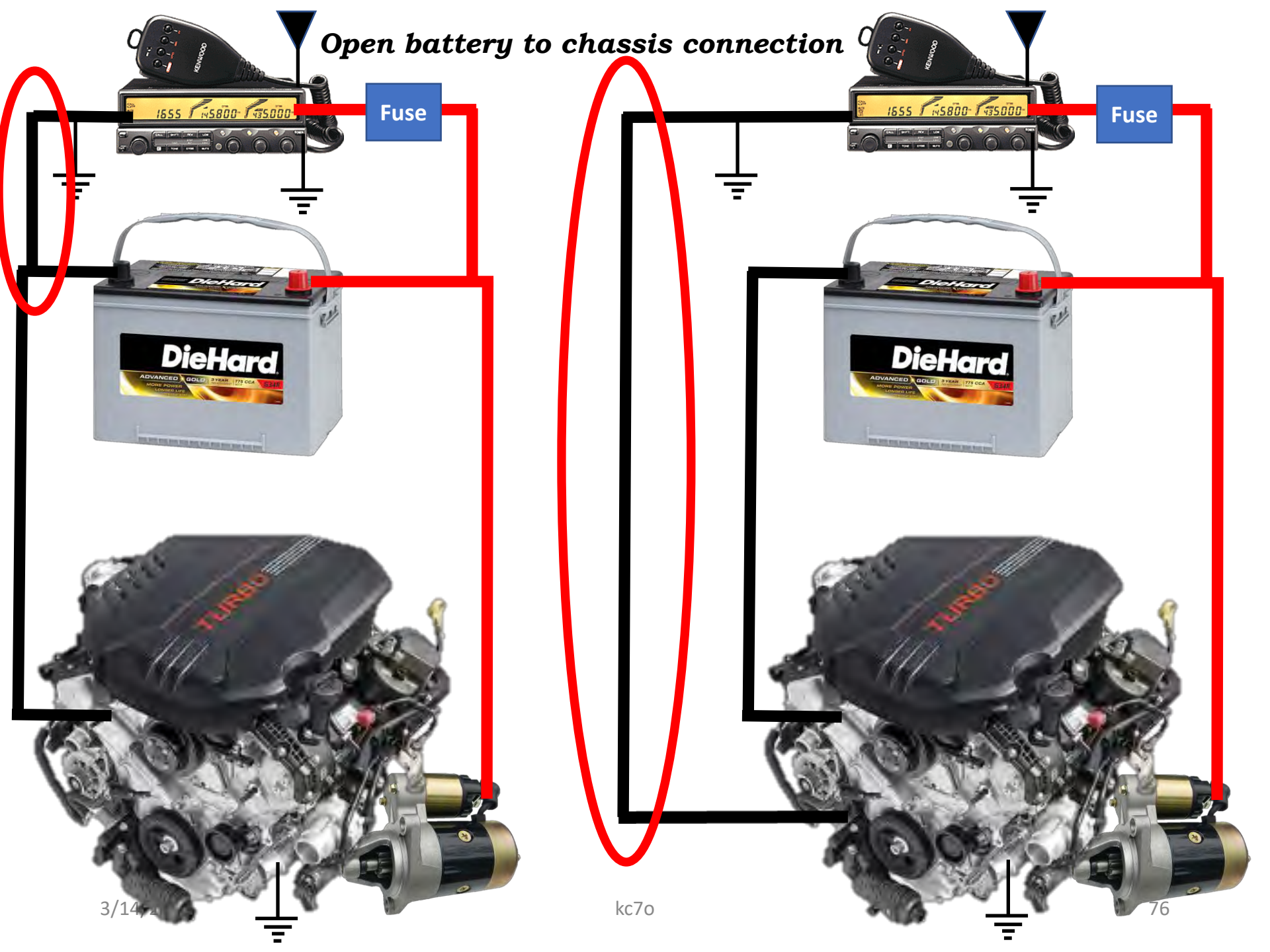
Figure 2-3 *Radio Installation (Dash Mount)*

https://learning.motorolasolutions.com/de/node/5233/download

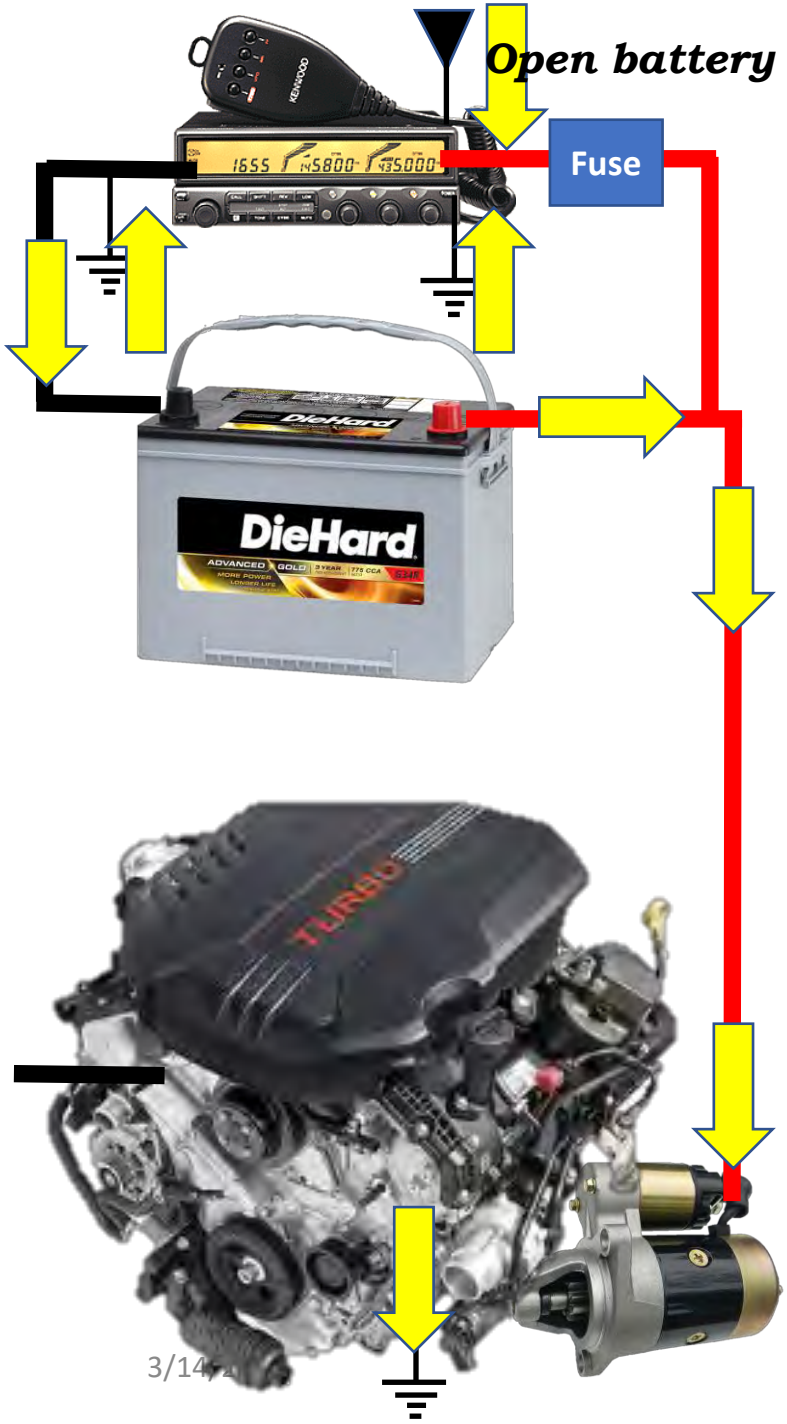
Why?

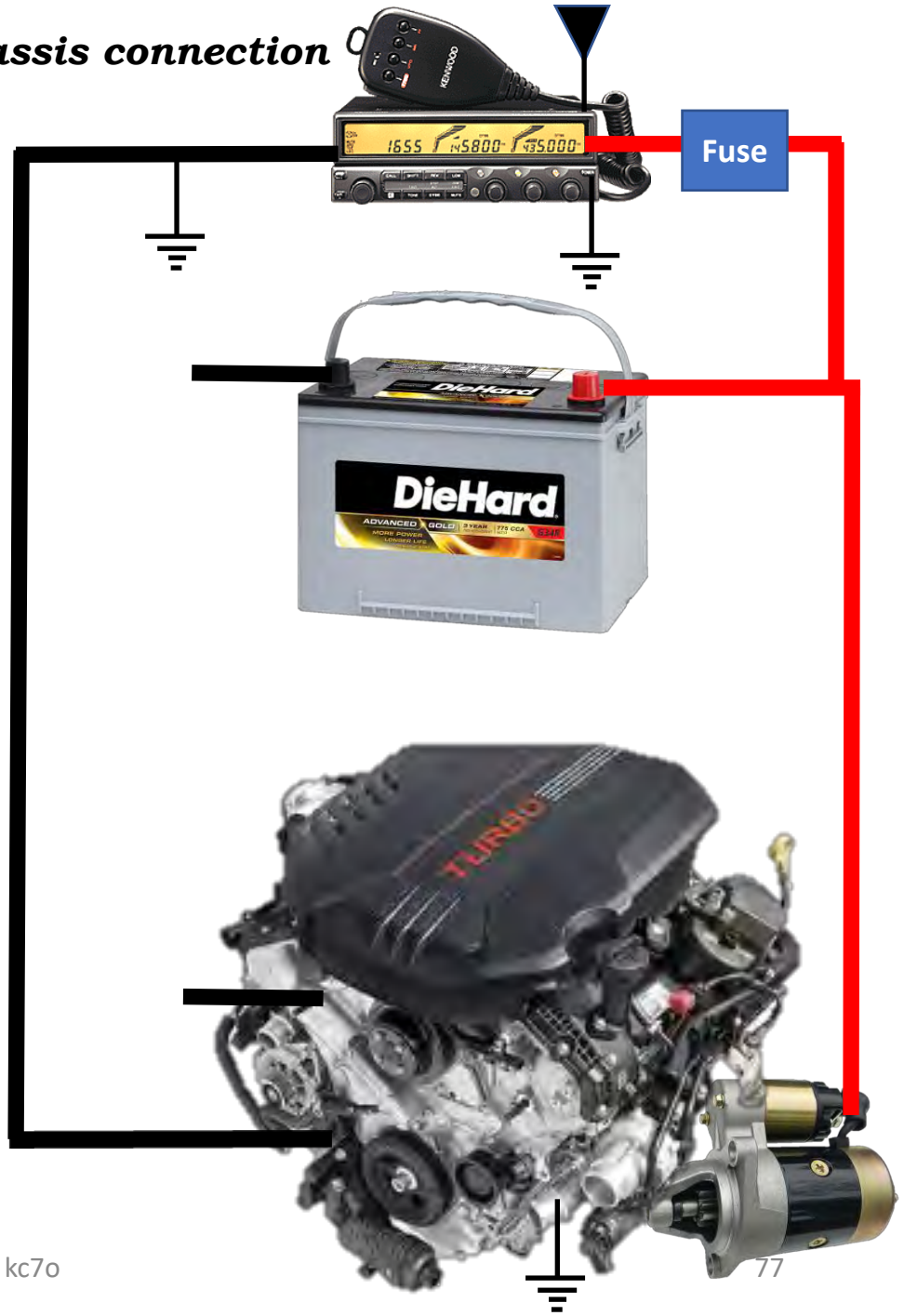

To car accessories
DieHard
TURBO
Push start - solenoid activates sending current through starter to ground

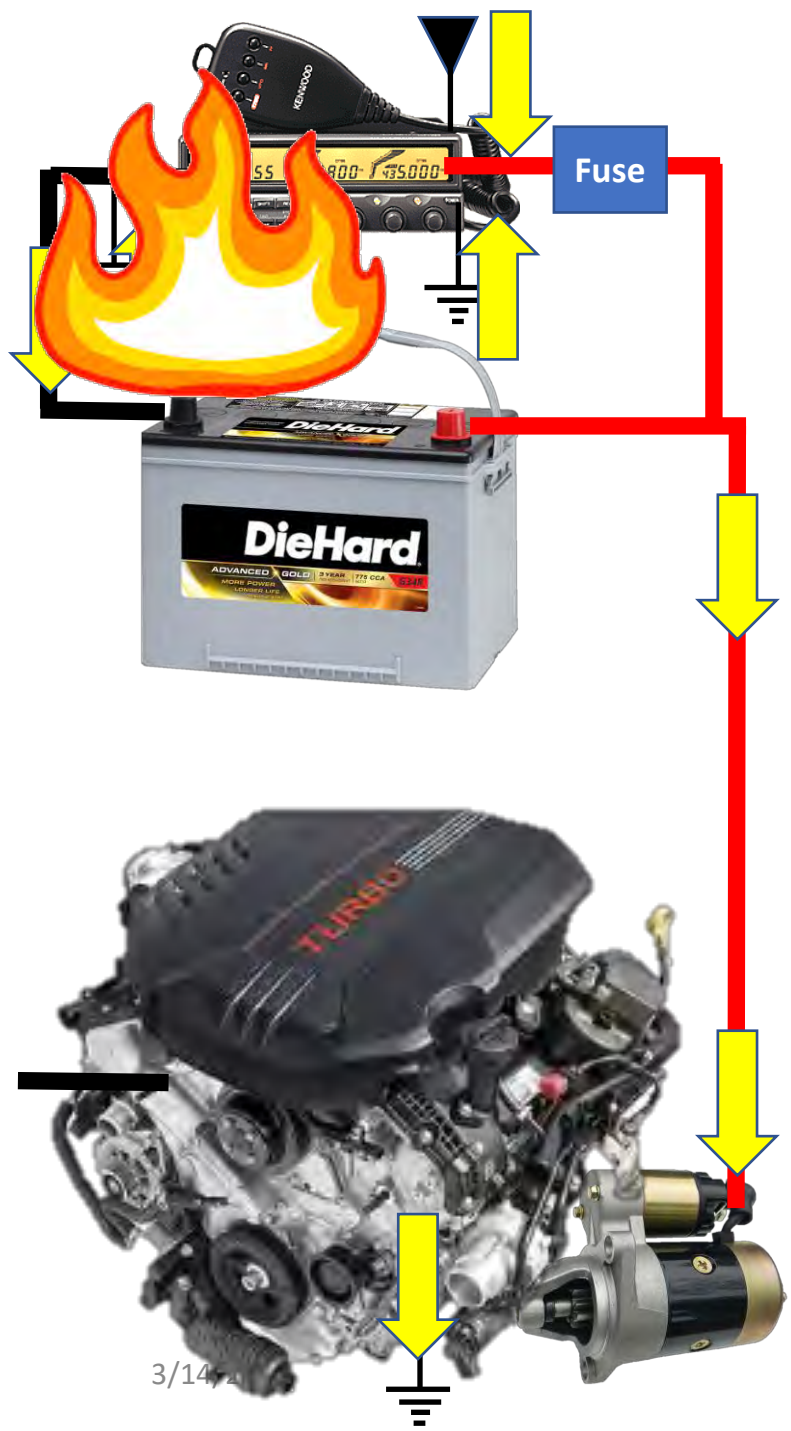
Open battery to chassis connection

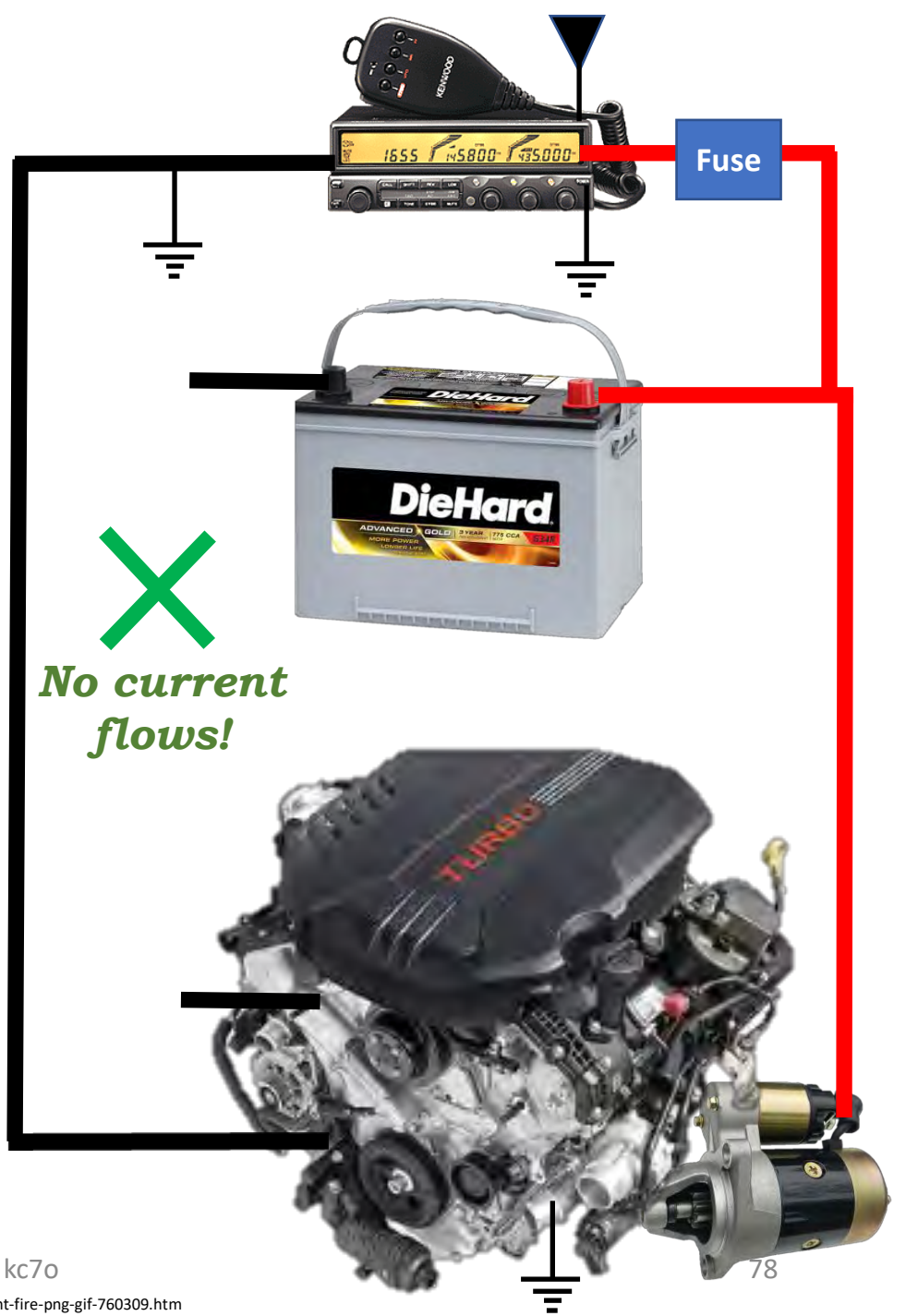


Open battery to chassis connection









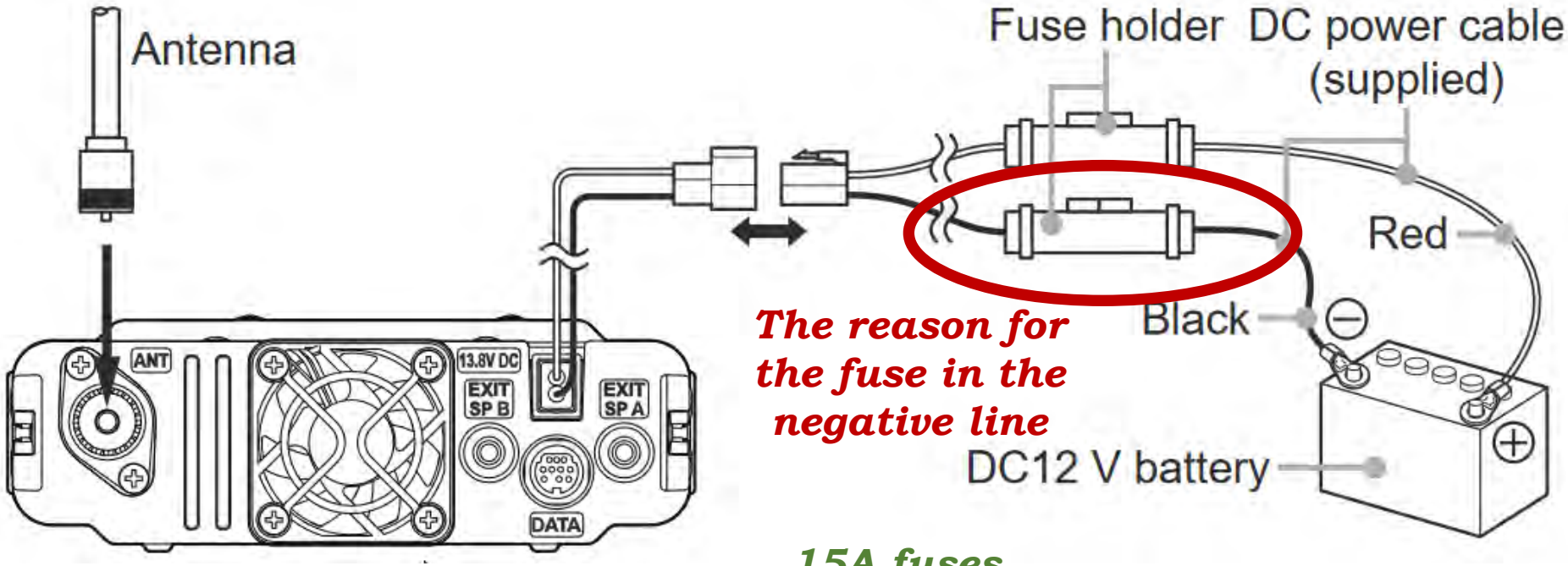
fire-gif-transparent-fire-png-gif-760309.htm

YAESU
The radio

C4FM/FM 144/430MHz
DUAL BAND DIGITAL TRANSCEIVER

FTM-200DR
FTM-200DE

Operating Manual



The reason for the fuse in the negative line

15A fuses

Car wash caps for SO-239's

2014 GS 350 Radio Installation – Original Configuration 2017

Cabin Armrest

Kenwood TM-742A

2M

440

CF-416 Diplexer

Common

220

GPS Ant

TinyTrack

Trunk Driver Side

Trunk Passenger Side

TM-221A APRS

220

2M

NCG1422D Diplexer

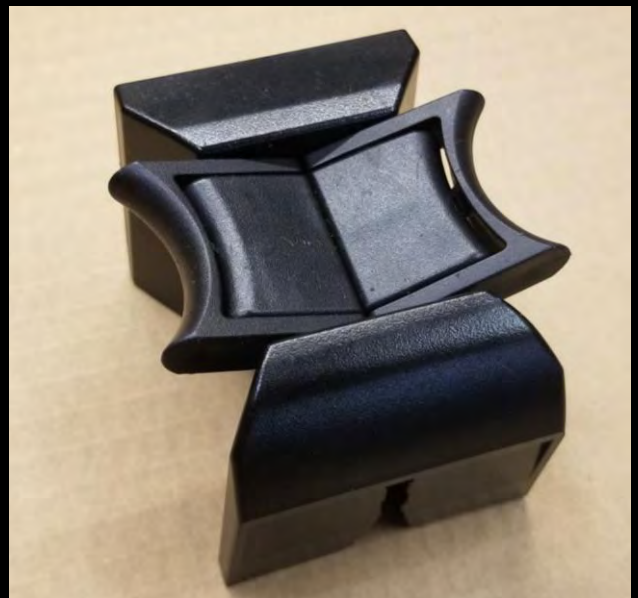
Common

2M/220 - Diamond CR214S

2M/440 - Comet B-20M

Original TM-742A Installation

Cup Holder




TM-742A


Stealth Inside
Before and After


APRS in Storage Bin


With Mat Lifted


Trunk Before and After

Upgrade to Tri-Band Anytone AT-5888UV III

Use diplexers and triplexers to minimize antennas

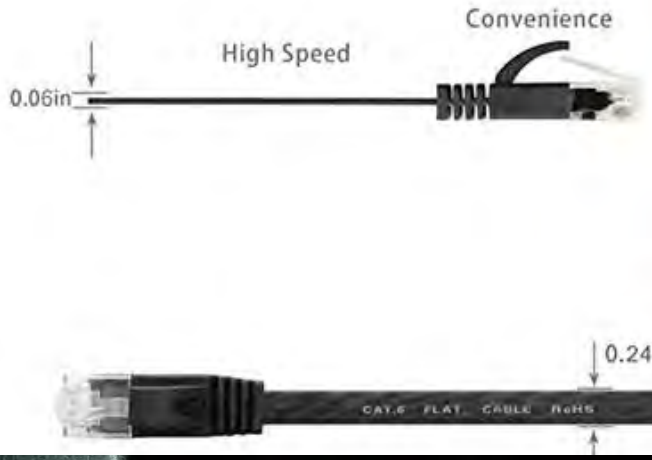
3 bands from one port


RADIO
MEDIA
AUTO
OFF
DISP
RES
SET
SPORT


TRI BAND FM TRANSCEIVER
TV/SQL
SET
PWR
MAIN
ENC DEC
ENC DEC
MUTE
LOW
V/M
HM
SCN
LOW
V/M
HM
SCN
REV
TONE
SUB


Spkr
Radio

Anytone AT-5888UV III uses CAT 6 cable for the remote-control head & mic to the radio - too fat to install



Cat 6 Ethernet Cable Black 3 ft (6 Pack) - Flat Internet Network Cable - Jadaol Cat6 Ethernet Patch Cable Short - Cat6 Computer LAN Cable with Snagless RJ45 Connectors - 3 feet Black (6 Pack)

Visit the Jadaol Store

4.5 ★★★★½ 5,212 ratings | 28 answered questions

List Price: ~~$11.99~~ Details

With Deal: $10.19 ($1.70 / Item) prime One-Day & FREE Returns

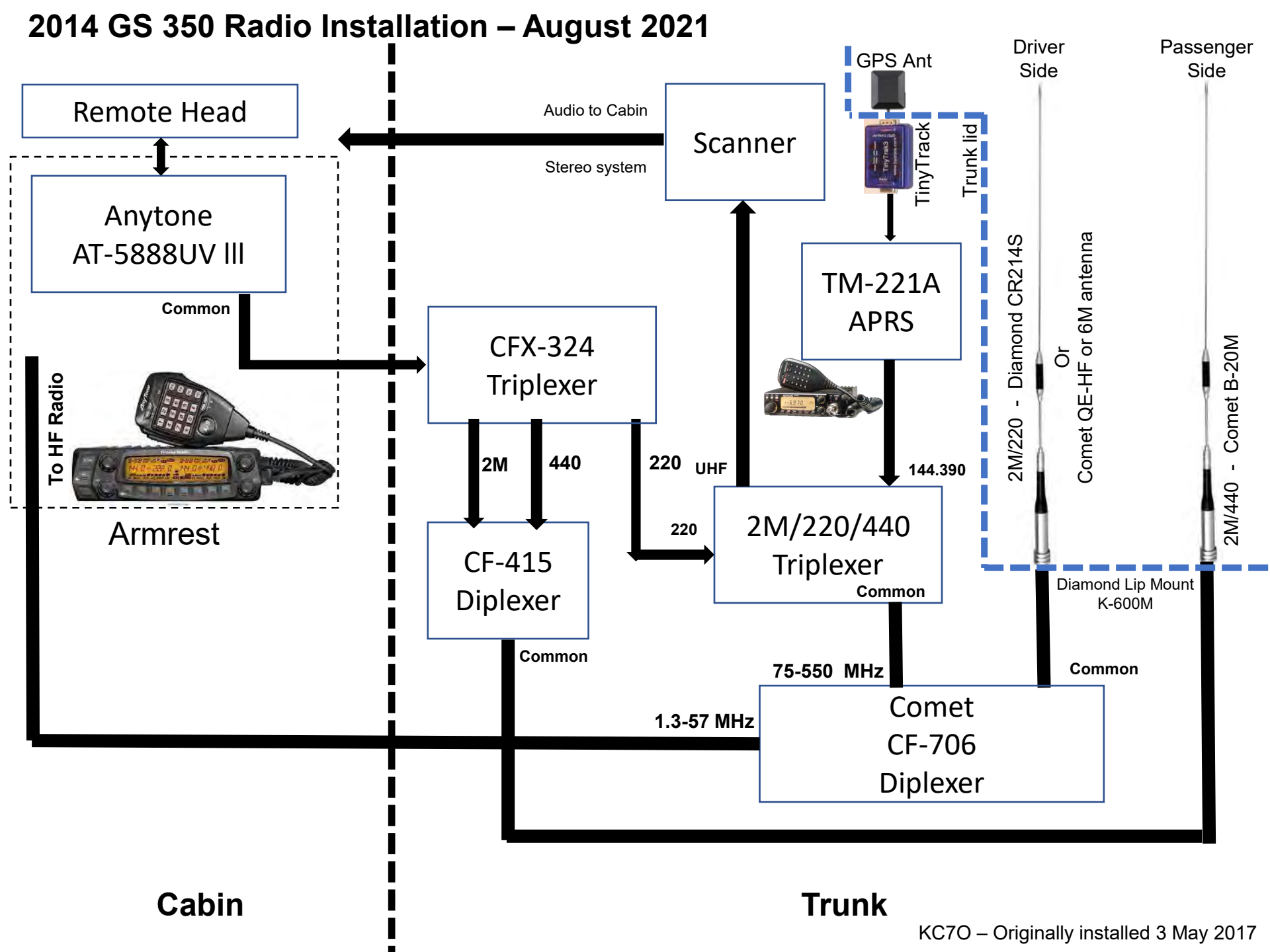
You Save: $1.80 (15%)

Thank you for being a Prime member. Get a $100 Gift Card: Pay $0.00 upon approval for the Amazon Prime Rewards Visa Card. No annual fee.

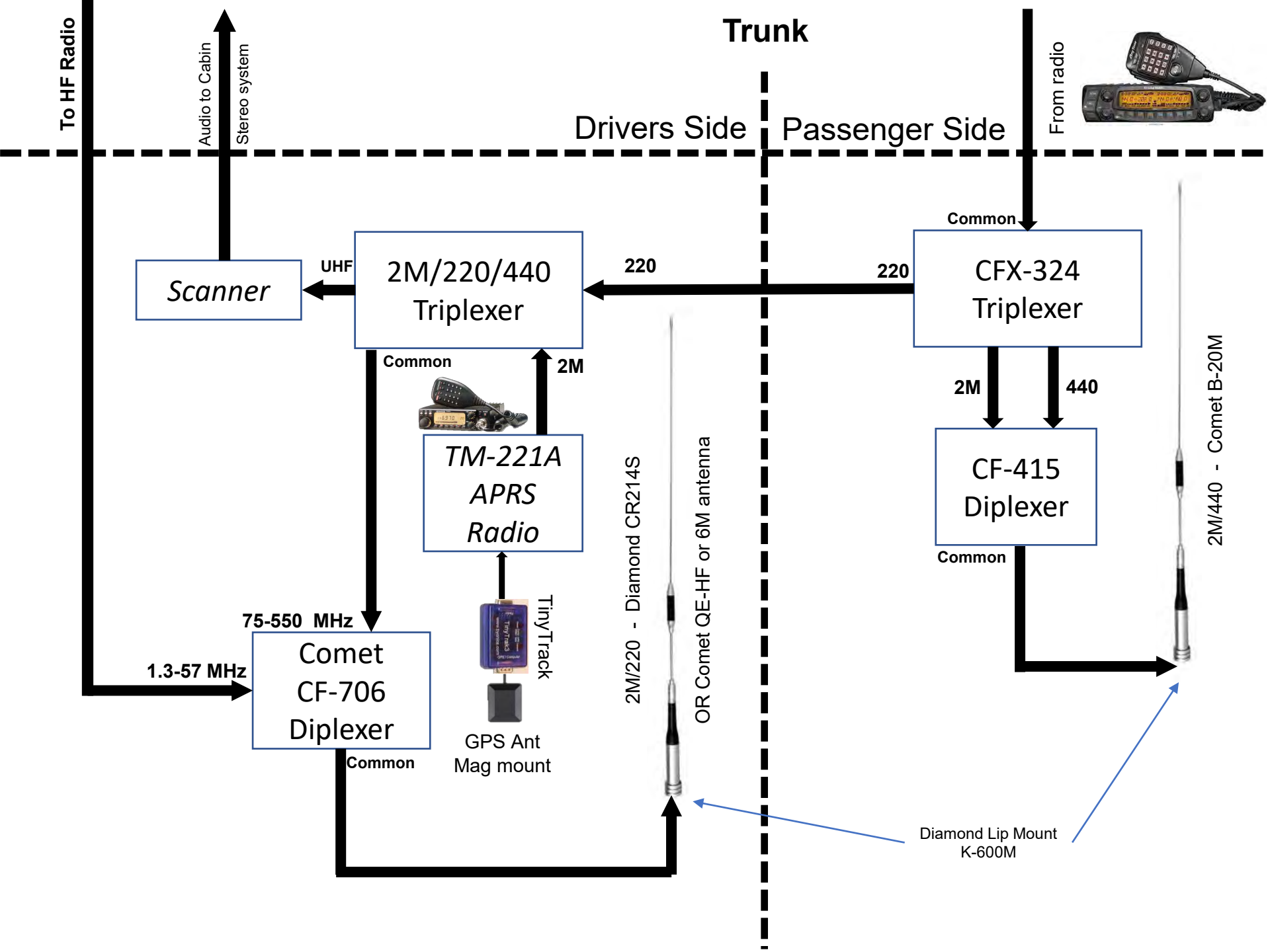
Eligible for amazonsmile donation.

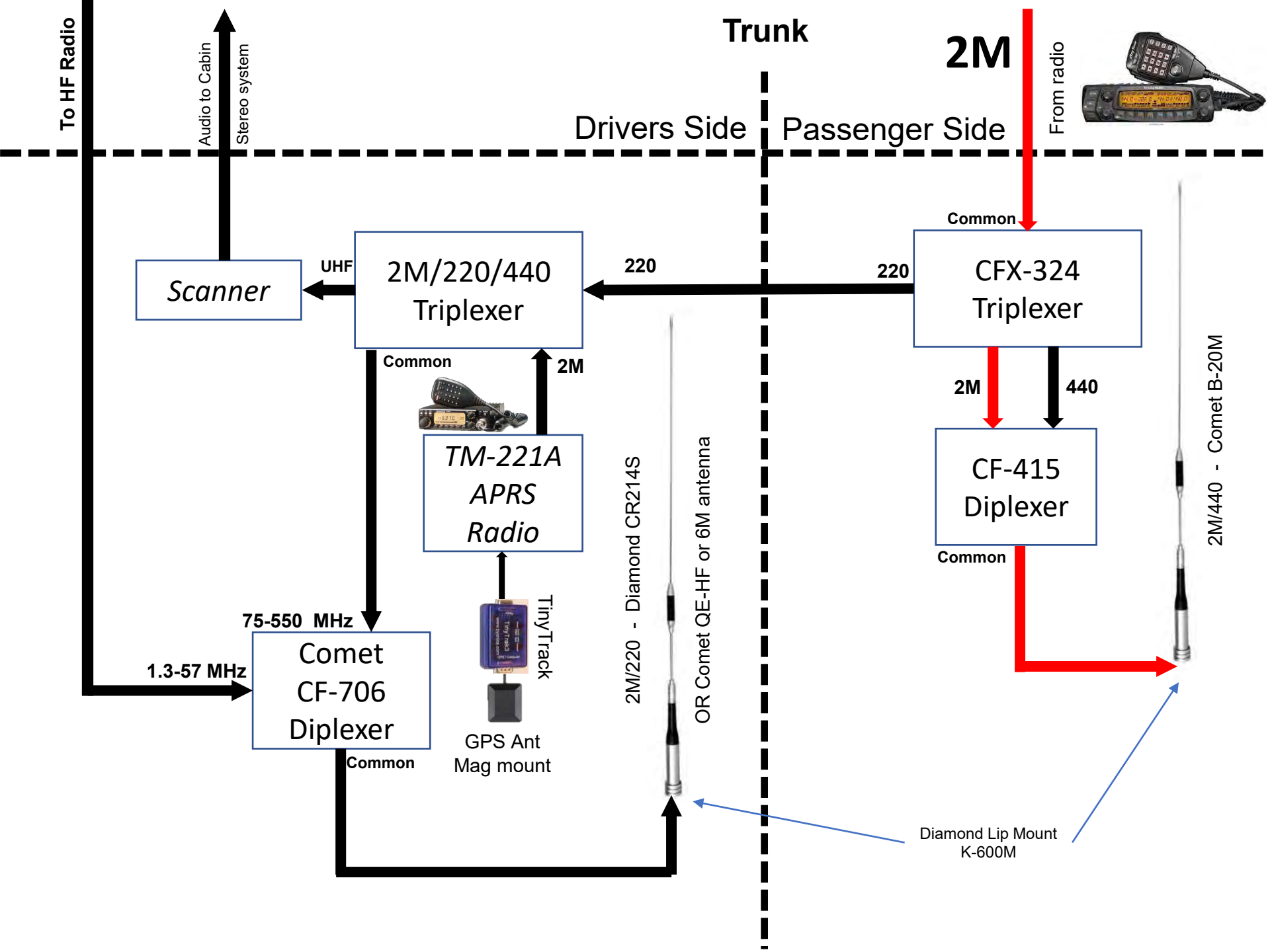
Size: **3ft-6Pack**

2014 GS 350 Radio Installation – August 2021



KC7O – Originally installed 3 May 2017


To HF Radio
Audio to Cabin
Stereo system
Trunk
Drivers Side
Passenger Side
From radio
Common
Scanner
UHF
2M/220/440
Triplexer
220
220
CFX-324
Triplexer
Common
2M
2M
440
TM-221A
APRS
Radio
CF-415
Diplexer
Common
75-550 MHz
1.3-57 MHz
Comet
CF-706
Diplexer
Common
TinyTrack
GPS Ant
Mag mount
2M/220 - Diamond CR214S
OR Comet QE-HF or 6M antenna
2M/440 - Comet B-20M
Diamond Lip Mount
K-600M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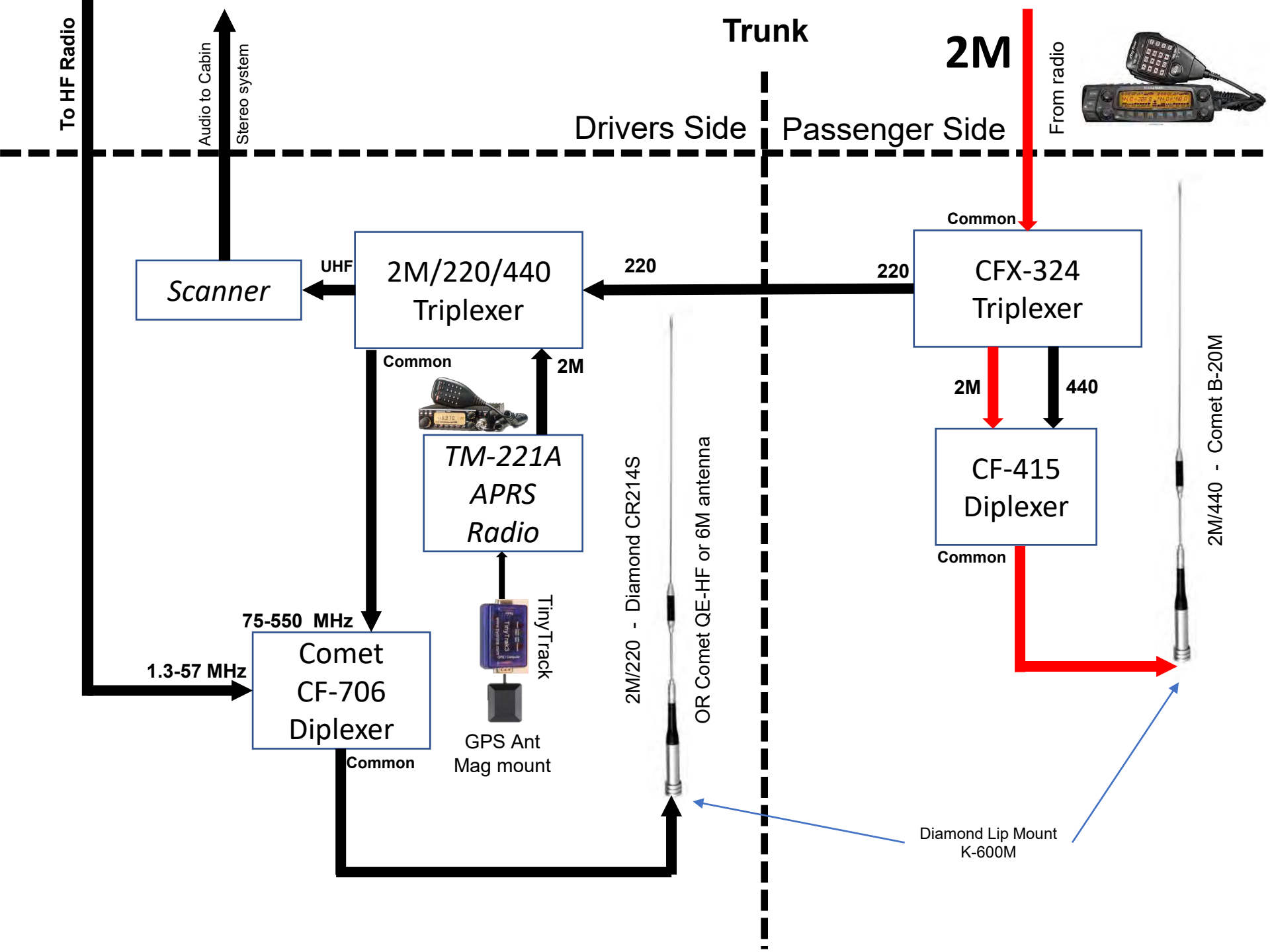
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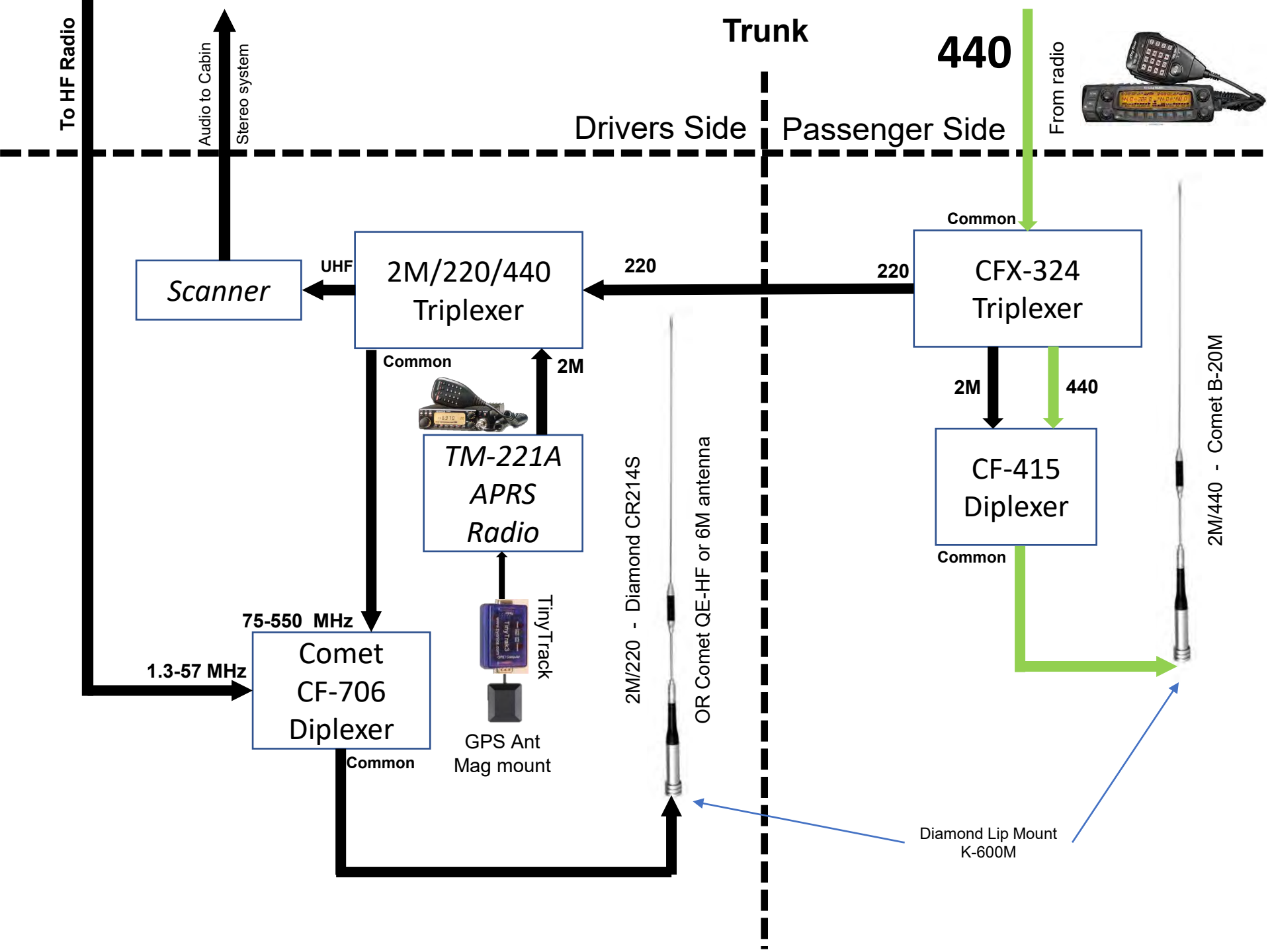
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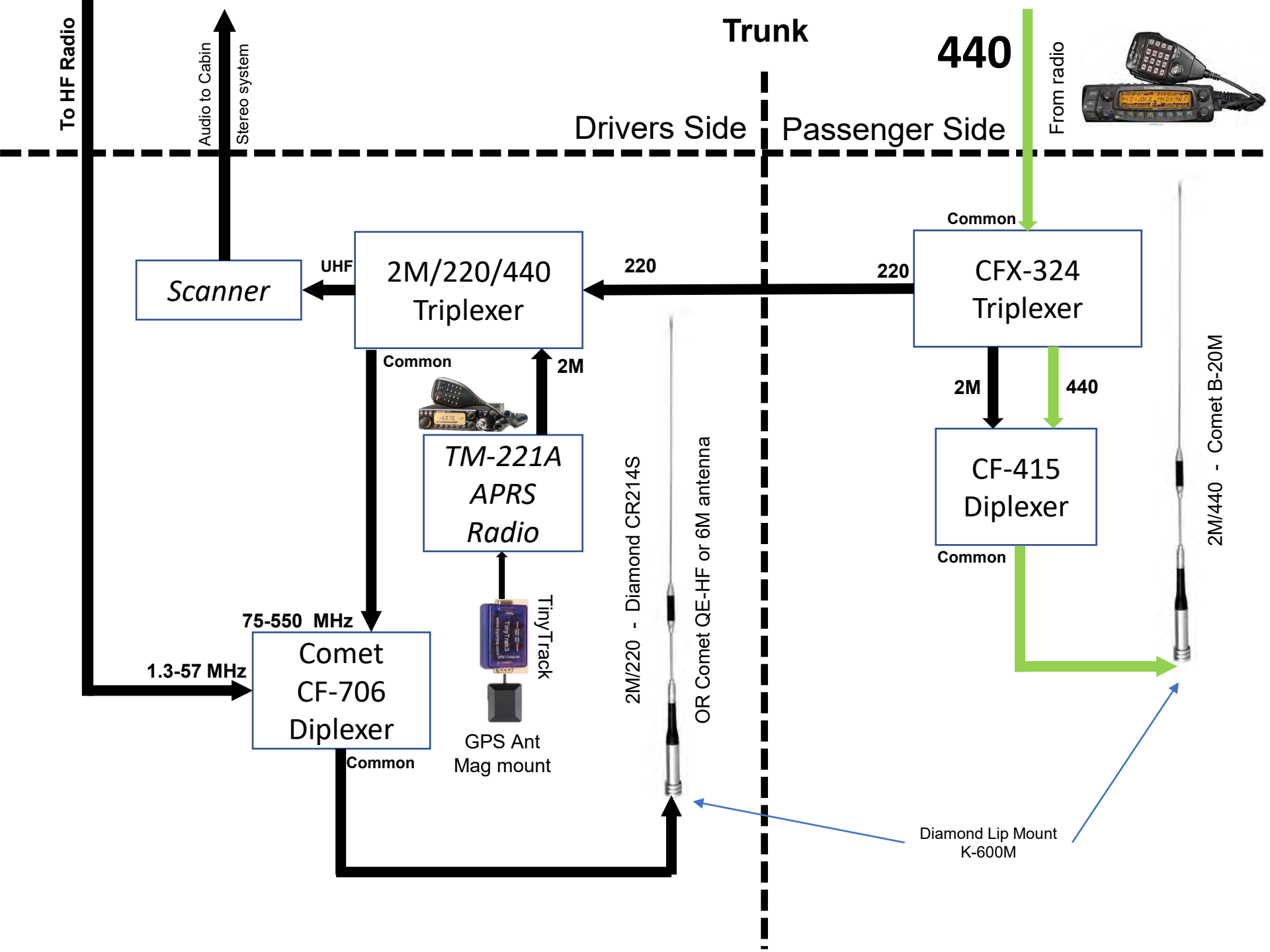
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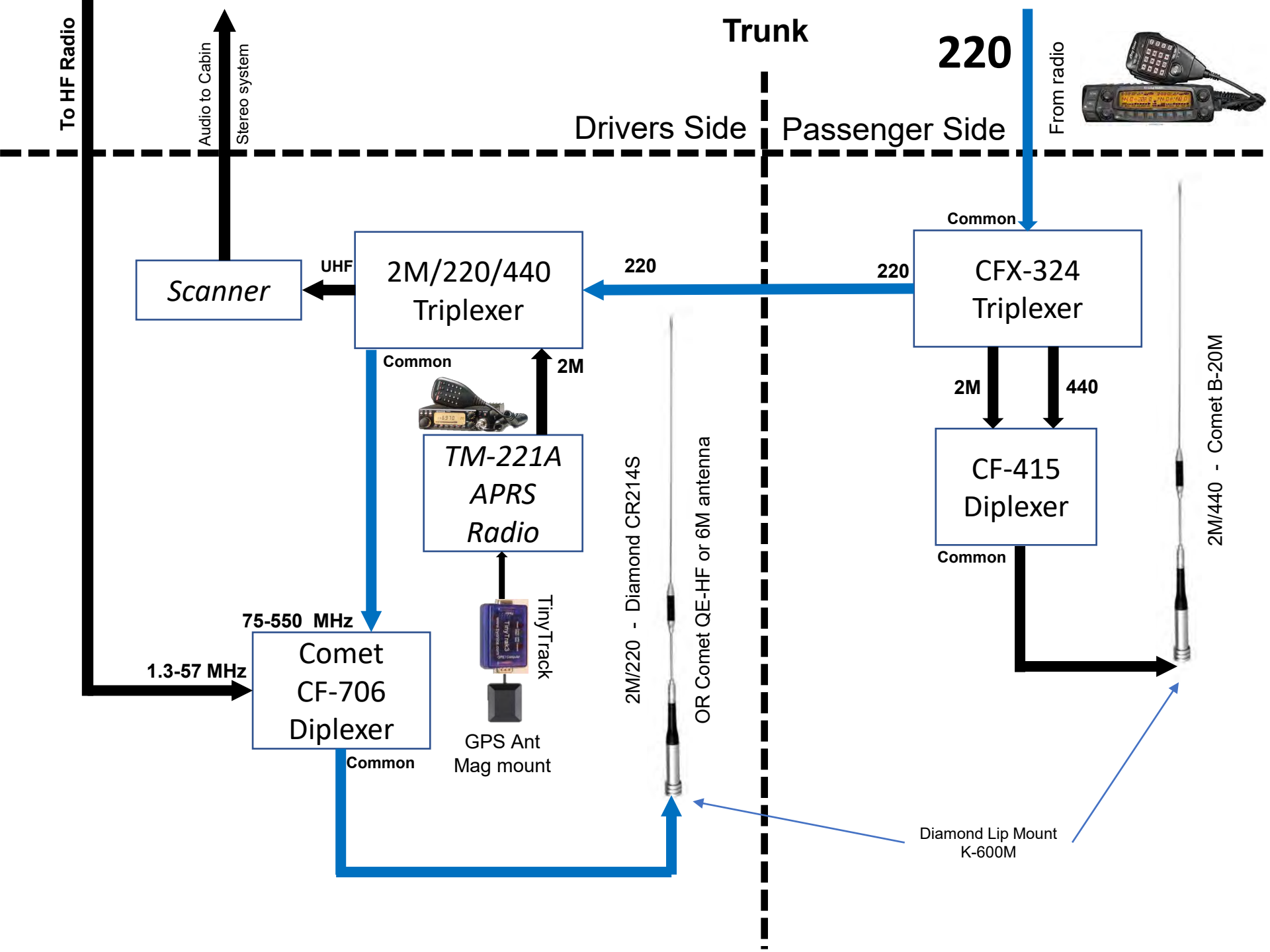
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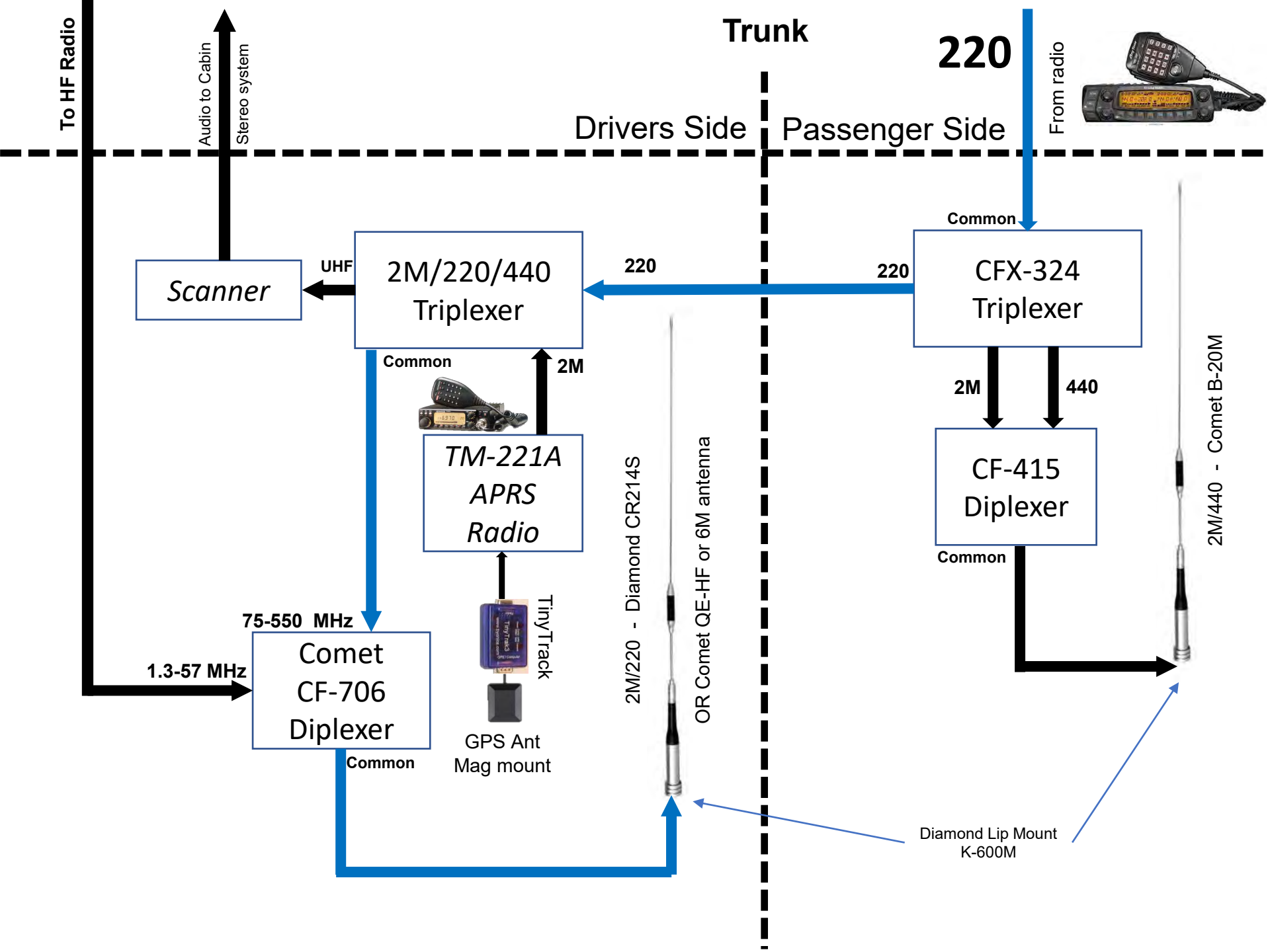
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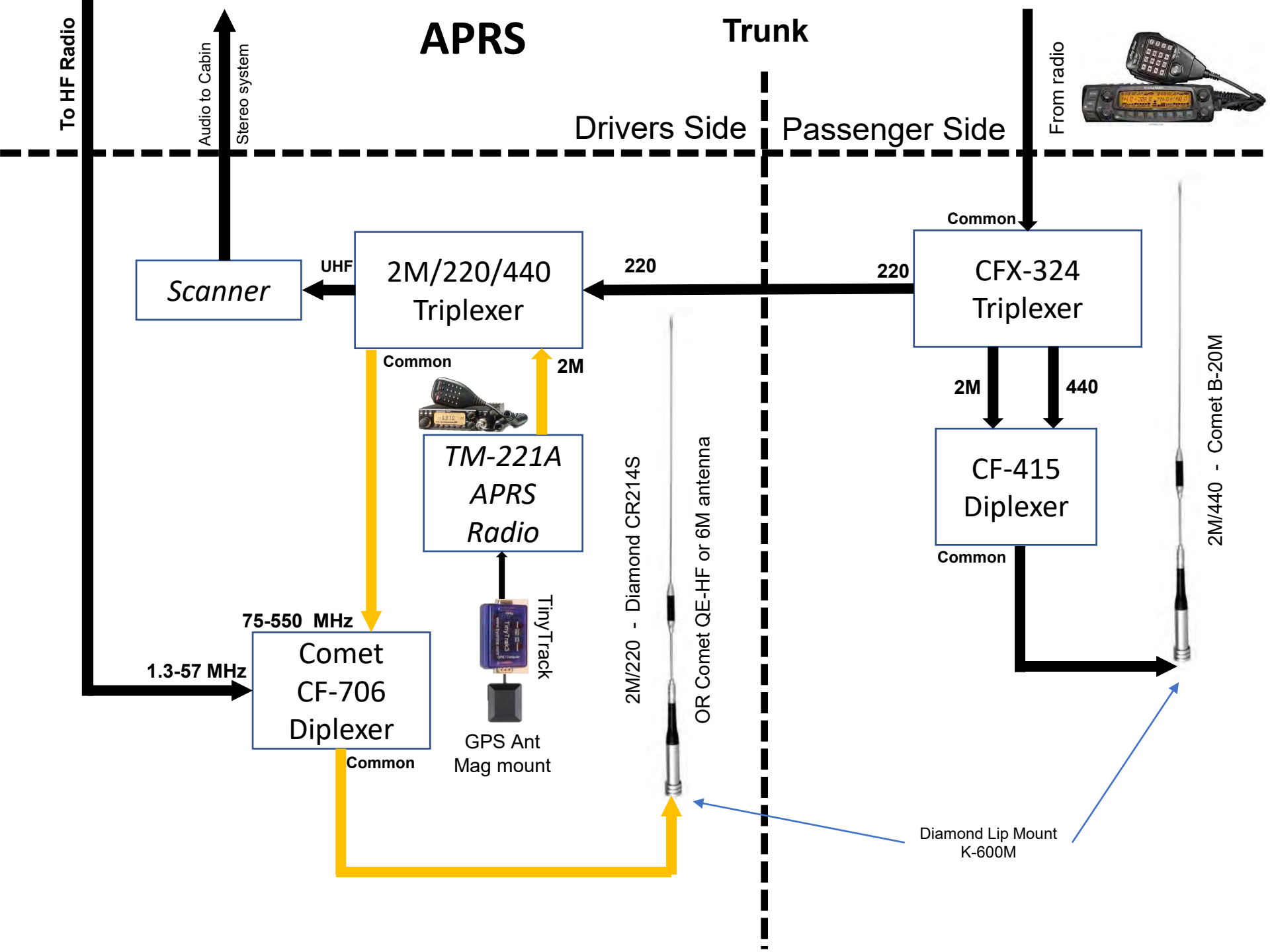
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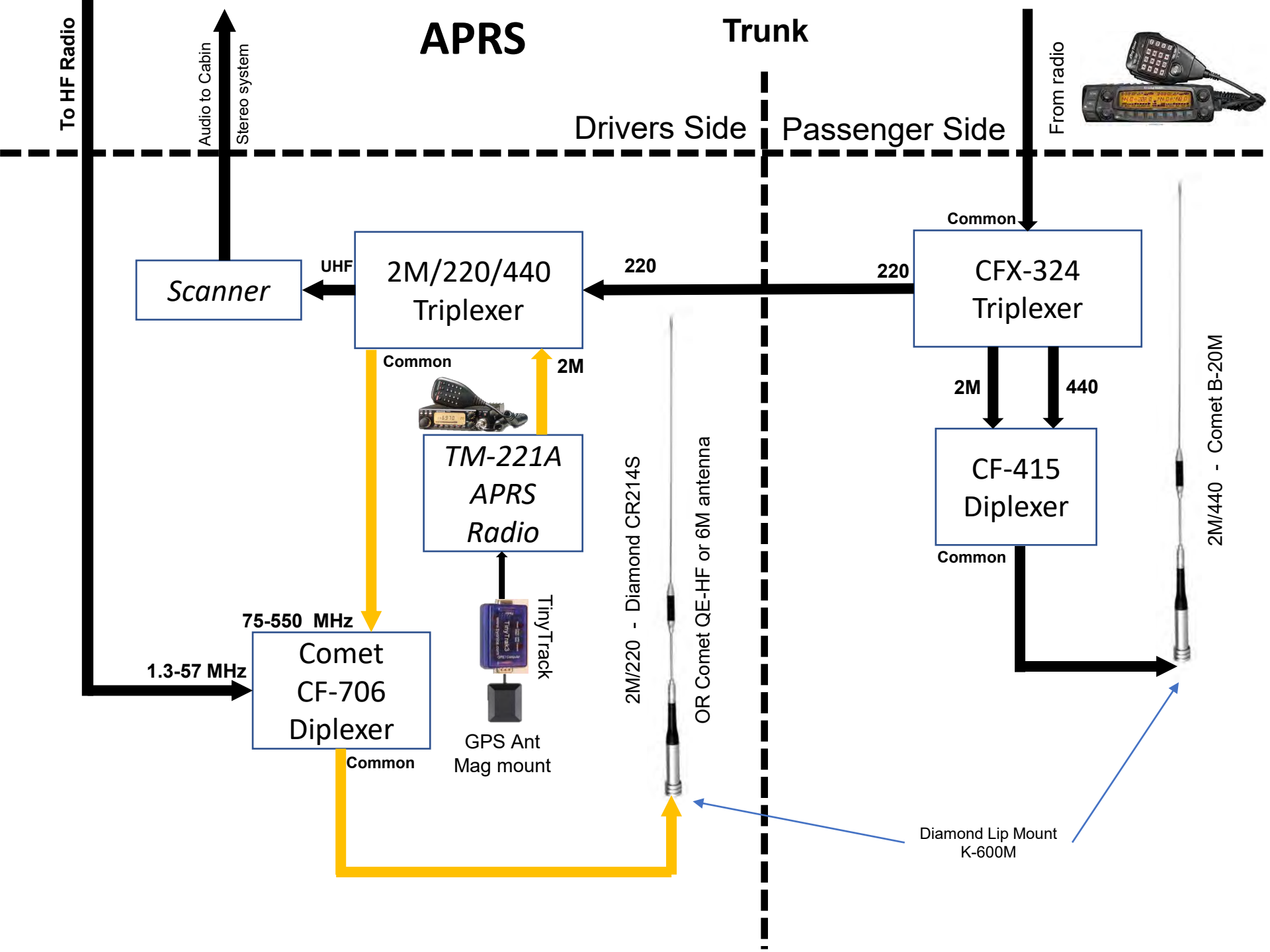
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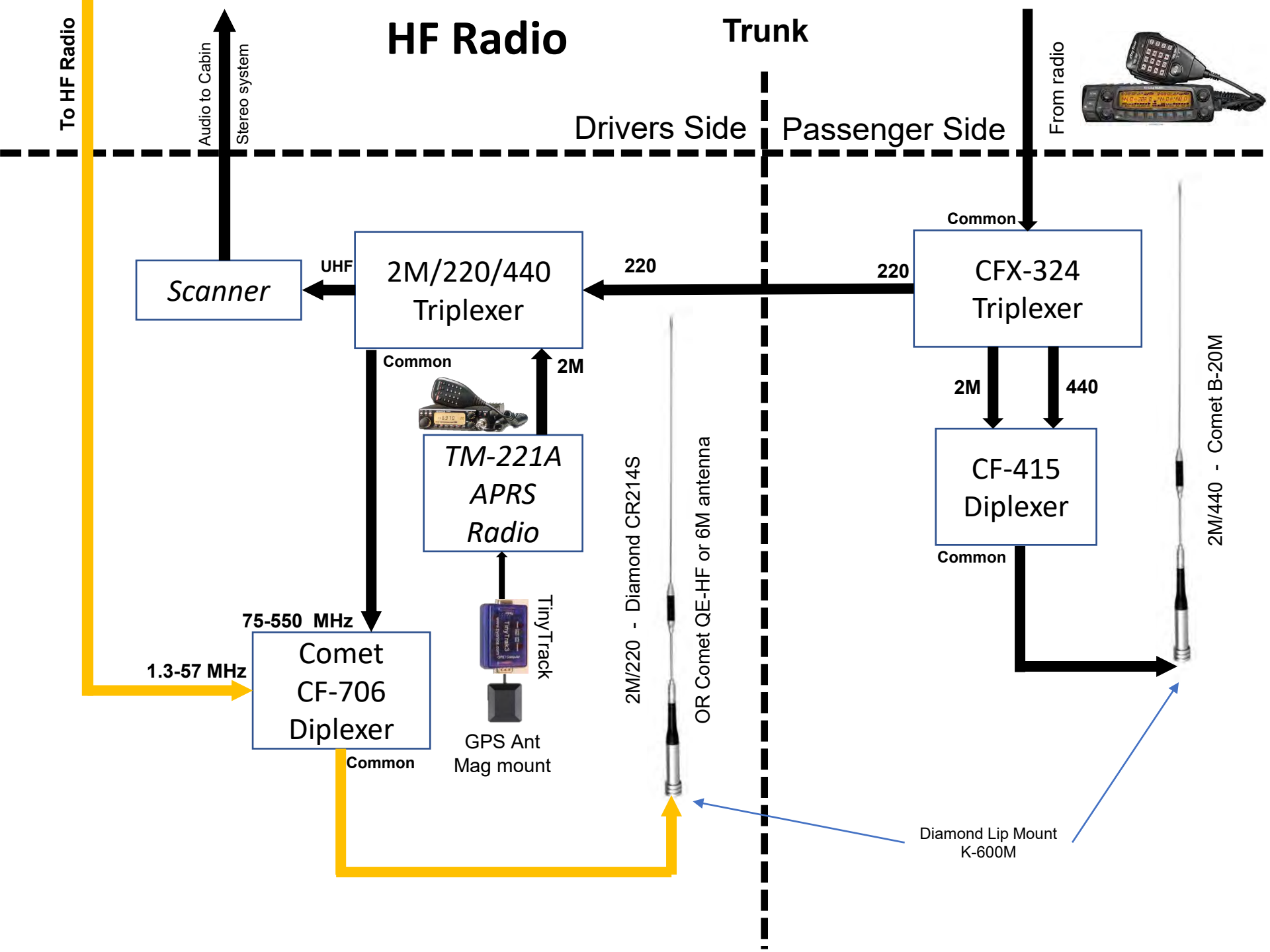
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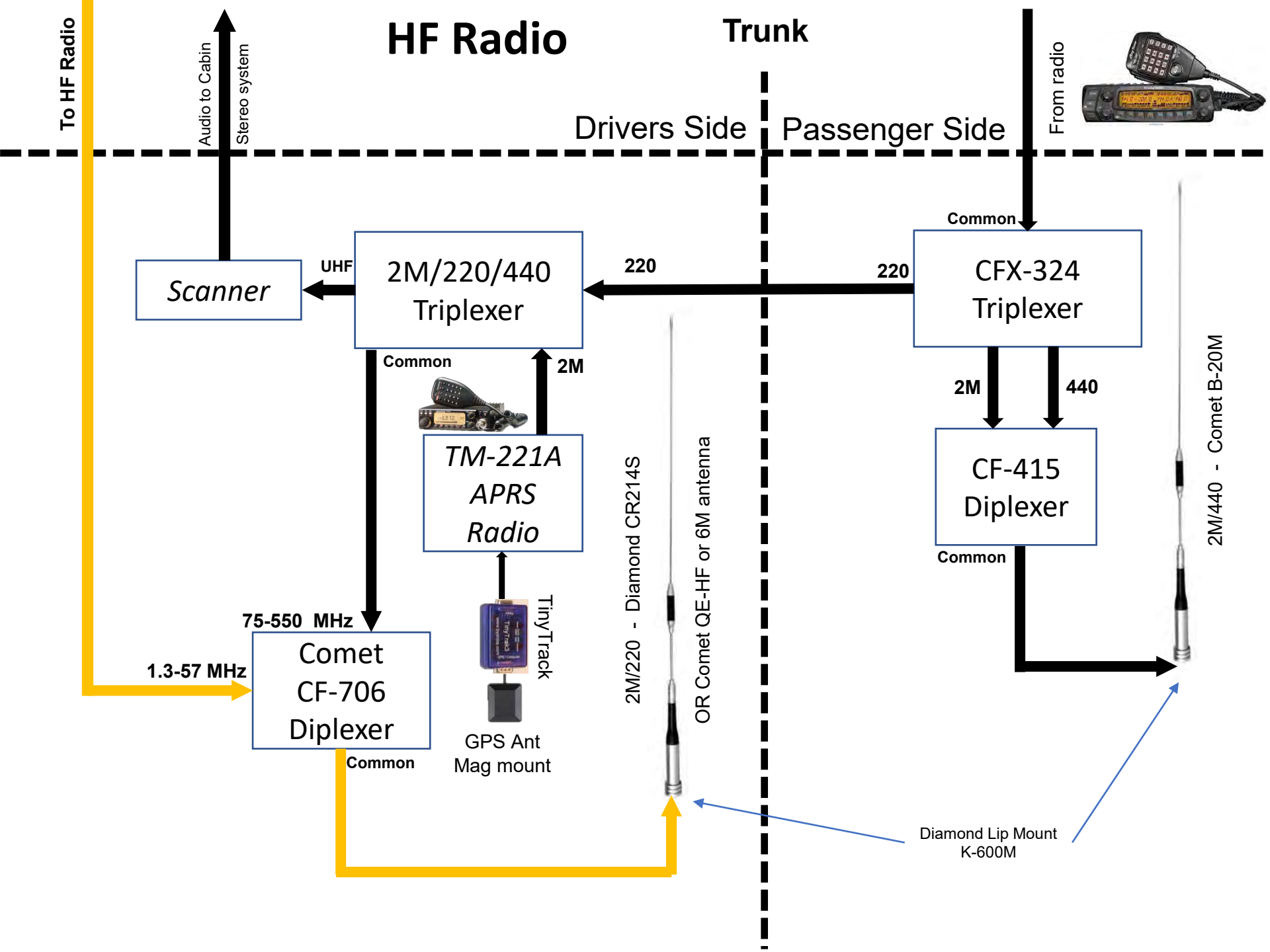
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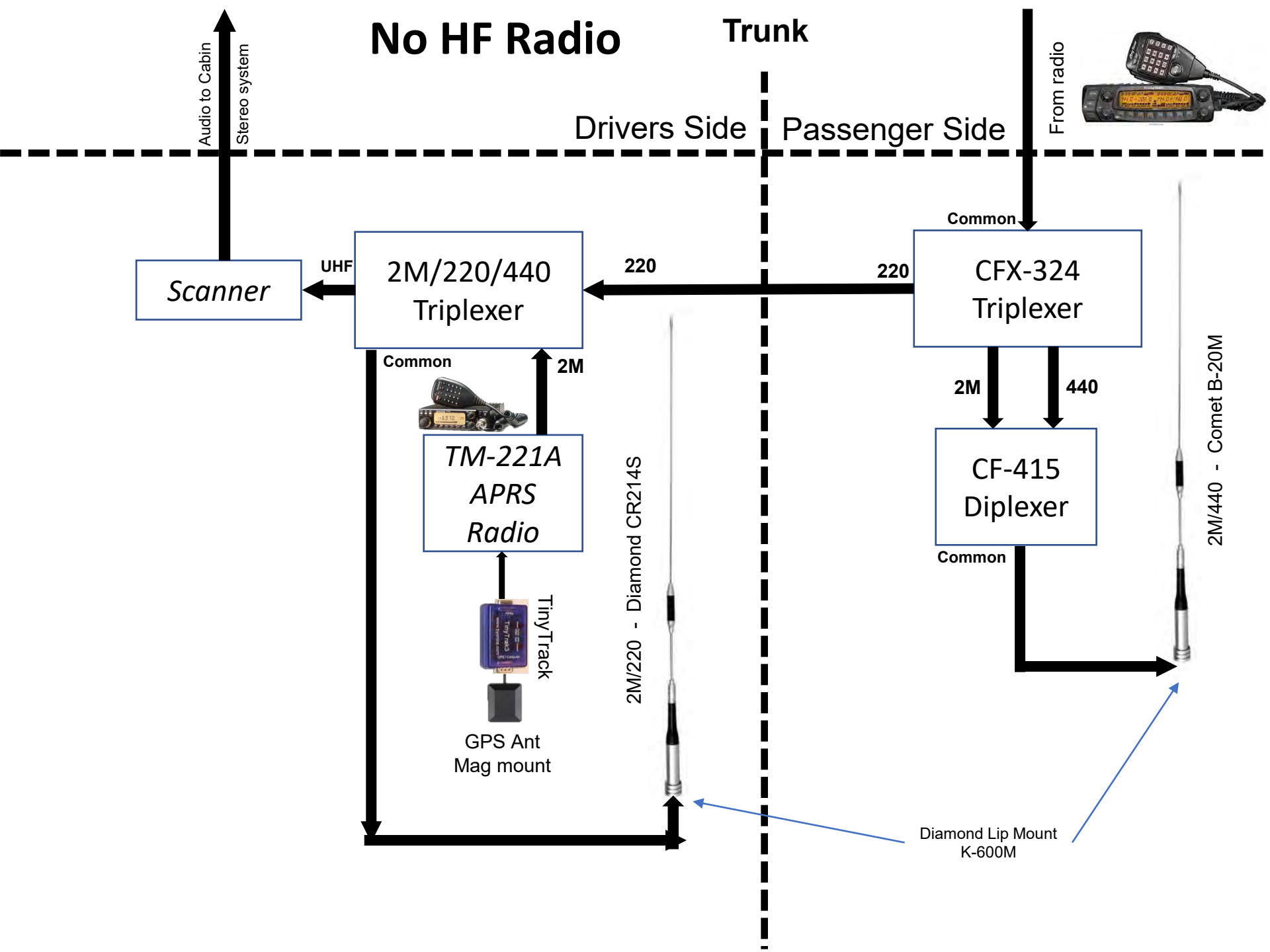
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From radio
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Passenger Side
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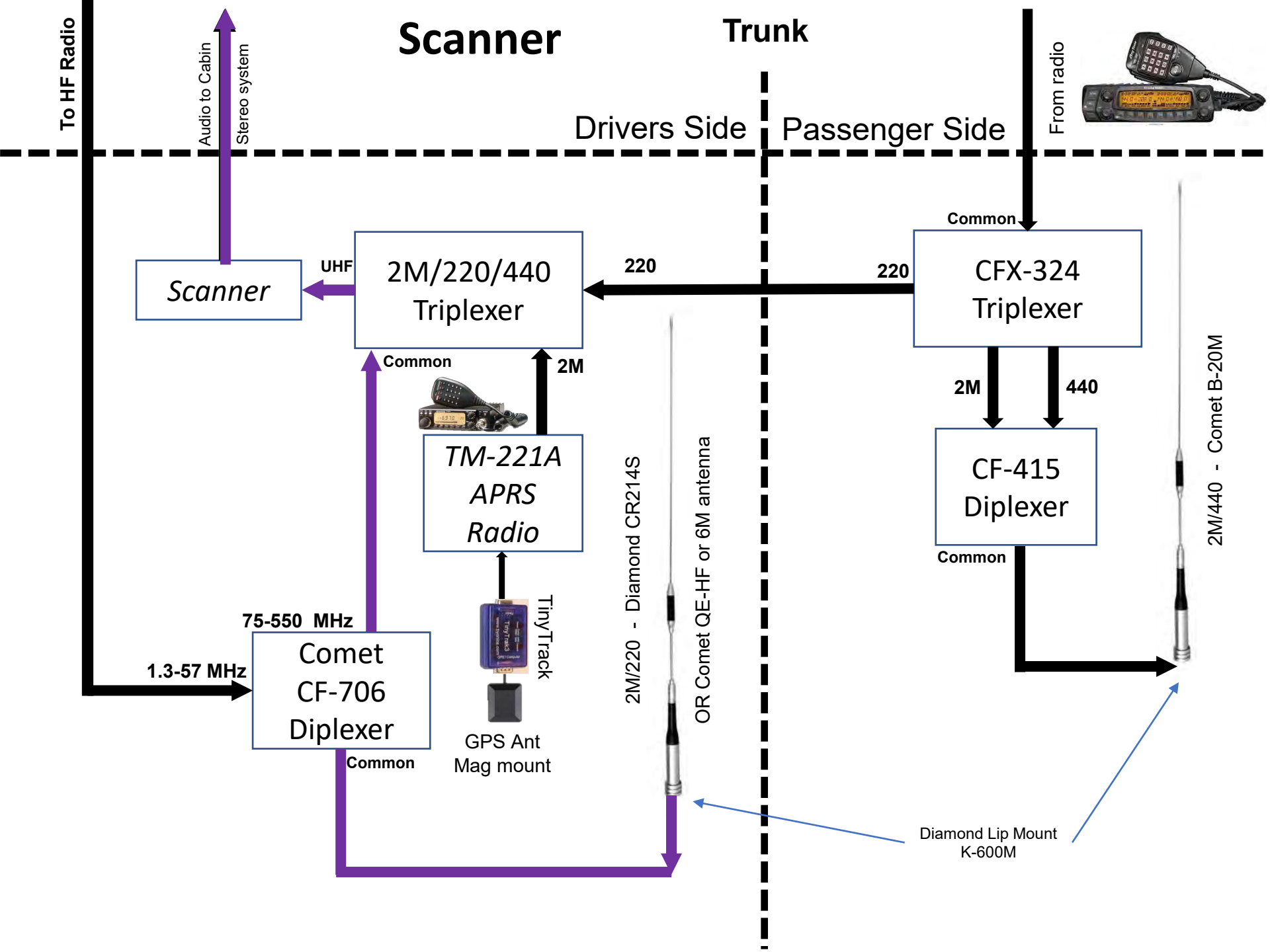
Scanner
Trunk
Drivers Side
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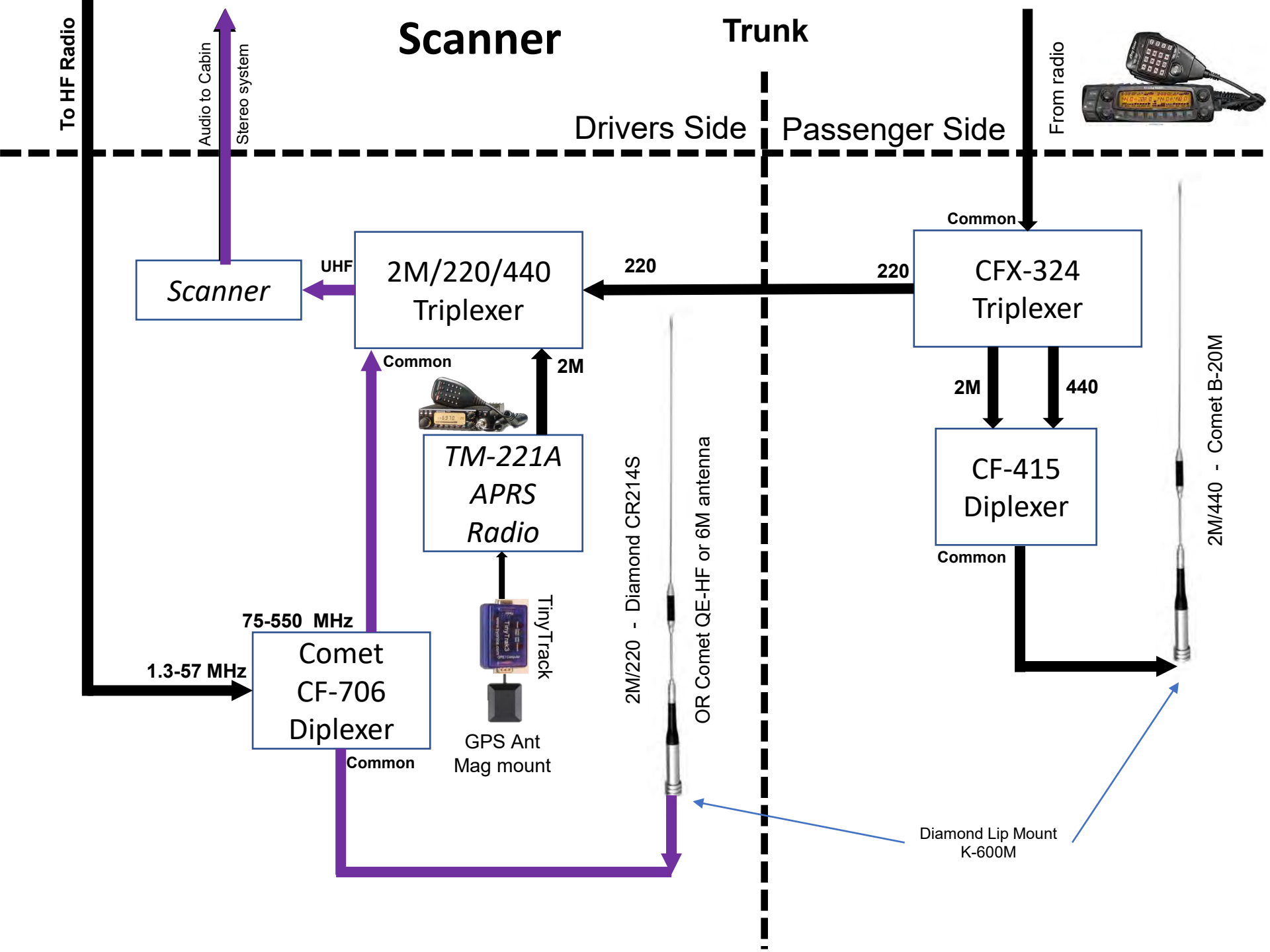
Scanner
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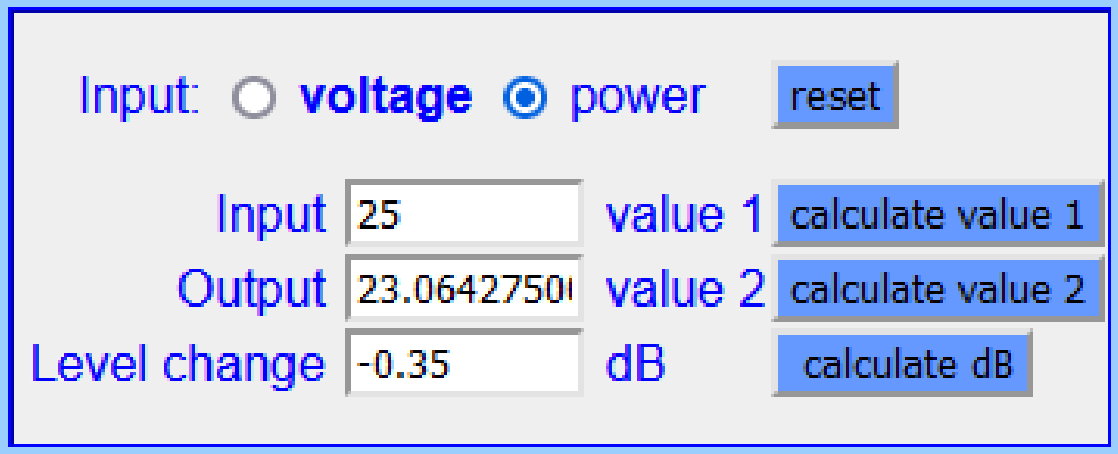
START
STOP
ENGINE
PWR
VOL
RADIO
MEDIA
<PRST·TRACK>
TUNE
SCROLL
TEMP
73
AUTO
OFF
REAR
PASSENGER
MENU
MAP
GUIDE
To listen to scanner

Loss through the diplexers and triplexers



http://www.sengpielaudio.com/calculator-amplification.htm

Band		2M	2M APRS	2M APRS	220	220	440
CFX-324	Triplexer	0.20	0.20	0.20	0.20	0.20	0.30
CFX-324	Triplexer				0.20	0.20	
CFX-416	Diplexer	0.15					0.25
CF-707	HF Diplexer		0.40	w/o HF	0.40	w/o HF	
	Loss in db	0.35	0.60	0.20	0.80	0.40	0.55
→	Input (W)	25.0	10.0	10.0	25.0	25.0	25.0
	Output (W)	23.1	9.3	9.8	20.8	22.8	22.0
	Power loss (W)	1.9	0.7	0.2	4.2	2.2	3.0

	RG-316 RG-174	USA-58 RG-58	USA-8X RG-8X	USA-240 LMR-240	USA-213 RG-213	9913	USA-400 LMR-400	USA-Flex Bury-Flex
3.5 MHz	1.5	.8	.65	.45	.3	.23	.2	.26
7 MHz	2.1	1.2	.85	.64	.5	.32	.3	.37
14 MHz	3.0	1.7	1.21	.91	.7	.46	.5	.53
28 MHz	4.2	2.4	1.74	1.29	1.00	.65	.7	.75
50 MHz	5.6	3.2	2.36	1.73	1.40	.88	.9	1.00
144 MHz	9.6	5.5	4.20	2.95	2.40	1.54	1.44	1.73
440 MHz	17	9.9	7.92	5.23	4.40	2.818	2.7	3.08
2400 Hz	41.4	24.8	22.80	12.65	12	7.48	6.6	7.63

Compare diplexer and triplexer loss to RG-8X coax

	RG-316 RG-174	USA-58 RG-58	USA-8X RG-8X	USA-240 LMR-240	USA-213 RG-213	9913	USA-400 LMR-400	USA-Flex Bury-Flex
3.5 MHz	1.5	.8	.65	.45	.3	.23	.2	.26
7 MHz	2.1	1.2	.85	.64	.5	.32	.3	.37
14 MHz	3.0	1.7	1.21	.91	.7	.46	.5	.53
28 MHz	4.2	2.4	1.74	1.29	1.00	.65	.7	.75
50 MHz	5.6	3.2	2.36	1.73	1.40	.88	.9	1.00
144 MHz	9.6	5.5	4.20	2.95	2.40	1.54	1.44	1.73
440 MHz	17	9.9	7.92	5.23	4.40	2.818	2.7	3.08
2400 Hz	41.4	24.8	22.80	12.65	12	7.48	6.6	7.63

100’ of RG-8X = 4.20 db loss @ 144 MHz
25’ of RG-8X = 1.05 db

A diplexer and triplexer @ 144 MHz = 0.35 db

	RG-316 RG-174	USA-58 RG-58	USA-8X RG-8X	USA-240 LMR-240	USA-213 RG-213	9913	USA-400 LMR-400	USA-Flex Bury-Flex
3.5 MHz	1.5	.8	.65	.45	.3	.23	.2	.26
7 MHz	2.1	1.2	.85	.64	.5	.32	.3	.37
14 MHz	3.0	1.7	1.21	.91	.7	.46	.5	.53
28 MHz	4.2	2.4	1.74	1.29	1.00	.65	.7	.75
50 MHz	5.6	3.2	2.36	1.73	1.40	.88	.9	1.00
144 MHz	9.6	5.5	4.20	2.95	2.40	1.54	1.44	1.73
440 MHz	17	9.9	7.92	5.23	4.40	2.818	2.7	3.08
2400 Hz	41.4	24.8	22.80	12.65	12	7.48	6.6	7.63

100’ of RG-8X = 7.92 db loss @ 440 MHz
25’ of RG-8X = 1.98 db

A diplexer and triplexer @ 440 MHz = 0.55 db

Useful Hint

- *If your have a fuzzy trunk liner*
- *You can use the hook side of sew-on Velcro to secure items like coax*


CALIFORNIA
KC70
Questions?