

A decorative background featuring a stylized circuit board pattern. The pattern consists of thin, light blue lines representing traces, with small circles at various points representing solder pads or vias. The pattern is most dense on the left side of the image and tapers off towards the right.

HOW TO GET ON 33CM / 900MHZ

PRESENTED BY: DAVID BROWN – WR6Z

WVARA MONTHLY MEETING - OCTOBER 2020

33CM / 900MHZ – WHY?

Yes, its one of the more obscure US amateur bands...

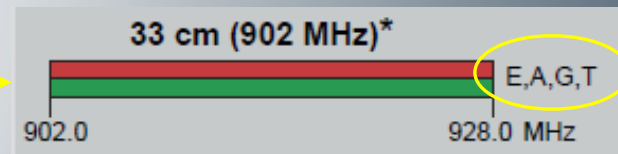
- Use it or loose it, all UHF spectrum is valuable for radio amateurs
- You don't have to spend a lot of money to get on their air
 - Much less expensive when compared to 1.2GHz
- True DIY band
 - Fun for experimenting and learning
 - Can't just buy a radio off the shelf and get on the air
- Great add on for VHF/UHF contesting!
 - 3pt. contacts and extra multipliers maximize your score

33CM / 900MHZ BAND BACKGROUND

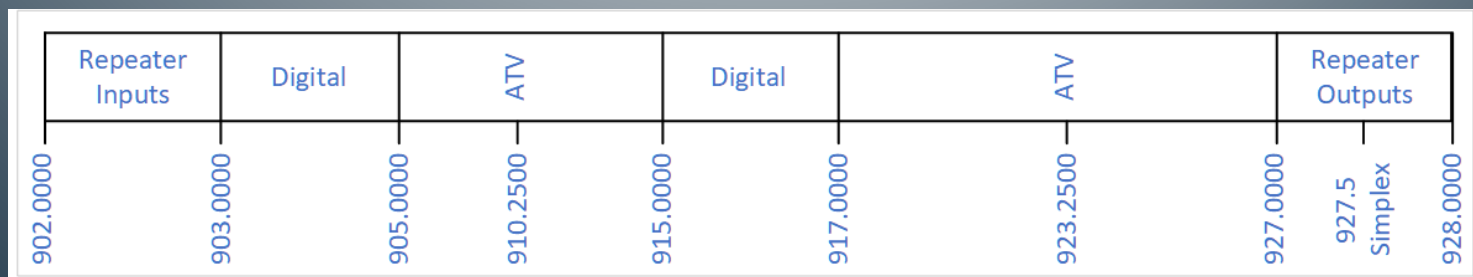
- In 1985 the FCC allocated 902-928MHz to Part 18 ISM devices
 - Allocations in ITU Region 2 only, meaning primarily North America with a few exceptions
 - ISM = Industrial, Medical and Scientific (devices for non-communications purposes)
 - Part 97 US amateurs were granted as secondary users as part of this allocation
 - Part 15 devices were also granted use of this spectrum as a 3rd tier user
 - Cordless phones, wireless networking, consumer electronics, wireless widgets, etc
- As with other spectrum allocations where US amateurs are granted as secondary users:
 - Part 97 devices may not interfere with and must accept interference from Part 18 Primary users
 - Part 15 device may not interfere with Part 18 or Part 97 devices and must accept interference from primary and secondary users

33CM / 902-928MHz AMATEUR BAND

Open to US all amateur license classes!

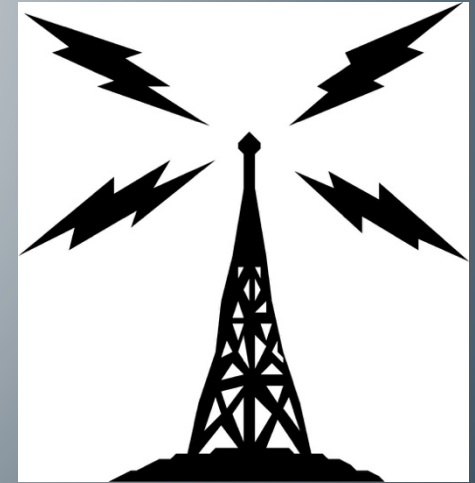


- Emissions - Part 97.305 (33cm): CW, phone, image, RTTY, data, SS
- Some areas of restricted operation and power limits
 - Similar to other UHF bands (420-440MHz)
 - Refer to FCC Part 97.301(n) and Part 97.313(g)
- Band Limits / Band Plan per NARCC: 902MHz to 928MHz



33CM PROPAGATION

- 33cm UHF propagation is very “line of sight”
 - Even more so than 70cm and not unlike the 23cm
 - If in good line of sight, very little Tx power is needed
- Anything can block or hinder signal paths
 - Trees, buildings, walls can effect propagation
- Sometimes 33cm can work better than other UHF bands
 - Signals easily bounce off mountains, buildings or other objects
 - Different multipath behavior can be interesting



HOW TO GET ON THE BAND

You will not find 900MHz radios at your regular ham radio retailer

- No major amateur equipment manufacturers make radios to operate on the 33cm band
 - One exception from Alinco and excluding transverters
- DIY! - Wide array of commercial radios available, but must be converted for amateur use
 - Radios intended for the LMR 896-901MHz(Tx)/935-940MHz(Rx) commercial band
 - Frequencies, modes and functions not readily front panel accessible
 - Must be pre-programmed via software
 - Conversions run from simple software editing to hardware modifications
- Where to get commercial radio gear:
 - Radios often sold by amateurs through 900MHz Yahoo/Google groups and found on eham, QRZ, etc.
 - Amateur Radio Swap meets
 - Commonly available on ebay - Caution: Know your model numbers and details!

PROGRAMMING AND MODIFICATIONS

Basic amateur operation with a commercial radio:

- TX ok over full 902-928MHz band
 - TX usually designed to operate from 896-901MHz and 935-940MHz for simplex op.
- RX typically good down 924MHz due to 938MHz front end filters
 - It ok – Needed FM voice RX is between 927-928MHz
- Software programming mods:
 - Motorola software requires hex editing to change programming band limits
 - Change limits from 896-901MHz and 935-940MHz to allow 902-928MHz frequency entries
 - Kenwood software enters frequencies by FFC channel number
 - Radio data file edited to ham frequencies by a freeware program
 - Written by a ham (N2MCI)

COMMERCIAL RADIO TERMINOLOGY

- **Motorola:**

- “CODEPLUG” = radio programming data file (origins in hardware configuration plugs)
- “Direct” Mode = simplex operation
- “Repeater” Mode = Tx/Rx frequency split operation
- Zone = specific memory bank of channels
 - Channel = specific radio channel programmed with a given frequency
- RSS = Radio Service Software (typically DOS based for older radio models)
- CPS = Customer Programming Software (typically windows based for newer radios)

- **Kenwood:**

- “Talk Around” or T/A = simplex operation
- System = Specific memory bank of channels
- Group = specific radio channel frequency

33CM RADIO MODELS TO LOOK FOR

Amateur Band Specific Radios – the one lone exception:

- Alinco

Commercial Radios:

- Motorola
- Kenwood

To a lesser extent:

- EF Johnson
- GE
- Harris
- Bendix

ALINCO

DJ-G29T – The only 33cm amateur band specific radio ever made

- Dual band radio covering 220MHz and 900MHz ham bands
 - Tx power: 5W at 222MHz and 2.5W at 912MHz
- Easy frequency entry and display
 - Exactly what you would expect for ham radio
- Easy to obtain software for programming
- No longer on production ☹... can find used on-line
 - Expect to pay \$400 or more for a used radio in clean condition



MOTOROLA

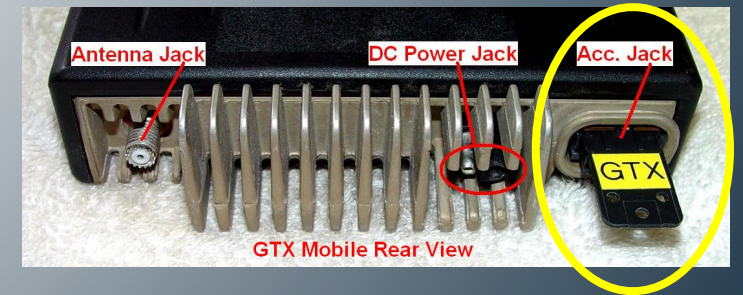
Many choices for Motorola 902-928MHz capable radios

- **Warning! Caution! Know your model numbers!**
 - 800MHz and 900MHz radio models look the same
 - Unscrupulous or uninformed sellers list 800MHz radios as “900MHz Ham”
 - Must differentiate 900MHz models by a “W” in the model number
 - Examples: H46WCH9PW7BN or M11WGD4CB1AN
 - Models with “U” = Useless! H46UCH9PW7BN = 800MHz model that won't work
- **Motorola software can be hard to source**

MOTOROLA – MOBILE RADIOS THAT WORK

Common Mobiles - Analog/FM, most only need modified software

Model Name	Model Number	Tx Power	Display	Cost Range
Maxtrac*	D27MJA7DA6_K	12W	Numeric	Free - \$50
GTX	M11WGD4CB1AN	15W	Numeric	\$25-\$70
GTX	M11WRD4CB1AN	30W	Numeric	\$35-\$90
MCS2000	M01WGL4PW6AN	15W	Numeric	\$30-\$100
MCS2000	M01WJN4PW6AN	30W	Alphanumeric	\$50-\$150
Spectra*	D37KMA/D45KMA	30-35W	Alphanumeric	\$50-\$150



- * Require hardware and software mods to get best performance
- All models have extensive rear accessory connectors allowing for easy external interfacing



MOTOROLA – HANDHELD RADIOS THAT WORK

FM / Analog Handheld Radios: \$20 to \$250

- Mods - software edit to open band limits and get on the air
 - Some hardware mods to improve performance but not necessary
- Some are FPP Capable – Front Panel Programmable”
 - Requires firmware flash

Model Name	Model Number	Tx Power	FPP Capable
GTX	H11WCD4CB1AN	3W	No
MTS2000	H01WCH4PW1CN	3W	Yes
MTX9250	AAH25WCH4GB6AN	3W	Yes



MOTOROLA – MIXED MODE ANALOG / DIGITAL

FM/Analog and P25 Digital Mixed Mode Radios

- All work over 900MHz amateur band with hex edited CPS
 - RadioReference.com flashcode decoder is very useful
- Watch out for analog only flashcodes

Radio Models:

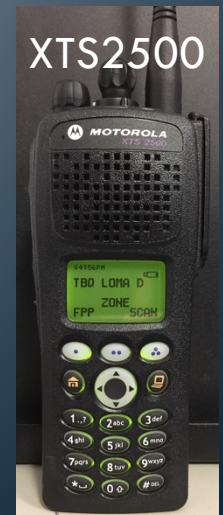
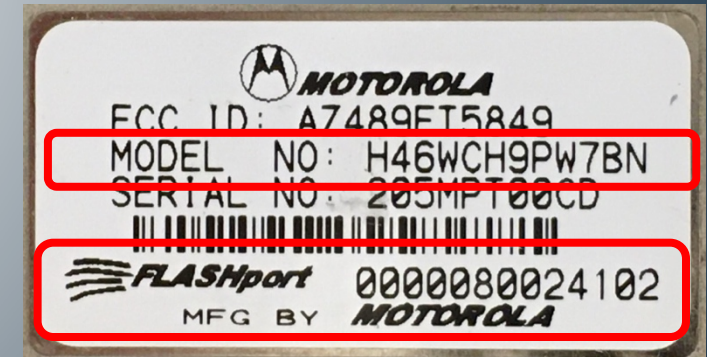
Model Name	Model Number	Type	Tx Power	Channels	Cost Range
XTS1500	H66WCD9PW5AN	HT	2.5W	48	\$150-\$375
XTS2500	H46WCH9PW7BN	HT	2.5-3W	800	\$175-\$500
XTL1500	M28WRS9PW1AN	Mobile	30W	48	\$150-\$375
XTL2500	M21WRS9PW1AN	Mobile	30W	Up to 1000	\$250-\$500

Other High-End Radio Radios:

APX series – no known mods available yet - \$\$\$\$

XPR and DTR Analog / DMR radios – no mods for some - \$\$\$

- 900MHz DMR not useful around Bay Area – no repeaters



KENWOOD

Kenwood 900MHz radio models: Straight forward – Easy to use

- 900MHz radios have specific model numbers so no confusion
- Software easier to obtain

Handheld Radios:

Model Name	Modes	Tx Power	FPP	Cost Range
TK-481	Analog FM	2.5W	No	\$200-\$300
NX-411	Analog/NXDN	2.5W	No	\$400+

Mobile Radios:

Model Name	Mode	Tx Power	Tx Freq. Split	Cost Range
TK-981	Analog FM	15W	Any / Custom	\$50-\$250
TK-941	Analog FM	15W	39MHz – simplex	< \$100
TK-931	Analog FM	15-30W	25MHz ok	\$25-\$100
NX-901	Analog/NXDN	15W	Any / Custom	\$400+

- NXDN radios not really worth it – No NXDN repeaters
- TK-980, TK-940 and TK-930 are 800MHz radios often listed as 900MHz
Avoid these radios, then will not work for 902-928MHz amateur operation

Kenwood Tri-band Radio

Undocumented Feature:

TM-741/742 UHF 900Hz RX

- Select 440MHz UHF Band
- Select VFO mode
- Press and hold the MHZ button
 - Press and hold MHz button again to return to 440MHz
- Hardware mod available to improve Rx sensitivity

KENWOOD TK-981

Great Starter Radio for 900MHz

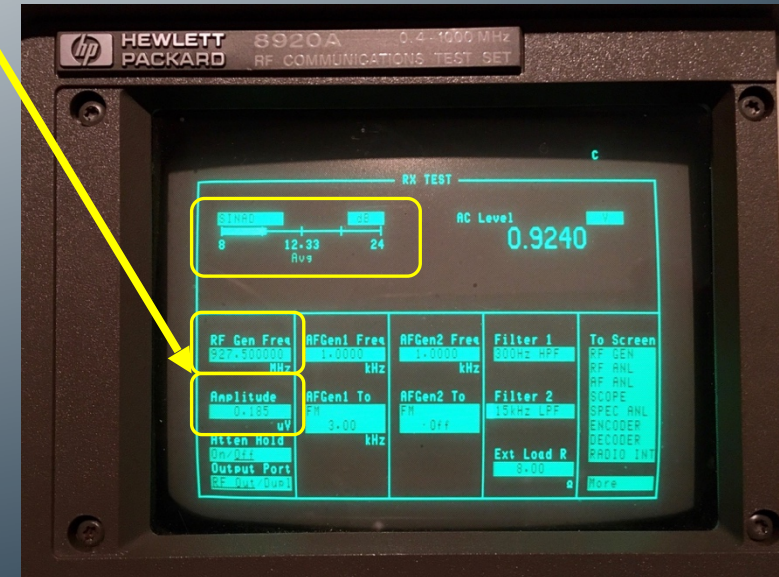
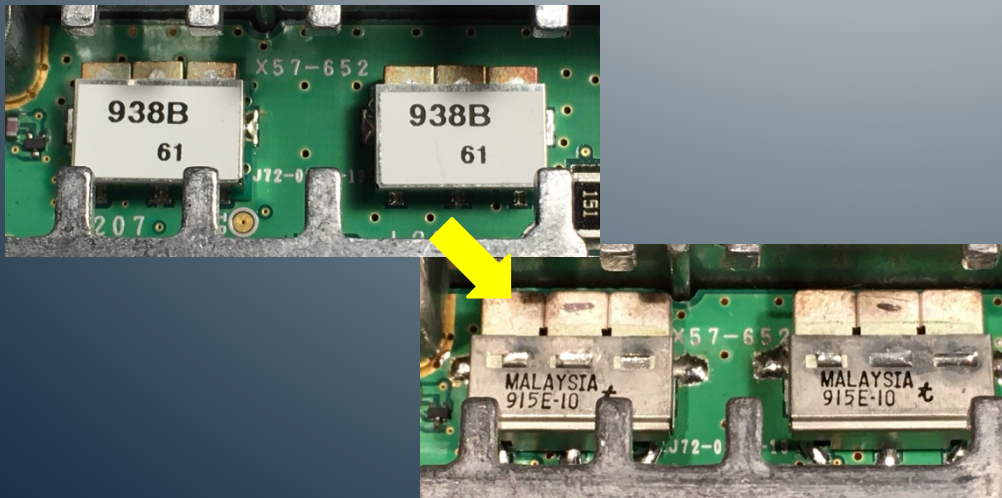
- Small, compact, good display with 1000 memory channels
- Many DIY possibilities for the project builder
- Two Versions spelled out clearly of the rear model number plate:
 - TK-981 Ver. 1 – uses DOS based programming software, firmware not upgradable
 - TK-981 Ver. 2 – uses modern windows software (KPG-49D), upgradable firmware
 - Old 15W PA models – Serial Numbers < 60600000
 - New 30W capable PA models – Serial Numbers > 60600001
- Can program standard 25MHz offset or custom TX offset frequencies
- Front panel buttons customized via software
- 15W output, adjustable via software



TK-981 MODS FOR THE EXPERIMENTER

RX Filter Swap - Change 938MHz front end filters to 915MHz

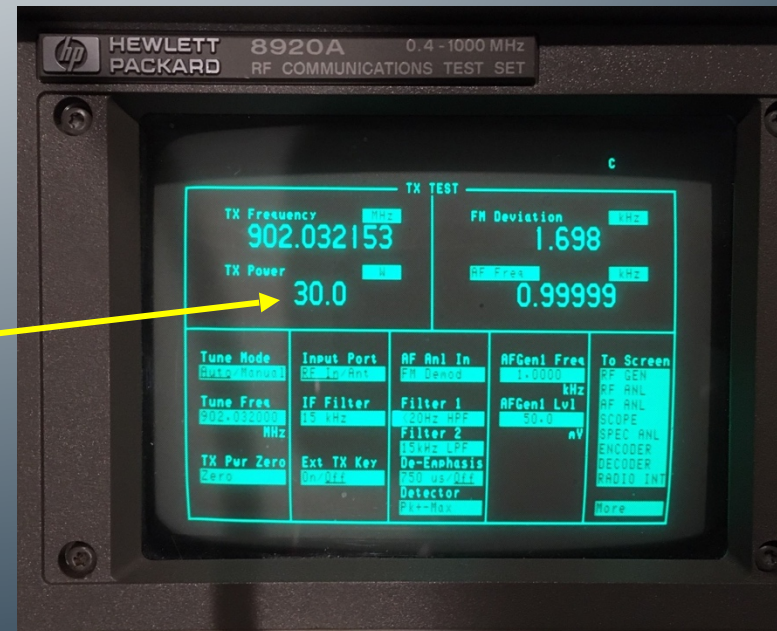
- Open up Rx to 916-928MHz and allow 12MHz Repeater offsets
- Improved RX sensitivity at 927.5MHz
 - Rx 12dB SINAD sensitivity spec is 0.25uV. Typically measure 0.22uV at 927.5MHz
 - Filter swap can increase sensitivity to 0.18uV at 927.5MHz (a 2-3dB improvement)
 - Good for weak signals during a contest



TK-981 MODS FOR THE EXPERIMENTER

“TK-981H” - TX Power mod 15W to 30W

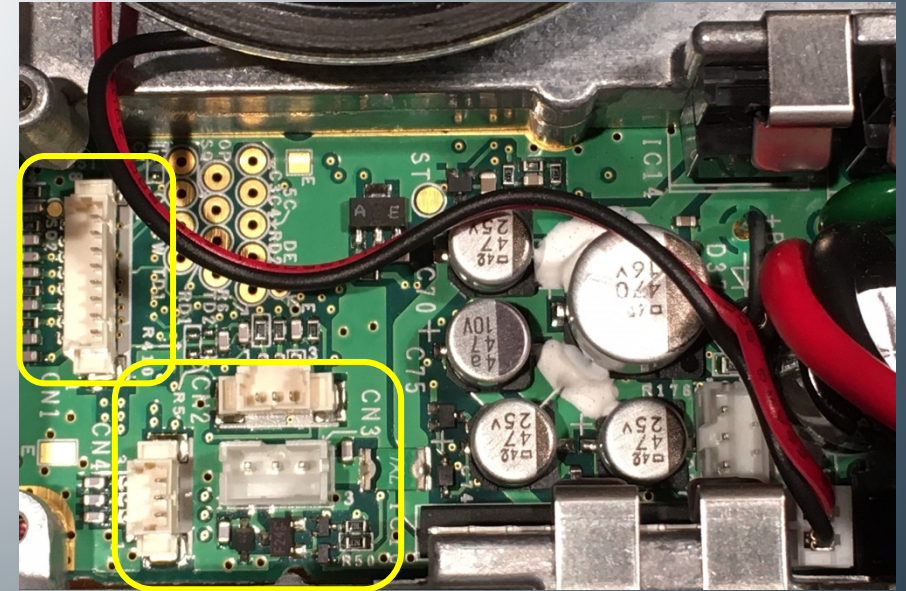
- Swap TK-981 Chassis for high power long heat sink from other HG models
- Older Ver.2 models require PA swap + a few parts and re-chassis
- Newer models only need chassis swap and turn up the power through software
 - S/N: 60600001 and higher



TK-981 MODS FOR THE EXPERIMENTER

Accessory Port for External Interface

- Connections for
 - TX Audio/Mic, RX audio/Speaker, PTT, COS
 - Radio on/off (ignition switch)
 - Data – TXD/RXD, GPIO
 - Switched 13.8V power (up to 750mA) & GND
- Many Possible Uses
 - Interface for repeater control
 - Remote base / Remote radio control
 - Allstar node
 - Packet / Data link radio



KCT-19 Accessory Cable

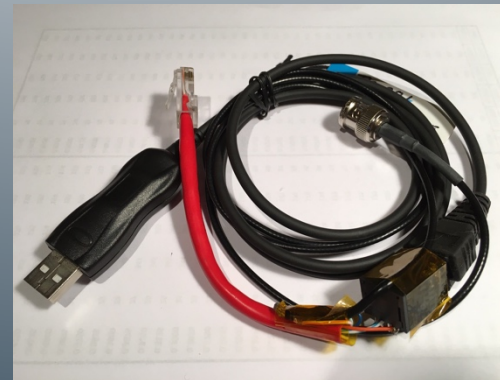
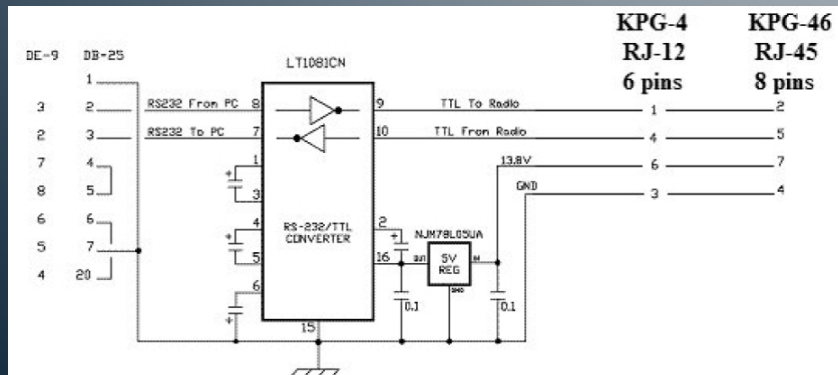
PROGRAMMING AND INTERFACE CABLES

Buy or DIY programming cables

- Buy – Typically \$15-\$45 on line depending upon the radio
 - USB and serial programming cables readily available
- DIY – Schematics / Plans on-line for just about any cable
 - Save \$\$
 - Helps if you start with a USB – Serial (RS-232) adaptor/dongle



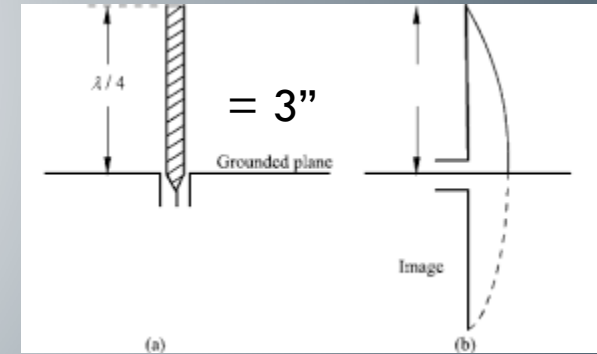
Tripp-Lite USB-DB-9 Serial Dongle
Model: USA-19HS



ANTENNAS

Antennas for 33cm are small and cute

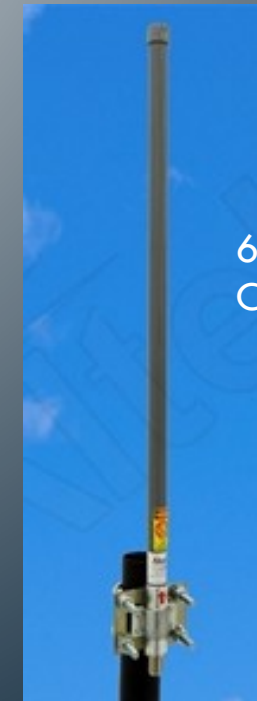
- A quarter wave vertical is only 3" tall at 915MHz
- Great for limited space or low-profile installations
- Many commercial antennas can be bought on-line cheap!
 - Surplus Part 15 commercial 902-928MHz antennas can cost in the range of \$10-\$50
 - Vertical gain antennas, Colinear, Yagi and mobile antennas



Inexpensive 902-928MHz Yagi



3dB Gain
No Ground Pane

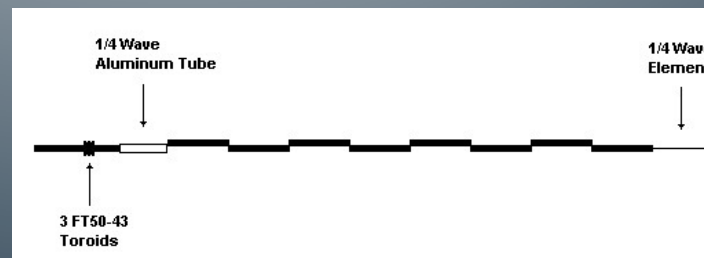
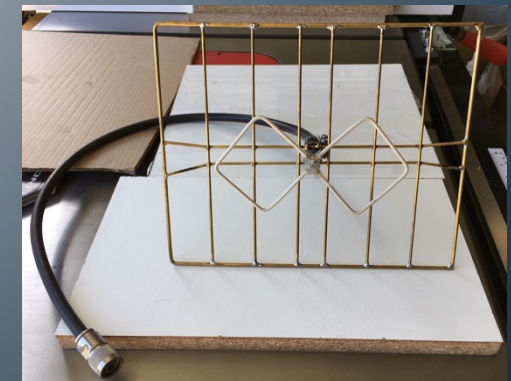


6dB Gain
Colinear

ANTENNAS

DIY - Make your own – it's not difficult and very inexpensive

- Simple quarter wave using a bulkhead N connector and a few inches of wire – cost about \$1
- Bi-Quad antennas are easy to make, wideband and forgiving to match
 - Directional wide band gain antenna
 - Typical 9dB Gain, 60-degree beam width
 - Several plans and dimension calculators in-line
- Co-Linear – not hard to make from coax scraps and PVC pipe
 - Omni-directional gain antenna
 - Plans and calculators on-line



FEEDLINE AND CONNECTORS

At 900MHz everything effects signal path loss.....

Connectors - N connectors are most common

- Assume up to 1 dB loss of every connector
- Mini UHF for Motorola ? (normally must get an N adaptor)
- Use high-quality adaptors if they must be used

Feedline – Use High Quality Cable!

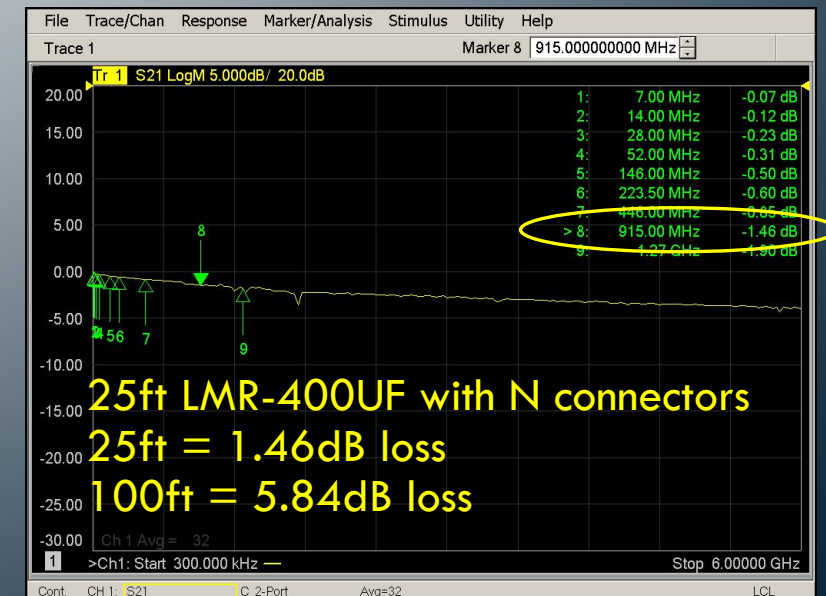
- LMR-400, LMR-600 or better recommended
 - LMR-400 has almost 6dB loss / 100ft
- Use Hardline if available to you
- RG-58, RG-8x only for mobile installations



N Connector – Yes



UHF / PL-259 – No



TESTING AND EQUIPMENT

Testing and Equipment can be a challenge

- Most amateur test gear won't operate at 900MHz
- Creativity can get you around this obstacle
- Radios might require alignment after programming or hardware modifications
 - VCO adjustments can usually done by setting frequency setting and a DVM
- For basic radio and antenna testing, a Bird 43 wattmeter is a great option
 - Use "E-Series" 400MHz to 1000MHz elements
 - Can measure RF output power, VSWR can be calculated based on forward and reverse power measurements
- Antenna analyzers for operation up to the gigahertz range (\$ to \$\$\$\$....)
 - Micro controller based nanoVNA's to high-end commercial analyzers



Bird 43 Wattmeter



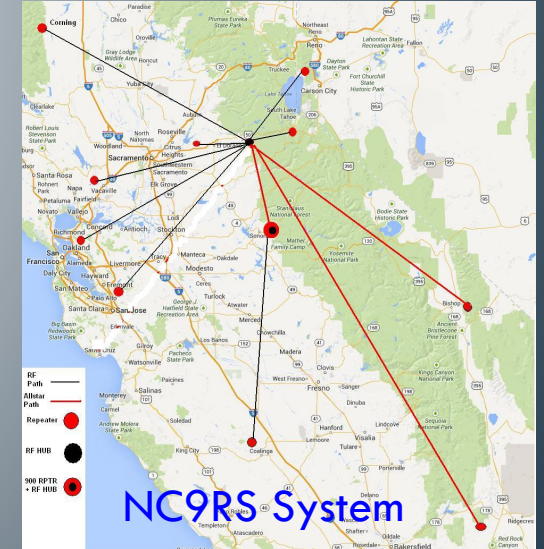
OPERATING

- Narrowband FM (NFM) operation is standard:
 - 12.5kHz channel spacing / 2.5kHz deviation
- Simplex
 - National simplex calling frequency: 927.5MHz
 - Optional PL 151.4Hz or 100.0Hz
 - Listen for activity during VHF/UHF contest weekends!
- Repeaters
 - Analog FM and P25 digital systems on the air in the Bay Area
 - All use PL or DPL encode and decode, P25 systems typically use NAC 293
 - 25MHz offset with 12.5kHz channel spacing
 - Inputs: 902.0125MHz to 902.9875MHz
 - Outputs: 927.0125MHz to 927.9875MHz
 - Caution – many repeaters use non-standard input frequencies to avoid interference



BAY AREA REPEATERS YOU CAN USE

- RepeaterBook, RadioReference listings are not always accurate for 900MHz repeaters!
 - NARCC and NC9RS web pages usually more up to date for listings of repeaters on the air
- NC9RS - All 900MHz System
 - All Analog FM with one common input frequency for most of the system
 - Allstar linked wide area linked system covering northern California and beyond
 - W6SRR input on Mt. Allison (above Milpitas) 927.1875MHz / Input 902.0125 pl 94.8Hz
- N6TBQ
 - Analog FM and P25 digital dual mode repeater – located on Loma Prieta
 - 927.9MHz / Input 902.0375MHz, DPL 411 / P25 NAC 293, Allstar Node: 41306
 - Allstar linked to numerous 900MHz, 2m and 70cm repeaters from Salinas to Napa
- N6NMZ
 - Analog / FM Located somewhere 2000ft above Los Gatos... 927.15MHz / Input -25MHz pl 156.7 Hz
 - Linked system to various 2m, 1.25m and 70cm repeater through out Northern California
- WW6BAY – Analog FM, 927.8625MHz / Input -25MHz, DPL 023 (crossband to 2m/70cm)
- WI6H - Analog FM and P25 digital – Inputs in SF (Sutro), Berkeley and Cupertino(?)



RESOURCES

- General:
 - [Google.com](https://www.google.com) - Once again, google can your friend to find 900MHz parts, manuals and info on-line
 - www.repeater-builder.com – vast site with technical information, manuals and how-to
 - www.users.innercite.com/kj6ko/page8.html - NC9RS system: repeater network maps and the most accurate listing of 900MHz repeaters that are really on the air (Also see N6TBQ.com)
 - <https://communications.support/> - Commercial radio discussion forum, has lots of info on how to fix issues with radios
- Kenwood Specific:
 - www.kw902.com – One stop source for all things related to Kenwood 900MHz gear by Alex, KD6VPH
- Motorola Specific:
 - www.batlabs.com – large site with discussion forum for all things Motorola, old and new
- Yahoo / Google Groups - some in transition
 - PNW-902MHz@groups.io, AR902MHz@groups.io, NC9RS @ yahoo groups

GO GET A 900MHZ RADIO AND ON THE AIR!

Questions?

Thanks for listening

73, Dave

wr6z@arrl.net

