HOW TO GET ON 33CM / 900MHZ

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33CM / 900MHZ – WHY?

Yes, it's one of the more obscure US amateur bands…

• Use it or lose 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
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 were 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 you models 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 wont work

• Motorola software can be hard to source
**MOTOROLA – MOBILE RADIOS THAT WORK**

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

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

- * 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

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Model Number</th>
<th>Tx Power</th>
<th>FPP Capable</th>
</tr>
</thead>
<tbody>
<tr>
<td>GTX</td>
<td>H11WCD4CB1AN</td>
<td>3W</td>
<td>No</td>
</tr>
<tr>
<td>MTS2000</td>
<td>H01WCH4PW1CN</td>
<td>3W</td>
<td>Yes</td>
</tr>
<tr>
<td>MTX9250</td>
<td>AAH25WCH4GB6AN</td>
<td>3W</td>
<td>Yes</td>
</tr>
</tbody>
</table>
MOTOROLA – MIXED MODE ANALOG / DIGITAL

FM/Analog and P25 Digital Mixed Mode Radios

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

Radio Models:

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Model Number</th>
<th>Type</th>
<th>Tx Power</th>
<th>Channels</th>
<th>Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>XTS1500</td>
<td>H66WCD9PW5AN</td>
<td>HT</td>
<td>2.5W</td>
<td>48</td>
<td>$150-$375</td>
</tr>
<tr>
<td>XTS2500</td>
<td>H46WCH9PW7BN</td>
<td>HT</td>
<td>2.5-3W</td>
<td>800</td>
<td>$175-$500</td>
</tr>
<tr>
<td>XTL1500</td>
<td>M28WRS9PW1AN</td>
<td>Mobile</td>
<td>30W</td>
<td>48</td>
<td>$150-$375</td>
</tr>
<tr>
<td>XTL2500</td>
<td>M21WRS9PW1AN</td>
<td>Mobile</td>
<td>30W</td>
<td>Up to 1000</td>
<td>$250-$500</td>
</tr>
</tbody>
</table>

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 900MHz radio models: Straight forward – Easy to use

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

### Handheld Radios:

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Modes</th>
<th>Tx Power</th>
<th>FPP</th>
<th>Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>TK-481</td>
<td>Analog FM</td>
<td>2.5W</td>
<td>No</td>
<td>$200-$300</td>
</tr>
<tr>
<td>NX-411</td>
<td>Analog/NXDN</td>
<td>2.5W</td>
<td>No</td>
<td>$400+</td>
</tr>
</tbody>
</table>

### Mobile Radios:

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Mode</th>
<th>Tx Power</th>
<th>Tx Freq. Split</th>
<th>Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>TK-981</td>
<td>Analog FM</td>
<td>15W</td>
<td>Any / Custom</td>
<td>$50-$250</td>
</tr>
<tr>
<td>TK-941</td>
<td>Analog FM</td>
<td>15W</td>
<td>39MHz – simplex</td>
<td>&lt; $100</td>
</tr>
<tr>
<td>TK-931</td>
<td>Analog FM</td>
<td>15-30W</td>
<td>25MHz ok</td>
<td>$25-$100</td>
</tr>
<tr>
<td>NX-901</td>
<td>Analog/NXDN</td>
<td>15W</td>
<td>Any / Custom</td>
<td>$400+</td>
</tr>
</tbody>
</table>

- 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 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
  - Alltstar 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 affects signal path loss……

Connectors - N connectors are most common
  • Assume up to 1dB 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

25ft LMR-400UF with N connectors
25ft = 1.46dB loss
100ft = 5.84dB loss
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
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](http://google.com) - Once again, google can be your friend to find 900MHz parts, manuals and info on-line
  • [www.repeater-builder.com](http://www.repeater-builder.com) – vast site with technical information, manuals and how-to
  • [www.users.inercite.com/kj6ko/page8.html](http://www.users.inercite.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/](https://communications.support/) - Commercial radio discussion forum, has lots of info on how to fix issues with radios

• Kenwood Specific:
  • [www.kw902.com](http://www.kw902.com) – One stop source for all things related to Kenwood 900MHz gear by Alex, KD6VPH

• Motorola Specific:
  • [www.batlabs.com](http://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](http://PNW-902MHz@groups.io), [AR902MHz@groups.io](http://AR902MHz@groups.io), NC9RS @ yahoo groups
GO GET A 900MHZ RADIO AND ON THE AIR!

Questions?

Thanks for listening

73, Dave
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