



ChristmasExpo

Holiday Lighting & Decorating Conference

Transmitting high quality display audio on FM radio

Greg Young



ChristmasExpo

Fm Broadcasting – Overview

- Advantages:
 - People can enjoy the music in their vehicles during inclement weather
 - Better sounding audio quality
 - Audio volume of the display can be controlled to avoid disturbing neighbors



Fm Broadcasting – Overview

- Disadvantages:
 - Increased cost
 - Potential legal issues
 - Potential interference issues in impacted neighborhoods

Radio Broadcasting

- Types:
 - Licensed
 - Unlicensed
 - AM
 - FM



Licensed Broadcasting

- AM
 - 250 watts ERP minimum
 - 25 mile coverage area (radius)
- FM
 - 100 watts minimum
 - 4 miles coverage area (radius)



Licensed Broadcasting

- There are defined minimum hours of operation for licensed stations
- Types of licensed stations:
 - Commercial
 - Noncommercial
 - Educational



Licensed FM Broadcasting

- Commercial FM broadcast stations operate from 92.1 – 107.9 Mhz
- Noncommercial FM broadcast stations operate from 88.1 – 91.9 Mhz
- Educational FM broadcast stations operate throughout the entire band, although most operate 88.1 – 91.9 Mhz



Low Power Broadcasting – the Law

- There are 2 types of low power AM and FM broadcasting:
 - Licensed
 - Unlicensed
- For the remainder of this presentation we will deal with FM broadcasting



Low Power Broadcasting – the Law

- Created under a new law in January 2000
- Licensed low power FM stations operate with a minimum of 1 watt, a maximum of 100 watts, ERP
- They are allowed to cover about a 3.5 mile radius



Low Power Broadcasting – the Law

- Low power FM radio licenses are available only to:
 - Noncommercial educational entities
 - Public safety/travelers' information entities
- **They are NOT available to private individuals or commercial operators**



Low Power Broadcasting – the Law

- That leaves us with unlicensed FM broadcast operation, as defined by Part 15 of the FCC rules (47 Code of Federal Regulations, Section 15.239)
- Part 15 governs other non-licensed transmissions as well, including wireless telephones, wireless internet, garage door remotes, etc.



Low Power Broadcasting – the Law

- Part 15 allows unlicensed FM broadcast:
 - **With an operational radius of 61 meters (200 feet)**
 - Actual measured **received** signal strength however is limited to 250uv/meter at 3 meters from the antenna
 - With sufficient antenna height that signal can be detected at 1.9uv 1200 plus feet (1/4 mile) away (modern FM receivers can receive 1.7 uv signals)
 - That exceeds the previously defined 200 foot range limit in Part 15, as described above



Low Power Broadcasting – the Law

- Unlicensed broadcasters may not cause any interference to licensed station operation, or operations must be shut down
- That means within your 200 foot range, you must have a clear frequency to operate, even under Part 15!
- Unlicensed transmitters must accept interference from other (electronic) devices
- Part 15 FM broadcast operations are allowed between 88.1 – 107.9 Mhz only.



Low Power Broadcasting – the Law

- Penalties for exceeding Part 15 allowances:
 - \$10,000 per day of operation, to a maximum of \$75,000
 - Equipment may be (usually is) confiscated
 - If it can be demonstrated the transmitter was “willfully and knowingly” operated outside of the allowances of operation under Part 15, there are criminal fines and imprisonment that may be imposed.
- It just isn’t worth taking any chances!



Low Power Broadcasting – the Law

- In summary, it's not the actual equipment that is legal/illegal, but rather the installation and operation of the equipment that may violate the law.
- Use the kits as intended, with whip antennas, and you **should** be safe.
- If in doubt check the transmitters range. If 200 feet or less you **will** be safe.



Low Power Equipment

- There are a number of FM transmitter partially/fully assembled kits available
- Look for transmitters with:
 - Frequencies that are PLL controlled, and switch selectable
 - Audio input limiters, (AGCs, adjustable audio potentiometers, etc.) to prevent audio distortion
 - 75 μ s (microseconds) de-emphasis is used in the US, vs 50 μ s in Europe and other countries. Try to avoid the Chinese imports that use 50 μ s as audio quality will not sound as full



FM transmitters

Here are some examples:

UX300 USB FM Transmitter



UX300 USB FM Transmitter

- The UX300 **USB FM Transmitter** is a USB device intended to transmit audio wirelessly from your desktop computer or notebook to nearby FM radios in your home or office. This USB transmitter is a truly plug-and-play device and is simply connected to your computer via the supplied USB cable. No drivers are needed. The transmitter installs itself within seconds as soon as you plug it into your computer.
- The USB FM transmitter appears as a sound card to your computer and any audio produced by the computer will be transmitted over the USB connection to the transmitter for reception on any standard FM radio. Power for the transmitter is provided through the USB port and therefore there are no batteries required



UX300 USB FM Transmitter

- Specifications:
- FCC Certified (FCC ID: SCSUX300)
- 30 to 50 foot Range
- Plug-and-Play USB device
- Transmission frequencies:
106.7, 106.9, 107.1, 107.3, 107.5, 107.7, 107.9 MHz
- Zero-drift Phase-Locked-Loop (PLL) Design
- Output power: 250 uV @ 3m (Limited per Part 15 FCC regulations)
- Frequency Response: 40 Hz - 15 KHz
- Channel Separation: 40 dB (Typical)
- Total Harmonic Distortion: 0.1% (Typical)



MS-100S FM Transmitter



MS-100S FM Transmitter

- The MS-100S is a “professional quality” stereo FM transmitter operating in the commercial FM broadcast band (88.1 - 107.5 MHz) and can be used in a wide variety of applications. Its outstanding RF and audio performances, ... make the MS-100S stand out from FM broadcasting systems. The MS-100S features DAFP technology (Direct Access Frequency Programmation). This technology allows the end user to program the frequency without any manual tuning inside the unit. The stereo generator section of the MS-100S features a full digital circuitry that allows a stereo separation of over 40 dB. It has near CD sound quality.



MS-100S FM Transmitter

- SPECIFICATIONS:
- Modulation: FM, 75 KHz deviation
- Frequency selection: 88.1 - 107.5 MHz
- Frequency precision: .005% Crystal.
- RF power: 250 μ V/m@3m.(FCC Part 1& DOC RSS-210),
1 milliwatt (DOC RSS-123)
- Spurious rejection: 45 dB min.
- Frequency response: 20-15 KHz
- Stereo separation: 40 dB min. THD: .05% max.
- Signal to noise ratio: 70 dB min.
- Input sensitivity: -15dBm to +15dBm (unbalanced)
- Dynamic range: 80 dB min.



Whole House FM Transmitter

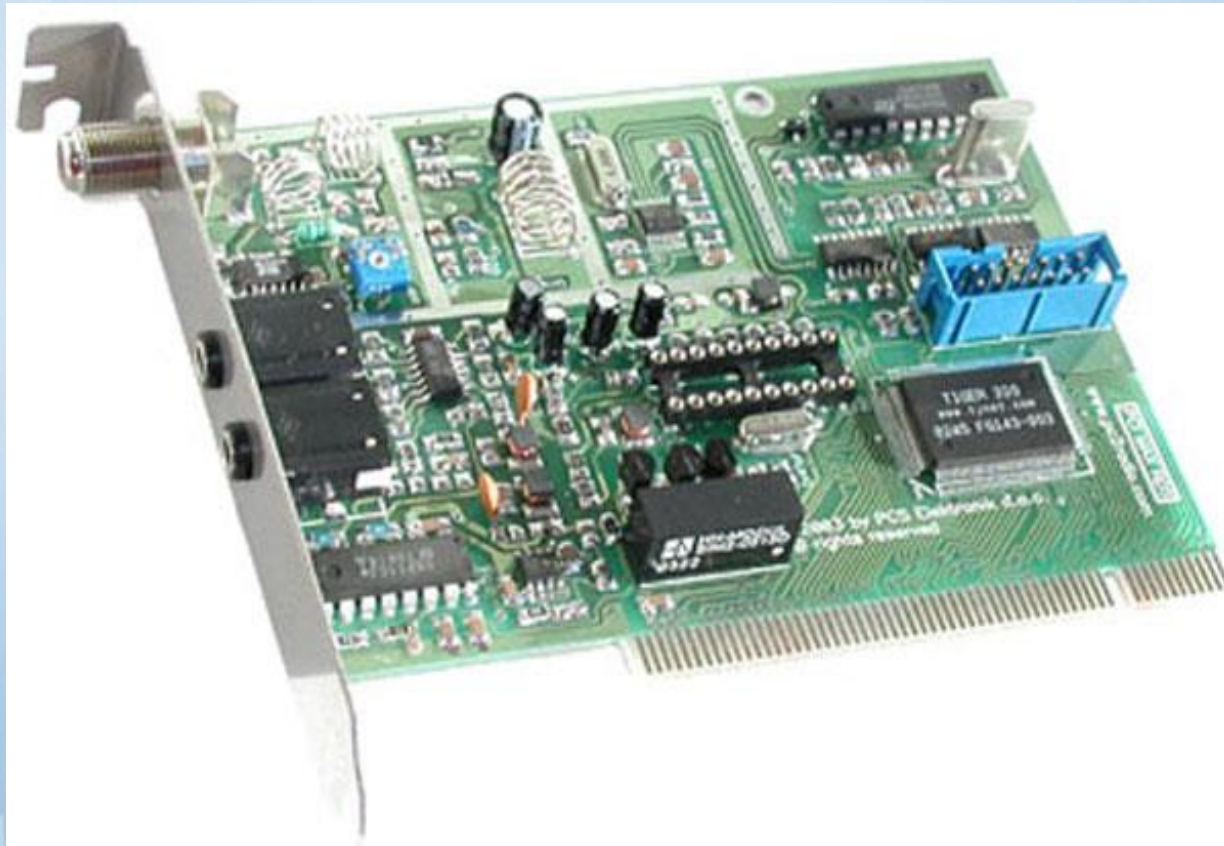


Whole House FM Transmitter

Transmission Output	We guarantee a radius of 150 feet
Frequency Range	88.0 ~ 108.0 in 0.1 MHz steps
Frequency Saving	3 preset buttons
Pre-emphasis	• US and EU Pre-emphasis Options
Power Options	•110/220v AC Wall Adapter •12/24V DC Mobile Power Adapter •Computer USB Adapter •Internal 3 “AA” Battery Compartment
Audio Options	•3.5mm (1/8”) Stereo Jack •RCA Adapter (red/white) •2.5mm Microphone Port (mic not included)
Power Control	Mechanical Power Switch
Frequency Response	20Hz ~ 15KHz
Signal to Noise Ratio	>65dB
Audio Performance	0.2% distortion
Stereo Separation	40dB
RF Harmonica Rejection	Operation Time
Antenna Design	•Reverse-threaded Screw Attachment • 6.5” Swivel SMA Style Antenna •Interchangeable Wire Extension



PCI-Max FM Transmitter



PCI-Max FM Transmitter

- **NOTE:** The PCI-Max does not meet the standards set forth in the [FCC Part 15 Regulations](#), and as such may be illegal to use in certain countries. Please check with your local authorities to confirm whether or not this unit is legal to use in your area.
- Power Output: 0 - 300mW (0.3 watts)
- Power Requirements: None, it runs off your PC power
- Stereo sound, digital stereo encoder completely built-in
- Stereo Specs: Better than 50dB. S/N > -60dB
- It uses a PCI slot in your computer and works with MS Windows
- Frequency Range: 88 - 108 MHz in 50kHz steps
- Freq. Stability: Excellent, it's PLL controlled (+/- 1kHz)



FM10C FM Transmitter



FM10C FM Transmitter

- The Ramsey FM10C is tunable anywhere in standard FM band... 88 to 108 MHz
- It operates on 5 to 15 VDC
- It has settable pre-emphasis of 50 or 75 uSec for use anywhere in the world
- It is an easy to build, low cost transmitter, and includes a matching case set!
- It tunes through the entire 88-108MHz band in three separate ranges with a tuned LC circuit.



FM25B FM Transmitter



FM25B FM Transmitter

- Need professional quality features but can't justify the cost of a commercial FM exciter? The FM25B is the answer! A cut above the rest, the FM25B features a PIC microprocessor for easy frequency programming without the need for look-up tables or complicated formulas! The transmit frequency is easily set using DIP switches, no need for tuning coils or "tweaking" to work with today's digital receivers. Frequency drift is a thing of the past with PLL control making your signal rock solid all the time - just like commercial stations. The FM25B's real claim to fame however is the use of the latest cutting edge stereo generator on the market.



FM25B FM Transmitter

- It has synthesized frequency selection from 88 to 108 MHz for no frequency drift!
- Professional quality for exercise clubs, drive-ins, etc.
- It has adjustable RF output power
- It is microprocessor controlled
- It is the ideal campus or school radio station
- It has no annoying hum – and even better stereo separation than the original!
- It features Line In and Loop Out 1/8" Stereo jacks!
- It features a F style antenna output jack



FM30 FM Transmitter



FM30 FM Transmitter

- FM30:
- PLL synthesized for drift free operation
- Front panel digital control and display of all settings and parameters
- Professional metal case for noise-free operation
- EMI filtering on audio and power inputs
- Super audio quality, rivals commercial broadcasts
- Available in kit or factory assembled versions



FM30 FM Transmitter

- **Frequency Range:** 87.9-108.1 MHz
- **Power Output:** 0-25mW, BNC (FM30) <- **LEGAL**
0-1.0W, BNC (FM35WT) <- **WAY ILLEGAL!!**
- **Audio Inputs:** Line level left and right
- **Controls:** Power on/off
- **Digital Controls:** Frequency, 256 step audio level, 256 step RF output level, 256 step audio balance, mono/stereo
- **Setup Digital Display:** Setup frequency, setup audio levels, setup audio balance, setup RF output level, setup mono/stereo, save settings
- **Normal Digital Display:** Frequency, RF power output, quality of signal
- **VCO Lock Display:** Front panel LED



Generic Chinese FM Transmitter



A Generic Chinese FM Transmitter

- **About this item**
- ✨ 【FCC ID】 This fm transmitter complies with US FCC part 15 certification (FCC ID: 2ASVO05B7CT200)
- ✨ 【Long range coverage】 AZWang fm broadcast transmitter pushes a clear signal easily up to a half mile which is much bigger than church campus. Best solution for a Drive-In Church. In the absence of obstruction, FM signals can even be transmitted up to 2 miles (such as used at sea).
- ✨ 【High quality transmission】 This fm mini stereo broadcasting equipment will transmit clean and strong with no annoying static or drifting. If you want to go the distance and get the most you will be better off with a well thought out broadcast location(preferably high on the roof or on a hill)
- ✨ 【Small but more powerful than expected】 The build of the transmitters is small but sturdy. You can conveniently create a FM broadcast station system via mobile phone, Laptop, PC, MP3/MP4, TV, external microphone and so on. You will be pleasantly surprised to find that it was surprisingly powerful to reach a city block with a clear line of sight and about half that distance when going through concrete walls.
- ✨ 【Wildly application】 This 0.1/0.5W FM transmitter is very suitable for broadcasting music, audio or voice to any FM receiver within a certain distance through the FM frequency band. This low power transmitter can also be used in outdoor car theaters, churches, parks, schools, factories, hotels, christmas lights show, home, parking lot.



EDM FM Transmitter



EDM FM Transmitter

Frequency Range	(87.7 - 107.9) MHz	0.1 MHz increments
Frequency Stability	< 0.0005%	Of set frequency
Frequency Accuracy	< 0.001%	Of set frequency
RF Output (Low range)	(1 - 10) mW	Adjustable
RF Output (High range)	(2 - 100) mW	Adjustable
Reduced RF Output	< -40dBc	While tuning
VSWR	Withstand 20:1	No damage
Phase Noise: (dBc/Hz)		VCO specs
60 Hz offset	-52 dBc/Hz	
1 kHz offset	-85 dBc/Hz	Phase Noise (1)
10 kHz offset	-115 dBc/Hz	Phase Noise (2)
20 kHz offset	-125 dBc/Hz	EDM vs CZH05B
100 kHz offset	-136 dBc/Hz	LCD vs FM30 noise
Residual FM:		CZH05B (13 Hz)
(300 - 3 kHz) BW	≤ 1 Hz	EDM VCO vs HP gen
Incidental AM	< 0.1%	
RF Harmonics:		RF LPF profile
LCD/ RDS model	- 60 dBc or better	vs FM30B
CS model	- 50 dBc or better	
SNR (Signal-Noise-Ratio):		
LCD/ RDS model	≥75 dB (1) (2)	FM30B (1) (2)
CS model	60 dB	
Audio Distortion(% THD)	Spectral	CZH05B (2%)
LCD/ RDS model	≤0.1 %	vs FM30B
CS model	0.3% or better	
Stereo Separation	30-45 dB	
Audio Response	20 Hz - 15 kHz	LCD filter profile

FM100B FM Transmitter



FM100B FM Transmitter

- Built-in mixer - 2 line inputs and one microphone input, line level monitor output
- Precision active low-pass "brick wall" audio filter
- Clean, filtered RF output suitable for RF amplification
- Frequency range 88.0 to 108.0 MHz, 100 KHz steps

FM100B FM Transmitter

- The included frequency display and audio level meters assist in easy operation. The "B" version now includes some additional functionality including a line level monitor output, improved stereo separation, spectral purity, audio clarity, and adjustable RF Output.
- Sound quality is impressive, and equal to or better than most commercial stations. Low pass input filtering plus peak limiters put maximum "punch" in your audio, and prevent overmodulation distortion.



Antennas – the Simple Dipole

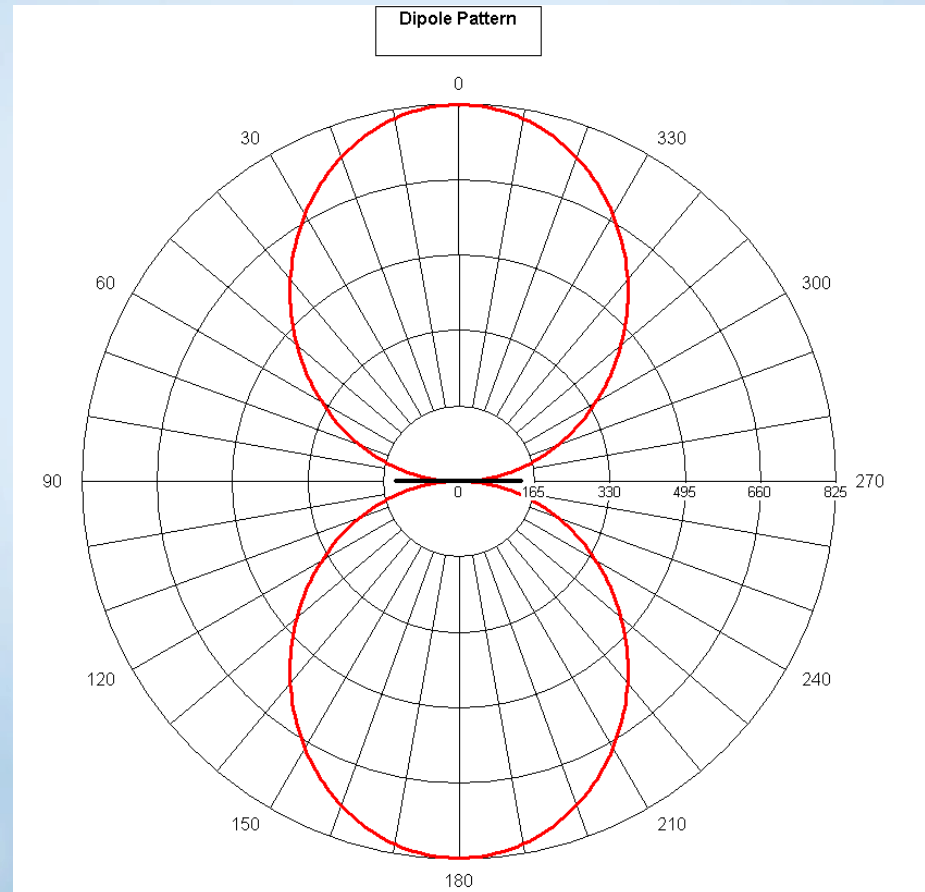


Dipole Antenna Lengths

- A dipole is one of the simplest antennas, as it can be made out of wire.
- You can use it to listen to most any frequency
- Frequencies world wide can be found in the [ABE Engineers Handbook \(455 kB\)](#).
- For the FM band (88.1-107.9 Mhz) a general overall length of a wire dipole would be 57" (28.5 inches on each half)
- You can calculate the specific lengths needed for a wire antenna, based on the frequency you are using: length in feet = $468/\text{frequency}$
- For middle of the FM band (which is 99.1Mhz) it would be $468/99.1 = 4.722$ feet, which is 56.7 inches which is where the 57 inches above came from



Dipole Antenna Patterns



Commercial Vertical FM Antenna

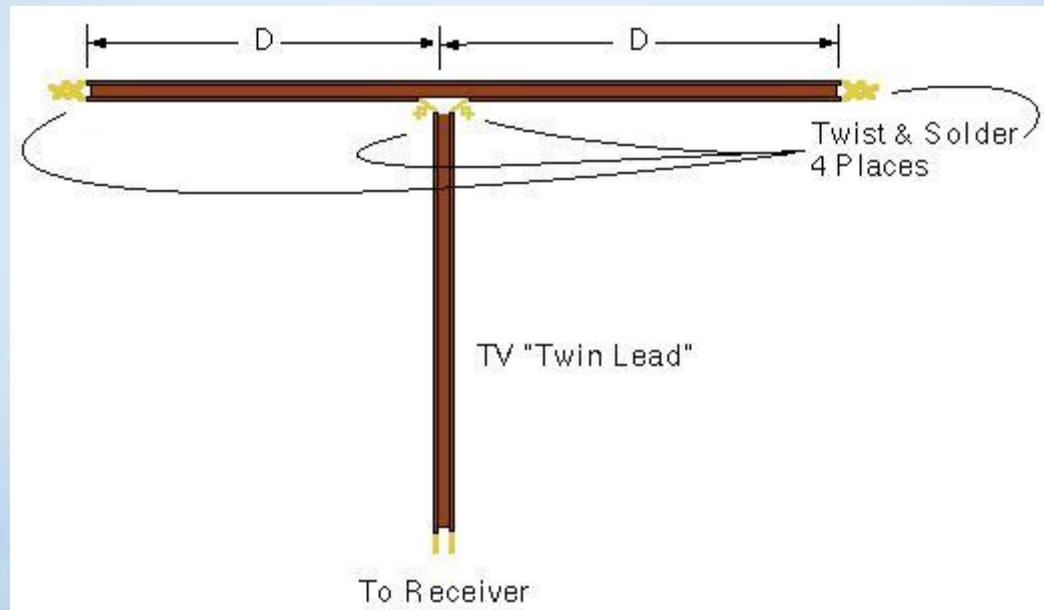


Commercial Vertical Antenna

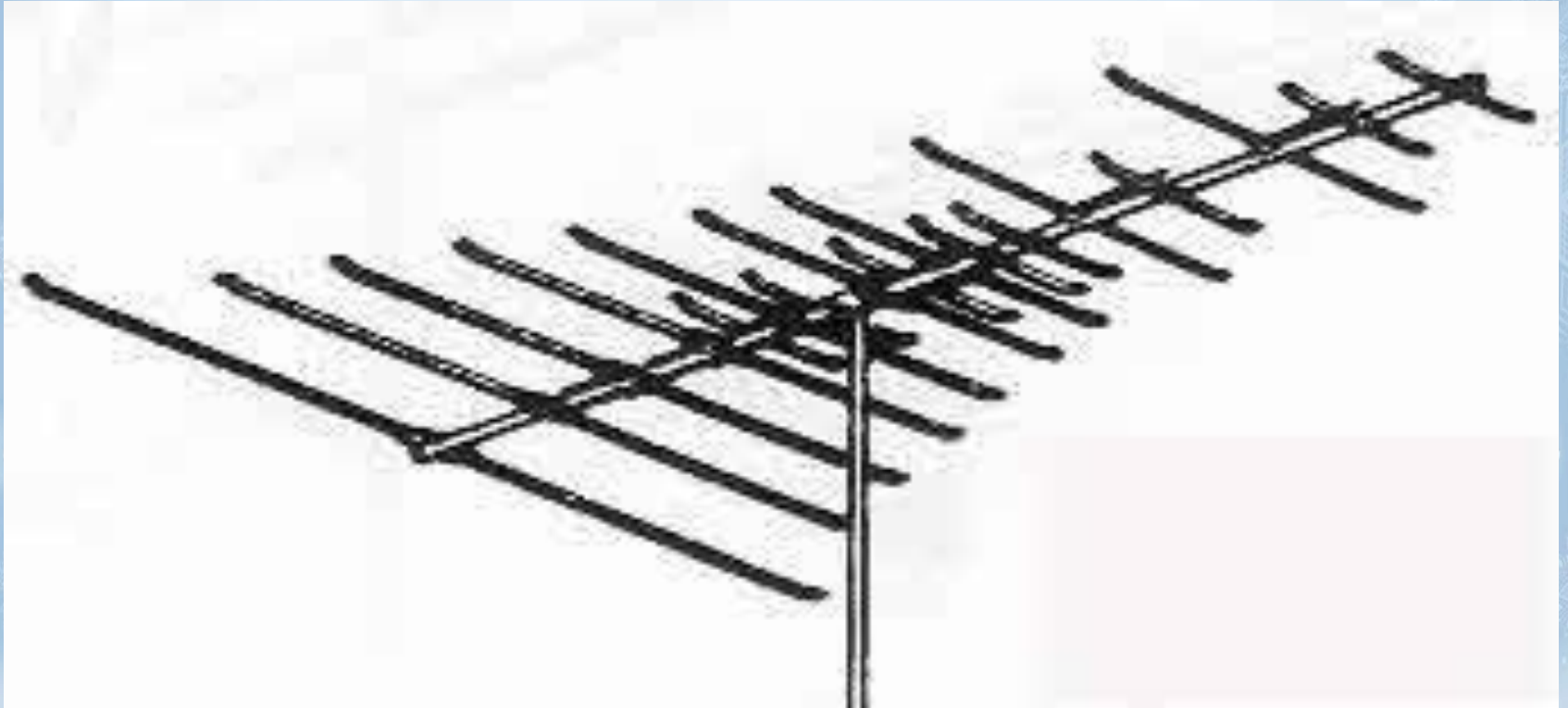
- Frequency: 88-110 MHz
- Gain: 3.4 dBi (this significantly increase the output of any of these transmitters to beyond the allowable limit).
- Maximum power: 200 Watts
- VSWR: Less than 1.5:1
- Length: 7' 7"
- Weight: 2.4 Lbs.



Folded Dipole Antennas



FM/VHF Yagi Antennas



Discone Antennas



Coaxial Cable



Coaxial Cable

- Types:
 - RG8/213 .405 inches - 50 ohms
 - RG8X .242 inches - 52 ohms
 - RG58 .195 inches - 53.5 ohms
 - RG6 .266 inches - 75 ohms
 - RG59 .242 inches - 73 ohms

Coaxial Cable Connectors



Audio Cables



Getting Started

- While folks may feel ready to go having acquired a transmitter, good quality audio cables, and perhaps even an external antenna with its connecting coaxial cable, their **first step** should have been to find an available frequency
- Many recommend going to the FCC website to lookup FM frequencies in use in your area. I don't.
- I recommend rather that you listen during the day and again at night to frequencies that appear to be unused
- Drive around a bit during the day and again at night to check
- There often are non commercial stations in operation that are not listed on the website
- Unfortunately finding an available frequency in large cities can in some cases be next to impossible, which is why in larger cities it would be better to check before purchasing anything...



Quality FM Broadcasting

- To sound good, you need to start with clean audio from your computer:
- Most people “crank up the volume” which adds distortion as it overdrives the transmitters audio inputs
- This makes up 90 plus per cent of the issues folks have
- The radios all have adjustable input levels, some (USB connected ones) use software, but the vast majority use hardware (trim pots) that adjust the levels
- Bottom line, ***your received signal's audio should NEVER sound as loud as commercial stations*** as they use audio compressors. If it does you are likely distorting your signal on audio peaks and can cause interference with neighbors.



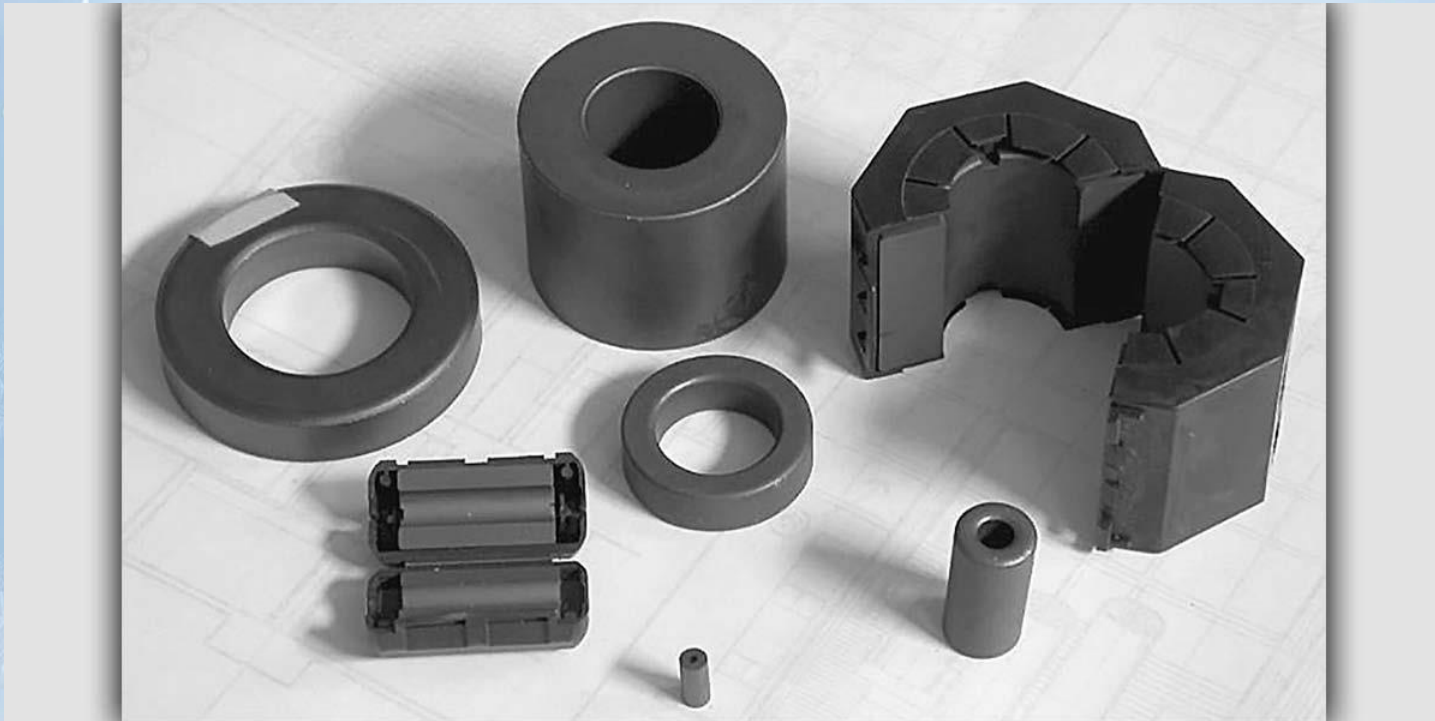
Quality FM Broadcasting

- If you hear hum on your signal, it is either a poorly filtered power supply (wall-wort in almost all cases), or you have interference coming in on your audio or power leads.
- In some cases moving the transmitter farther from the computer will solve it. In other case the use of ferrite chokes will help eliminate/limit hum that is due to ground loops between the equipment.
- Better quality transmitters use metal cases which help shield them from getting stray rf into the transmitter and if its case and the computer's case is grounded to an earth ground that can help eliminate ground loops



Quality FM Broadcasting

- Here are some examples of ferrite chokes that can help eliminate ground loops and the hum they cause:



Quality FM Broadcasting

- If you hear crackling or static when you tune to your station on a FM radio it usually indicates a weak signal
- The first thing to check is whether or not your whip antenna is securely connected to the antenna jack on the transmitter
- If you are using an external antenna, the next thing to check is the cable leading to your antenna (usually a coaxial cable)
- Check the connectors on both ends of that cable!
- If the connectors are good, check to be sure there is not a break in the antenna's connection to the cable
- If that checks out relocating your antenna is the next step
- If relocation doesn't improve your signal it usually indicates an issue with the transmitter's power output, which can also happen if your audio level is too high!



FM Broadcasting - Summary

- We began with a review of the FCC laws applicable to FM broadcasting
- Discussion focused on unlicensed (Part 15) FM broadcasting useful for our displays
- Currently available FM equipment, both assembled and in semi-kit form, was reviewed
- We discussed the types of antennas available to get your FM station “on-the-air”
- We concluded with tips on getting quality sounding signals from your equipment



Any Questions?

