A Mobile Radio System with a Professional Look

Installing a radio system in a vehicle is challenging, especially if you prefer a "no-holes" professional look.

Mobile radio has always interested me but I have never been able to figure out how to install a system that combines good performance *and* appearance. This line of thinking has discouraged me for quite a while, but after reading "K5LXP's No Holes HF Installation"[1], reviews of the Icom IC-706MKIIG[2], and Yaesu FT-857[3], the mobile fever hit again and I decided to take another look.

Requirements

Up until now my mobile rig consisted of a handy-talkie feeding a homebrew J-pole antenna mounted to a 2 x 4 in the bed of my pickup. I could hit most of the area repeaters but discovered that I missed the excitement of HF, so I came up with the following wish list:

1. Remote head must mount in the open pocket below Radio/CD with no holes in the dash or console
2. Transceiver must mount in the compartment under the rear passenger seat
3. No external speakers
4. No external meters
5. Screwdriver antenna must cover 6m - 40m and mount with no holes
6. Radio and antenna must be easily removable or hidden from view to deter theft

The size and mounting schemes of the IC-706 and FT-857 convinced me that they would satisfy requirements one, two, and six provided I could come up with suitable brackets. However, getting by without an SWR meter and external speaker posed some serious problems. Most screwdriver antennas are manually tuned with a toggle switch while watching the SWR meter. And, mounting the transceiver in the rear compartment meant the rig's speaker would be in a place where I would not hear it.

Solutions

While riding with NG4T to a local hamfest, I began a detailed checkout of his mobile system. I was impressed with the setup but the attention grabber was his sound system. His rig's audio output was fed to a cassette deck with an adapter. The resulting audio coming out of the car stereo system sounded great, so I felt that I was on the right track for solving the third requirement. When we arrived, I began a close examination of the assorted mobile antennas and mounts in the parking lot. Of the small screwdrivers that caught my eye, one in particular looked promising and was the subject of discussion with a local dealer. The Yaesu ATAS-120 is designed to work with the FT-857 by automatically tuning the antenna through the coax without an external switch or SWR meter since these features are built into the rig. Opinions of this antenna (and its predecessor, the ATAS-100) at the hamfest were mixed but I felt that this could be a solution for the fourth and fifth requirements.

Since my truck has an aftermarket Radio/CD the cassette interface wouldn't work. Searching the Internet yielded a solution: FM modulator. These units connect to the vehicle's FM radio antenna jack and modulate external audio inputs to the FM radio band. The JVC model KS-IF200[4] appeared capable of doing the job at minimal cost with the ability to choose from eight preset FM frequencies, stereo or mono audio input, and automatic source switching. I decided to start proving my installation theory at this point by purchasing the least expensive item first.

Decisions

While waiting for the FM modulator to arrive, I began to look at mounting a remote head in the desired location. Detailed dimensions of these heads and brackets were nonexistent, so I made scaled pictures from published ads and dimensions. I then printed and cut out the images to see if they would fit.

The IC-706 faceplate cutout fit but its height would prevent it from clearing the hinged Radio/CD door above. The FT-857 faceplate was actually smaller than the Radio/CD and would easily fit. By removing the plastic pocket (mounted below the Radio/CD) I was able to see how much space I had and how to mount the FT-857 faceplate to the existing Radio/CD bracket. A trip to Home Depot yielded a couple of Stanley brackets and some 2" x 36" x 1/8" aluminum stock. I cut the aluminum to a length of 6-1/2"and used #6 thread-cutting screws to fasten it to the brackets. Things were beginning to take shape and the only thing I needed was the FT-857 remote head bracket and faceplate depth dimension to complete this part of the installation.

At this point I started reading everything I could get my hands on concerning mobile radio installation. There are several informative articles in the ARRL Lab Notes[5] as well as General Motors[6] and Ford[7] installation tips and should be followed as closely as possible to minimize interference. I researched prices and noted that Yaesu was featuring a special that included a considerable rebate and free DSP unit. This clinched the decision and I ordered the FT-857, remote mounting kit, and ATAS-120.

Radio Installation

I placed the FT-857 remote head bracket on my homebrew bracket and began the process of fit up. When I was satisfied, I drilled screw holes and spray painted the assembly flat black to reduce it's visibility. Next, I mounted the FT-857 bracket on the aluminum plate and then mounted this assembly on the Radio/CD bracket. Realizing I would need to splice the rig's power wiring, I bought some #12AWG wire and grommets. The FM modulator was so small and light that I fastened it to the bottom of the Radio/CD using double-sided foam tape.

Wiring Installation

I knew the location of the electronic control module (ECM) and planned to route all wiring away from it to reduce the possibility of interference. I removed the driver side floorboard trim and looked for a convenient grommet in the firewall. The only penetration I could find in proximity was full of wiring and I could not force the two #12AWG wires through without cutting the grommet. So, I decided to drill a small hole

in the firewall and use one of the new grommets. Keeping the wires near the chassis, I routed them from the battery area toward the firewall and cut the harness several inches away from the new grommet. I then stripped the insulation back and twisted and soldered the new #12AWG wires, adding electrical tape and heat shrink tubing for insulation. These harness extension wires were then routed to the rear seat compartment where I reattached the other end of the harness in the same manner. While the path was open, I installed the remote head, speaker, and microphone cables from the compartment back up to the remote head in the dash. To keep from breaking the delicate clips on the RJ-45 plugs, I first fished a stiff wire through any tight openings. I then looped the cables around this stiff wire, temporarily fastening them with electrical tape, and gently pulled them through one at a time. Once finished, I closed up the floorboard trim, made all connections in the dash, and reinstalled the Radio/CD and FT-857 remote head in the dash. I soldered ring terminals to the fused end of the harness wires and attached them to the battery.

Antenna Installation

This is definitely the hardest part of the installation, as the decisions made here will affect how well the antenna radiates. A trade-off is usually made between the optimum antenna location and what is practical. I had been thinking about the antenna mount for several weeks now and had looked at all of the commercially available units. None of them appeared suitable for clamping anywhere in or on the truck bed and the rear bumper meant a very low mounting height. Turning again to the truck bed, I discovered the tie-downs screwed into each inside corner. I grabbed a screwdriver and removed one, noticing that the screws were fairly large and threaded into the bed frame. After some experimentation, I cut one 7-1/4” and two 3-7/16” pieces of 1” square x 1/8” wall aluminum tubing. To get the required spacing, I also cut three 3-7/16” long pieces of 1” x 1/8” aluminum. I transferred the 65-mm truck bolt spacing to all six pieces and drilled clearance holes for the 8-mm mounting bolts. I then used a ¾” hole punch on one side of the 7-1/4” piece to provide clearance for a socket wrench. The other end of the square aluminum tubing was drilled to accept a Lakeview 276 bracket and attached with stainless steel screws and nuts. I removed the Lakeview connector, enlarged the hole to 5/8”, and installed a SO-239 double-female bulkhead connector. To provide more stability, I added a 1-1/2”OD x 7/8”ID x 5/32” thick washer around the SO-239 nut to increase the contact area at the antenna base. The final assembly is bolted to the bed frame with 8-mm x 3” long bolts and is sturdy, rustproof, requires no bending or welding, and places the entire antenna whip above the cab. The bed mounted J-pole was often in the way so I added a Comet CF-706A duplexer to the FT-857 to allow the ATAS-120 to be used for 2m/70cm.

Test and Checkout

After putting the system through a complete checkout I came up with one problem. I had previously set the JVC FM modulator to automatically detect audio and turn on. This worked fine for SSB, but in FM mode the squelch would turn the FM modulator off after 10 seconds of inactivity. I realized I would have to use the FM modulator “remote mode” to turn the modulator on whenever the FT-857 was on. This meant fishing another wire from the FM modulator to the +13.8VDC pin on the FT-857 CAT connector. With a sigh

of relief I discovered that a Radio Shack 6-pin mini-DIN plug would fit into the 8-pin CAT socket if you cut the plastic tab off of the plug. I soldered the new wire into the plug and reset the FM modulator for remote power detection.

The FT-857 is an amazing little package. The menus are similar to the FT-817 and are easy to learn. The noise blanker and DSP filters work well and provide the user with the ability to remove most receiver noise. On full power 2-meter FM, a squeal would result when keying the Mic. I remedied this with ample use of snap-together RFI chokes installed on all cables near the transceiver. On the HF bands there was some radiated RFI impulse noise that took some time to reduce. I attempted to add grounded copper braid over the spark plug wires[8, 10] but the braid (which was stripped from RG-8) was too small to fit over the plug boots. When I tried to remove the boots I discovered the manufacturer had glued or molded them onto the wires. I eventually shielded the three coils and plug wires with 3M 1181 copper tape (which has a conductive adhesive) and grounded them to the engine block. This reduced the RFI by four to five S units. I also added grounded the engine block, hood, muffler, and antenna mount to the frame. Now that the RFI has been reduced I can hear other sources of noise (i.e. windshield wipers and heater fan) that I will deal with as time permits.

Tuning the ATAS-120 is a joy. Just press the rig's TUNE button and the antenna automatically moves to the lowest SWR without taking your eyes off of the road. It has gotten confused a few times on which way to go but it resets in a minute and then travels to the correct length. The stock whip is 0.078" OD and is very flexible but bends a bit too much in the wind during interstate driving so I enlarged the hole and replaced it with a whip from an Iron Horse antenna. In order to see how well it tunes, I compiled a chart (Figure 1) showing the automatic and manually tuned SWR at the beginning, middle, and end of each HF band. In another test, I used PolarPlot[9] to plot the signal strength around the truck to check the antenna radiation pattern (Figure 2). This program was designed to collect data from a rotor-mounted antenna, but I was curious to see if the reverse would work (i.e. data collected by circling a fixed antenna). I mounted a laptop, FT-817, soundcard interface, 12V battery, and a 15m Iron Horse antenna on a hand truck. The hand truck was configured as a cart with all four wheels on the ground and the equipment strapped on. The largest unused open area I could find was a parking lot that allowed a circle diameter of 125 feet, so I scribed a chalk line to this dimension. With the FT-817 AGC off and the RF gain adjusted to get a usable signal, the audio output was patched through the interface into the laptop's microphone input. I parked the truck mounted ATAS-120 over the circle's center and set the FT-857 to transmit at it's lowest power of five watts at 21.1 MHz. This proved to be much too strong of a signal at this distance so I substituted an MFJ-259B antenna analyzer as the signal source. The analyzer will output 20 mW into 50 ohms and the resulting signal was more manageable. Tuning the ATAS-120 to 21.1 MHz with the FT-857 and then swapping the antenna coax to the analyzer, I pushed the hand truck around the chalk line until the number of PolarPlot samples was just under 360 for a complete revolution around the truck. I made several runs and compared the results to be sure I was getting an accurate picture. Granted, this test was for one frequency, one elevation (0° take-off angle), and a very short distance from transmitter to receiver, so the results are open to discussion. Nonetheless, the plot does

reveal that there are some nulls toward the rear and through the cab, which is probable given the antenna's mounting location.

Since I like to work the digital modes I decided to add a soundcard interface for my laptop (while not driving, of course). Based on the Model II by KK7UQ[11], my version provides audio isolation only. Instead of using a dedicated serial port to key the PTT function, I use software CAT commands to achieve the same thing. (For example, in the MixW PTT/CAT Menu click the box labeled "PTT via CAT Command"). The circuit is built on perfboard and fits neatly inside a Radio Shack box with jacks for audio and the DATA connector on the rig. Having controls to adjust the waterfall and transmit drive signals makes it easy to set the audio levels for proper operation.

Conclusion

All of my goals were met with the exception of having to drill one hole in the firewall. From a safety standpoint, the equipment is securely attached to prevent flying objects in the event of an accident, and all wiring is installed to minimize hazards and interference. Aesthetically, the dash-mounted remote head looks it came from the factory, the transceiver is hidden from view, and there are no meters or speakers hanging from the dash or console. Ergonomically, the controls are within inches of the gear shift, and, coupled with automatic antenna tuning, make it easy to operate while keeping both eyes on the road. The rig and antenna can be removed and ready for home or portable use in several minutes. The FT-857 and ATAS-120 provide continuous coverage on all bands from 6m - 40m and 2m/70cm. On-the-air results are still being compiled, but so far I am very happy with the performance, operation, and appearance of the system.

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Notes

[1] *K5LXP's "No Holes" HF Installation*, Mark Brueggemann, http://www.qsl.net/k5lxp/mobile/HFMobile/HFMobile.html

[2] *Icom IC-706MKIIG HF/VHF/UHF Transceiver*, QST July 1999, http://www.arrl.org/members-only/prodrev/pdf/pr9907.pdf

[3] *Yaesu FT-857 MF/HF/VHF/UHF Transceiver*, QST August 2003, http://www.arrl.org/members-only/prodrev/pdf/pr0308.pdf

[4] JVC KS-IF200 FM Modulator, http://www.jvcservice.com/store/ProductDetail.asp?part=KS-IF200

[5] *Mobile Installations and Electromagnetic Compatibility*, Lab Notes, Ed Hare, KA1CV, QST March 1995, http://www.arrl.org/tis/info/pdf/39574.pdf

[6] *Radio Telephone / Mobile Radio Installation Guidelines*, GMNA Engineering Centers, General Motors Corporation, http://service.gm.com/techlineinfo/radio.html

[7] *Mobile Radio Installation Guidelines*, Ford Motor Company, http://www.fordemc.com/docs/download/Mobile_Radio_Guide.pdf

[8] *Automotive RFI Elimination*, Stuart G. Downs, WA6PDP, QEX Jan/Feb 2000, http://www.arrl.org/tis/info/pdf/001qex32.pdf

[9] *PolarPlot*, Bob Freeth, *G4HFQ*, http://www.g4hfq.co.uk/index.html

[10] *Noise Suppression Techniques*, Brian Johnson, K2BJ, http://www.k2bj.com/Pages/Noise/Intro.htm

[11] KK7UQ Model II, Clinton Hurd, http://www.waypoint.com/users/~discobay/amateur_radio.htm

Band	Frequency (MHz)	SWR Auto Tune	SWR Manual Tune
40m	7.000	1.3:1	1.3:1
	7.150	1.5:1	1.4:1
	7.300	1.5:1	1.4:1
30m	10.000	1.1:1	1.1:1
	10.125	1.1:1	1.1:1
	10.150	1.3:1	1.1:1
20m	14.000	1.1:1	1.0:1
	14.175	1.1:1	1.0:1
	14.350	1.1:1	1.0:1
17m	18.068	1.5:1	1.2:1
	18.118	1.2:1	1.2:1
	18.168	1.3:1	1.2:1
15m	21.000	1.4:1	1.4:1
	21.225	1.5:1	1.4:1
	21.450	1.4:1	1.4:1
12m	24.890	1.6:1	1.5:1
	24.940	1.6:1	1.5:1
	24.990	1.6:1	1.5:1
10m	28.000	1.5:1	1.5:1
	29.000	1.4:1	1.4:1
	29.700	1.4:1	1.4:1
6m	50.000	1.2:1	1.1:1
	52.000	1.3:1	1.1:1
	54.000	1.3:1	1.1:1

Figure 1

The above measurements were made with a Vectronics Directional RF Wattmeter (Model VEC-730, 1.6 - 60 MHz) temporarily inserted between the FT-857 and ATAS-120.

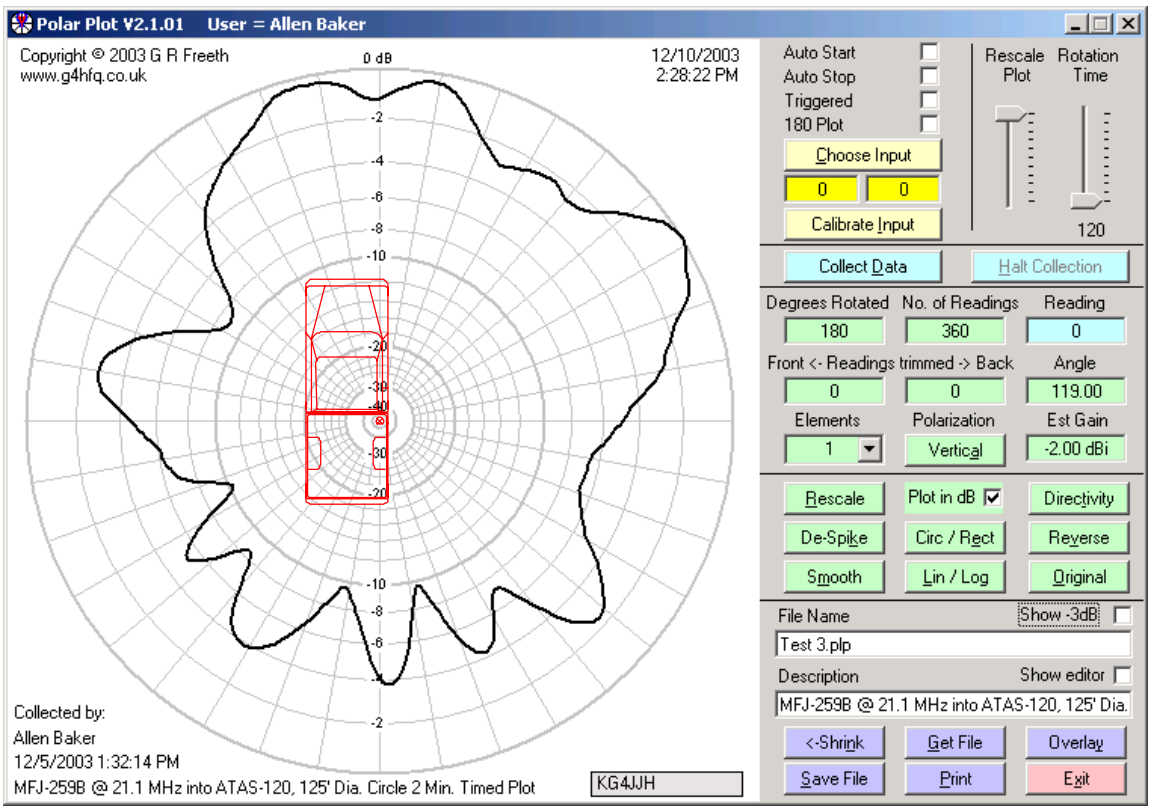

Figure 2

The above plot was generated by transmitting 20mW at 21.1 MHz from an MFJ-259B into an ATAS-120 antenna and measuring relative field strength along a 125 foot diameter. A plan view of the truck (shown in red) has been added with the antenna centered in the plot. The receiving equipment consisted of a Yaesu FT-817 fed by an Iron Horse 15m antenna. The height of both antennas was 9 feet. The data was collected and displayed using a Compaq laptop running PolarPlot (G4HFQ). Figure 3 is an elevation of the truck showing the antenna location.

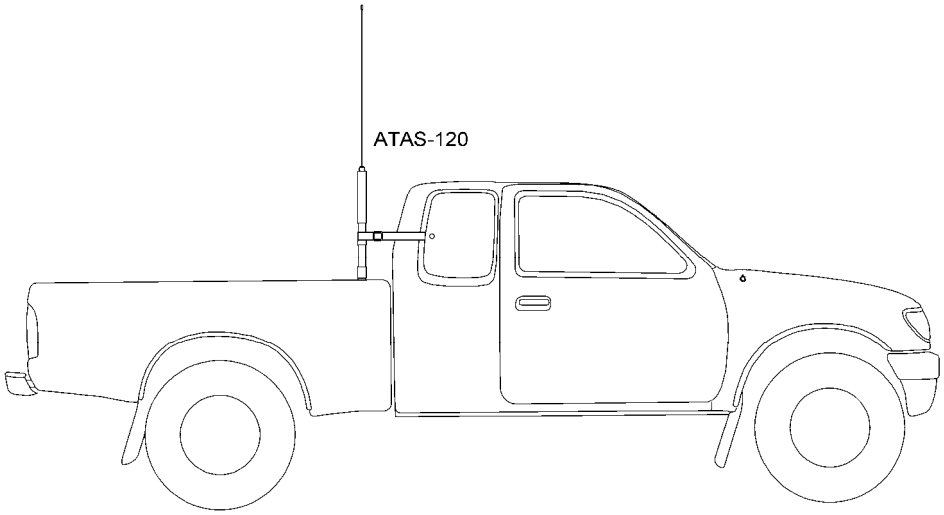

Figure 3