simple, high-frequency mobile antenna matcher

Are you frustrated because you can't move up and down the 40- and 75-meter bands while driving down the freeway? The stumbling block, of course, is the narrow bandwidth of the antenna system on these bands, particularly on 75 meters. The higher the antenna Q, the worse the situation.

Fortunately, the simplest remotely operated antenna matcher/tuner for high-frequency mobile operation also just happens to be highly efficient, very effective, and ridiculously easy to operate. It consists of just *one lonely variable capacitor in the car trunk*, tunable from the driver's seat. In my case, this is accomplished using a *limber* 1/4-inch (6.5 mm) plastic rod.

In a typical two-door sedan it's easy to rotate the capacitor manually from the driver's seat. With this simple arrangement one can move from 7150 to 7300 kHz with a VSWR not exceeding approximately 1.1. On 75 meters, the VSWR is less than 1.2 over most of the 3800-4000 kHz band; it increases rapidly to about 1.5 at the phone-band edges. The exact numbers will vary slightly with antenna mounting, arrangement, car size, and road surface.

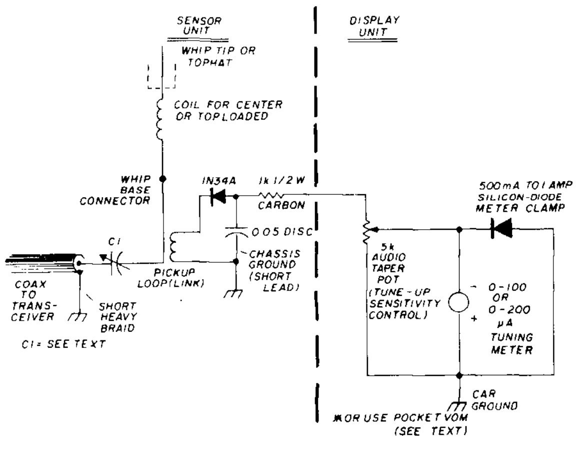

fig. 1. The "Simplest Remote Mobile Antenna Matcher" consists of a sensor and display unit. Mechanical parts consist of a tuning capacitor and a drive shaft, appropriately supported between driver's compartment and antenna.

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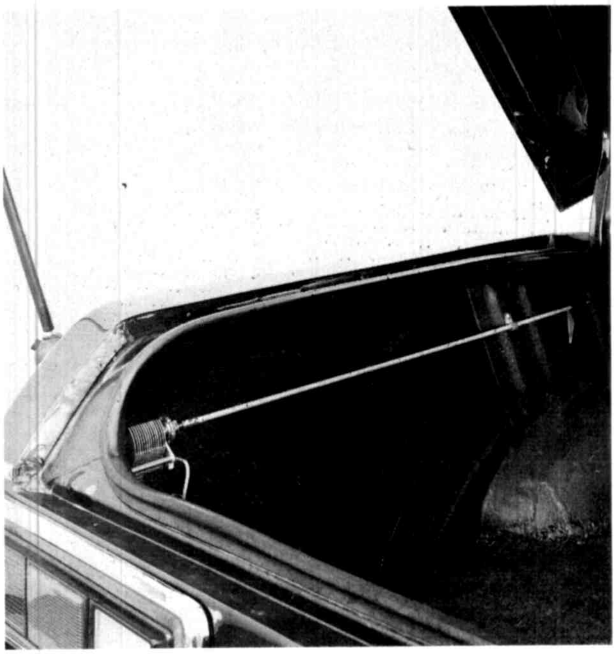
typical application

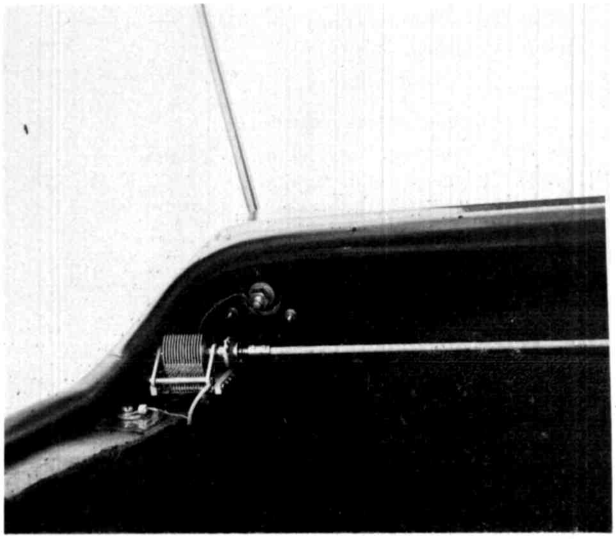
In my two-door sedan, the limber shaft drives a planetary gear arrangement attached to the capacitor frame. Unfortunately, this method doesn't lend itself too well to a four-door sedan configuration, although it can be done if you're willing to go to the trouble of running the shaft through the passenger compartment at floor level — not an easy trick but still feasible on many four-doors. In this case, the driver reaches down instead of left and over to change frequency.

My Mercury Monarch is probably typical of most compact and intermediate two-door sedans of domestic manufacture circa 1970-80. The limber shaft terminates at a small knob located at the forward edge of the left-quarter plastic trim panel (to the rear of the door frame), slightly above the armrest. The shaft runs snugly against the trim panel and is rarely noticed by passengers. Its height is such that it's possible to reach it briefly without interfering with normal driving tasks. The best height seemed to be about flush with the back of the seat (not the headrest).

Once the antenna for a particular band has been trimmed for equal VSWR at the band edges, it's not necessary to touch the antenna again. Just rotate the capacitor for maximum *radiated* power. (I assume the rig is an all-solid-state transceiver with untuned 50-ohm output).



Tuning capacitor and limber shaft mounted in author's car. Planetary drive at capacitor prevents backlash and wind-up "hop" by reducing torque at capacitor.



Another view of the tuning capacitor and coupling assembly installed in the author's car trunk.

circuit

One arrangement I've used successfully is shown in **fig. 1**. A small, imported, illuminated tuning meter of questionable ancestry is mounted on the back side of the sun visor (to be at eye level and close enough for easy reading while driving). Voltage to actuate the meter is derived from a 1N34A diode inductively (link) coupled to the lead between the capacitor and the antenna base connection. (Before I found the tuning meter I used a pocket multimeter placed on the seat. It had the advantage of sensitivity selection for tune up, but had the disadvantage of not being at eye level.)

The word *limber* is appropriate in describing the drive shaft because, unlike a flexible shaft with an outer sheath, the limber shaft is simply a 1/4-inch (6.5-mm) shaft stiff enough to avoid objectionable wind-up yet flexible enough to allow for some misalignment, or change in direction.

The limber shaft is made to behave by supporting it in guides spaced at appropriate points (photo). Loose-fitting cable clamps act as shaft guides. The use of the planetary drive unit eliminates backlash and wind-up hop by reducing the torque that the shaft must deliver. At the same time, it acts as a friction brake to discourage the inherently unbalanced capacitor rotor from being vulnerable to shock and vibration.

The planetary drive I used has a ratio of 6.5 to 1,

table 1. Readings and observations, 40 meters.

initial conditions

"High power" 40-meter Hustler resonator (coil and tip) RM-40-S. (Standard resonator RM-40 gave readings nearly identical.)

obervations

best VSWR with no shunt or series C		1.15
best VSWR with optimized shunt C (≈ 260 pF) and tip lengthened accordingly		1.0
best VSWR with optimized series C (≈ 75 pF) and tip lengthened accordingly		1.0
1.5-VSWR bandwidth; no tuning or adjustments. (1) no C, (2) optimum shunt C, and (3) optimum series C		
all three configurations		≈ 58 kHz
While shunt or series C was required to bring the VSWR below 1.15, the 1.5-VSWR bandwidth with *fixed tuning* is not changed significantly.		
While optimum shunt C can reduce VSWR to approximately 1.0, there's no reactance compensating effect if shunt is optimized as frequency is increased or decreased. Therefore, to make the tunable capacitor effective over as wide a frequency range as possible, it must be in *series*.		
VSWR obtained with resonator tip optimized for 40-meter phone and tuning only with series capacitor	7150 kHz	1.1
	7300 kHz	1.1
VSWR with resonator tip optimized for entire 40-meter band	7000 kHz	1.22
	7300 kHz	1.24

which appears to be about optimum — but anything between 5 to 1 and 10 to 1 should be satisfactory.

A few electronic parts stores carry planetary drives (such as the British-made Jackson Bros.). But if you have trouble locating one, note that they are available as replacement parts for a number of ham transceivers.

My original plan was to rig up a motor-driven mechanism using the actuator from a remotely operated telescoping auto-radio antenna obtained from an auto parts junk yard. However, obtaining and assembling the stuff turned out to be a more formidable task than expected. So I made a lashup using manual drive through the limber shaft. It has been so satisfactory that, nearly three years later, the motor-driven project still is awaiting development.

typical installation

I use two separate and considerably different high-frequency mobile-antenna installations above the same ball mount. The first is a standard Hustler installation and is normally used around town because with it it's easy getting in and out of the garage and driving up to canopied gas pumps (and along residential streets with low telephone lines) without having to worry about the antenna hitting something. The other antenna is much more elaborate and is used only on out-of-town trips.

results

Because the matcher/tuner works equally well with both systems, and because so many Hustler installations are already in use, the VSWR figures (**tables 1** and **2**) are actual readings taken with the standard Hustler installation, and with the car in a vacant parking lot on asphalt paving. Tuner performance isn't significantly different on other paved surfaces or with other top or center-loaded antennas.

To minimize interference and avoid spurious VSWR readings as a result of harmonic output, all readings were made with the smallest amount of drive to my 350-XL final amplifier that would produce usable readings with the VSWR meter set for maximum sensitivity. After all VSWR measurements were completed, the meter made an unofficial visit to a calibration lab, where it was checked for accuracy. Readings below 2.0 on the meter turned out to be sufficiently accurate on the bands of interest that application of a correction factor was not necessary.

table 2. Readings and observations, 75 meters.

initial conditions

Standard 75 meter Hustler resonator RM-75

observations

best VSWR with no shunt or series C, tip length optimized for F		1.4
best VSWR with optimum shunt C (≈ 600 pF) at center of phone band and tip *lengthened* accordingly		1.0
best VSWR with optimum series C (≈ 240 pF) at center of phone band and tip *lengthened* accordingly		1.0
1.5-VSWR bandwidth; no tuning or adjustments.		
no shunt or series C (VSWR 1.4 at resonance)	spot frequency only	
with optimum shunt or series C at center frequency		≈ 19 kHz
To stay below 1.5 VSWR, only spot (fixed) frequency operation is possible without shunt or series C.		
Even with optimum shunt or series C at center frequency, it isn't possible to move F very far when tip length and C are fixed.		
VSWR obtained with resonator tip optimized for 75-meter phone band and tuning only with series capacitor	3800 kHz	1.5
	4000 kHz	1.55
Over most of band	better than	1.2

other bands

No readings are shown for 20, 15, and 10 meters because, on those bands, the VSWR will be reasonably low if the capacitor is simply tuned near maximum capacitance once and the antenna pruned as though the capacitor were not in use. If you want to go to the trouble of making the adjustments, though, the VSWR can be reduced to approximately 1.0 over these three bands by making use of the capacitor, as on 40 and 75 meters.

initial adjustments

The initial adjustment that has to be made only once (for each band on which you'll want to take advantage of the capabilities of the capacitor) is simple. It involves trimming the resonator whip length (in the case of a Hustler) or top hat capacitance to the value that gives equal VSWR readings at the band edges when the capacitor is rotated for minimum VSWR. With the 40-meter Hustler resonator, for example, this will involve lengthening the whip perhaps 3 inches (7.6 cm) from the normal midband setting. Once this is done, a VSWR meter is no longer essential, as long as you stay within the band limits, because proper setting of the capacitor can be made simply by tuning for maximum output, as noted elsewhere.

On 75 meters, my 75-meter Hustler resonator "just barely got there" before running out of resonator tip. So I attached a miniature hose clamp above the coil to the top of the fat part of the top section, with the free end of the clamp (about 1-1/2 inches, or 3.8 cm) providing some additional capacitance. While minor adjustments may have to be made to accommodate the variable capacitor, planetary drive, and the limber shaft to a particular car, the considerations will be generally the same.

The best place for the antenna is as *far back* on the left rear fender as possible; or, if you don't want to drill a hole for the ball mount, place it on the left side of the bumper using a bumper mount.

precautions

It's extremely important that a bumper mount be jumpered as directly as possible to the sheet metal of the car body with two separate, flat braids at least 1/2 inch (12.7 mm) wide, terminating at points about 12 inches (30 cm) apart. Drill pilot holes for sheet-metal screws if there are no suitable points of attachment. This is especially important with the new bumpers, like those on my car.

The ball mount (or bumper mount and braid terminations), the tuning capacitor, and the planetary drive unit must *all* be clustered close together, with minimum bend in the limber shaft drive. Some bending of the shaft can be tolerated, as long as it doesn't make too sharp a bend radius anywhere along its length. In my car, the capacitor is mounted on a horizontal and flat section of the fiberboard trunk liner, where it houses the connections to the left-hand stop, turn, tail, and back-up lights. Capacitor frame must be floated.

some final observations

Tuning for maximum power output with a VSWR box is simple if you're parked. But reaching around to tweak the tuning knob, while mentally subtracting the reflected power reading from the forward power reading, is definitely not recommended as something to be accomplished while in traffic. Tuning for maximum output on a single meter at eye level is much quicker and safer. However, you should first make sure that the MAX INDICATOR peak correlates reasonably well with maximum *radiated* power.

In a mobile installation there often are strange currents flowing in the car metal. "Wattless" displacement currents that unintentionally get coupled into a sampling antenna or pickup loop can upset the accuracy of the reading insofar as correlation with the actual radiation well beyond the induction field. At first I obtained an appreciable discrepancy when tuning for maximum "net" power on the VSWR box then peaking the reading obtained with the 1N34 sampler previously described. I found that very effective rf filtering was required on the wire bringing the rectified dc to the driver's position. Also, correlation was better when the very small pickup loop was placed right against the lead between the tuning capacitor and antenna base, rather than the lead between the coax and the capacitor. A larger link spaced from the lead caused some problems with stray fields.

To make absolutely sure that the maximum "net" reading on the VSWR box correlated with maximum *radiated* power, I took field-strength readings at 75 feet (23 meters) through a target spotting scope. The car was parked in a vacant parking lot, with no wires between the field-strength meter and the car.

Correlation between field-strength peak readings and readings on the tune-for-max indicator was, for practical purposes, 100 percent after changes were made in the sampling loop (link) position; one side of the link was grounded *at the link* and filtering of the 1N34A dc lead was improved.

When you get your "world's simplest mobile antenna tuner" installed and ready to go, first make sure your "output power peaker" (if you use one) correlates reasonably well with the *net* readings of the forward and reverse power readings on a VSWR meter. Then you can forget the entire VSWR hassle and tune for MAX, which is more fun than tuning for a dip.

ham radio