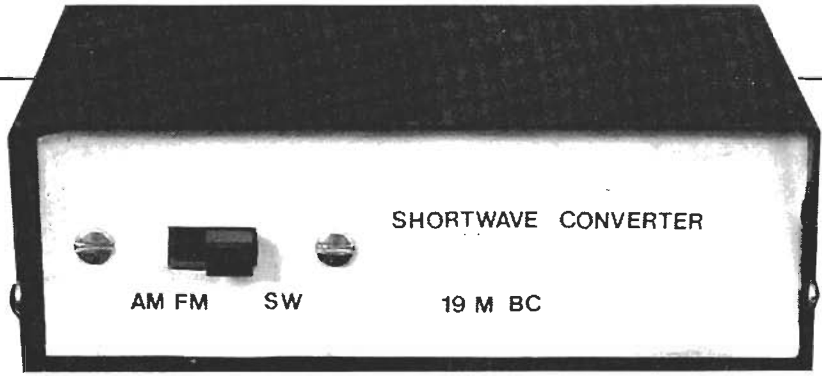
ONE-BAND SHORTWAVE CONVERTER



RUDOLF F. GRAF and WILLIAM SHEETS

With our shortwave converter and your car radio, cruising for burgers won't ever be the same.

BORED WITH AM TALK-RADIO? TIRED OF FM rock-n-roll and obnoxious DJ's? Wish you had another choice, but don't think that one's around? Then look no further—try our converter that turns any ordinary car radio into a shortwave receiver.

Because our converter goes between your antenna and car radio, no vehicle or radio modifications are required. The converter covers any 1-MHz segment between 5–30 MHz depending on the components you select. It draws only 10 mA at 12 volts, so a simple hookup to your car battery is all you'll need. The front end has good sensitivity, and works well with any 31-inch car antenna, although a longer whip works slightly better below 10 MHz.

Circuit description

Figure 1 shows that switch S1, a 3-*P*ole *D*ouble *T*hrow (3PDT), selects whether the antenna signal is routed directly into the converter for shortwave reception, or bypassed around the converter for standard AM/FM reception.

For shortwave reception, place switch S1 in the SW position. The radio signals enter jack J1, to S1-a, where they're inductively coupled to the converter's RF front-end via two turns of insulated wire around L1, which resonates at the input frequency due to C1 and C2. Finally, capacitor C1 is primarily for tuning, while C2 matches the L1-C1-C2 tank to Q1.

Transistor Q1 is a grounded-base amplifier. The signal developed across R1-C2 is fed to the emitter; R1 is a bias resistor for Q1. Components R2 and R3 bias the base of Q1, and C3 is a bypass capacitor that keeps the base at AC ground. The common-base transistor allows easy matching from a tuned circuit over a wide frequency range, and is less likely to suffer from RF instability at the shortwave frequencies that our converter covers. Resistor R4 suppresses parasitic oscillations, preventing Q1 from oscillating spuriously at VHF–UHF frequencies. The C4-L2 tank is tuned to the converter's input frequency, and serves as a load for RF-amplifier Q1. DC power is supplied through R5, and C5 is a supply-bypass capacitor.

The amplified signals are coupled through C6 to the emitter of Q2, a

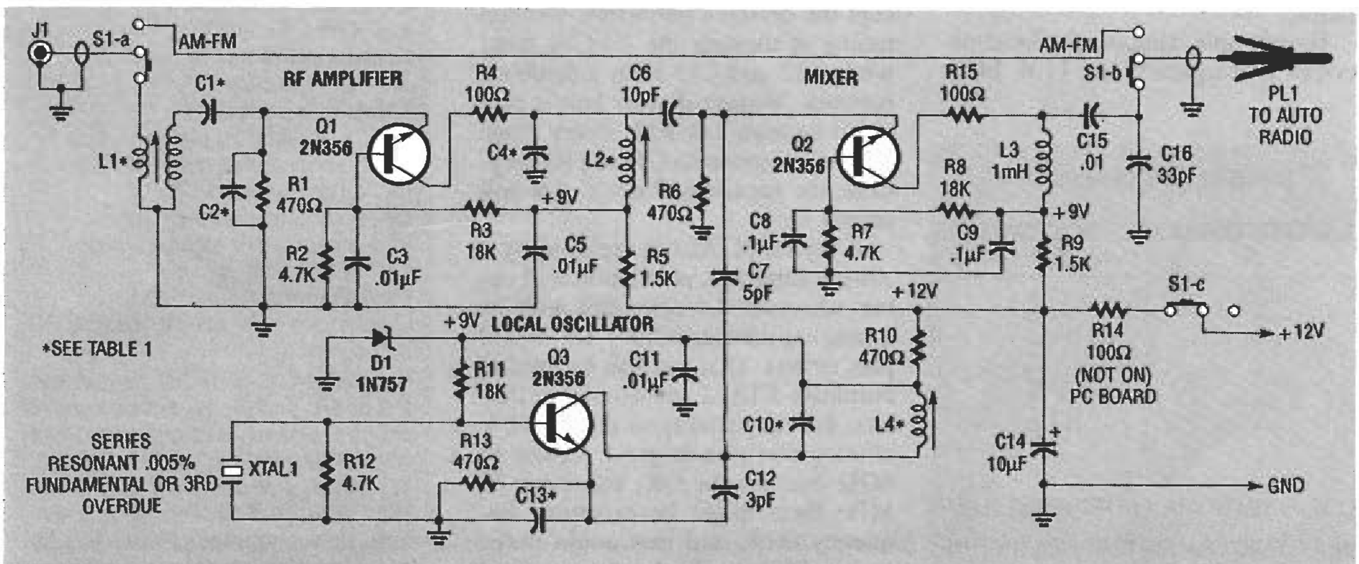


FIG. 1—VHF TRANSISTORS Q1, Q2, AND Q3 work easily up to 50 MHz, where they're "loafing" and still have high gain. Transistor Q1 is the RF amplifier, Q2 is the mixer, and Q3 is the local oscillator.

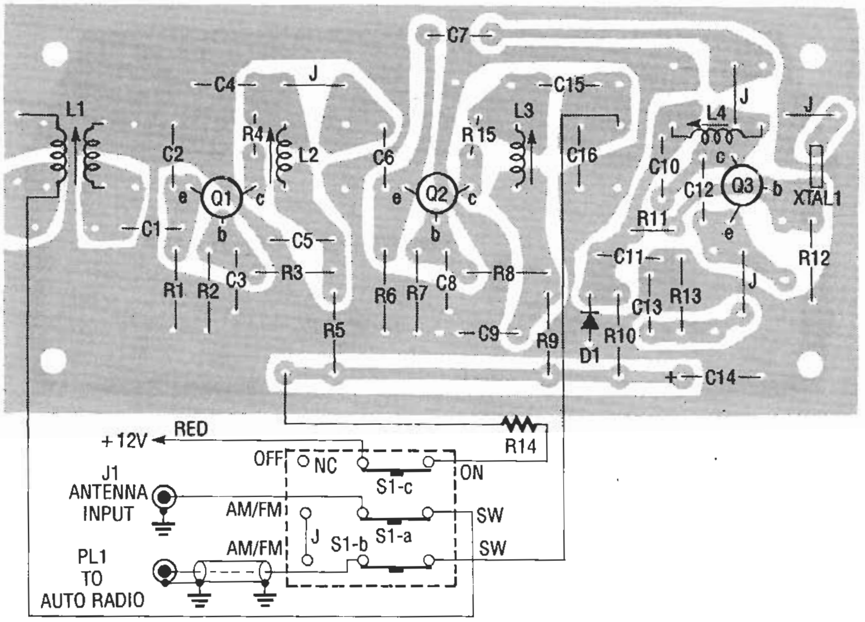


FIG. 2—PARTS PLACEMENT IS STRAIGHTFORWARD. The copper pads are extra wide to accommodate coil forms of different sizes; drill an extra hole wherever your coils fit best.

common-base mixer, which heterodynes the incoming RF signals with the local oscillator. Capacitor C7 couples the local-oscillator signal to the emitter of Q2. Resistor R6 biases the emitter, and R7-R8 biases the base, which is AC-grounded for RF signals. DC power is supplied through R9, and C9 is a supply-bypass capacitor. The mixer output is developed across L3, a 1-mH RF choke. Capacitor C15 blocks DC, and C16 bypasses unwanted mixer products to the ground. The difference-frequency output across C16 is equal to the input frequency minus the local-oscillator frequency. That difference signal is routed through S1-b, then through PL1, and finally inputted to the car radio.

For example, suppose the local-oscillator frequency is 11.0 MHz (11,000 kHz), then the shortwave converter will receive frequencies in the 11.5–12.5-MHz range. After the shortwaves are down-converted in the mixer, the frequencies going into the car radio will be in the 500 kHz–1,500 kHz range. And because the AM band lies between 525 kHz and 1,605 kHz, our converter makes tuning the shortwave band on your AM dial quite an easy task.

The Colpitts local-oscillator (Q3) uses crystal XTAL1 as the frequency-controlling element. The crystal is a series-resonant, fundamental or third overtone type, which AC grounds Q3's base only at its series-resonant frequency; that prevents Q3 from oscillating at any other frequency except the crystal's frequency. General tuning is through the L4-C10 tank, while C12 and C13 form a feedback network. Voltage-divider bias is provided through R11–R13. Zener diode D1 and components C11 and R10 regulate the local-oscillator's +9-volt supply.

If crystal XTAL1 is replaced by a .01-µF capacitor, oscillation will occur whenever L4 resonates with its tuning capacitance (C10 + C7 + C12 plus strays). That fact can be used to eliminate XTAL1 and save a few dollars, but the stability of the local-oscillator won't be as good. Below 10 MHz that may be OK; but above 30 MHz there might be excessive frequency drift, and that could make tuning difficult. We therefore suggest that you use the crystal as your frequency-determining element.

TABLE—1 COIL DIMENSIONS

L MICROHENRIES	NO. TURNS (APPROXIMATE)
0.75	8
1.3	10
1.8	15
2.2	17
3.0	19
5.5	27

COIL FORM ¼" DIA. WITH TUNING SLUG.

INDUCTANCE RANGE DEPENDS ON TUNING SLUG, BUT TYPICAL TV COIL SLUG WILL GIVE −30 TO + 50%.

Assembly

- As shown in Fig. 2, the converter is constructed on a single-sided PC-board whose size is 2 inches × 4¼ inches. Printed-circuit artwork is provided in PC service for those wishing to etch their own, or a kit containing the PC board and all parts that mount on the board is available from the source in the Parts List.
- First install the resistors and capacitors, then the transistors, and finally the coils L1, L2, L3, and L4. Suggested coil dimensions are given in Table 1, while the various inductance values are specified in Table 2.
- The shortwave signals are inductively coupled into the RF front-end by winding a two-turn link over L1. The link is formed using ordinary insulated hookup wire: Solder one end of the wire to the PC-board

PARTS LIST

All resistors are ¼-watt, 5%
R1, R6, R10, R13—470 ohms
R2, R7, R12—4700 ohms
R3, R8, R11—18,000 ohms
R4, R14, R15—100 ohms
R5, R9—1500 ohms
Capacitors
C1, C2, C4, C10, C13—see Table 2
C3, C5, C8, C11, C15—.01 µF, ceramic disc
C6—10 pF, ceramic disc
C7—5 pF, ceramic disc
C9—.1 µF, mylar
C12—3 pF, ceramic disc
C14—10 µF, electrolytic
C16—33 pF, ceramic disc
Inductors
L1, L2, L4—see Table 2
L3—1 mH, RF choke
Semiconductors
Q1–Q3—2N3563
Other components
XTAL1—crystal frequencies, see Table 2, series resonant, .005% fundamental or 3rd overtone.
J1—automotive antenna jack
PL1—automotive antenna plug
S1—3PDT slide switch
Miscellaneous
Cabinet, wire, hardware, solder, PC board, etc.
Note: A 14-30-MHz kit containing PC board and all parts that mount on the board is available from North Country Radio, P.O. Box 53, Wykagyl Station, New Rochelle, NY 10804. (A 5-14-MHz kit is available upon request.) Price: $32.50 plus $2.50 for postage and handling.

TABLE—2 FREQUENCY DETERMINING COMPONENTS

FREQUENCY RANGE	XTAL 1 FREQ. (MHz)	TUNING INDUCTANCE µH			CAPACITANCE pF				
		L1*	L2*	L4*	C1	C2	C4	C10	C13
5.5–6.5 MHz (49 METERS)	5.0	5.5	5.5	8.0	150	1000	120	220	100
9.2–10.2 MHz (3-METERS)	8.7	3.0	3.0	3.2	100	820	91	150	100
11.5–12.5 MHz (25 METERS)	11.0	2.2	2.2	2.1	82	680	68	100	100
13.2–14.2 MHz (21 METERS)	12.7	1.8	1.8	1.6	82	680	68	100	100
14.5–15.5 MHz (19-METERS)	14.0	1.6	1.6	1.6	82	470	68	82	82
17.5–18.5 MHz (17 METERS)	17.0	1.3	1.3	1.1	68	470	56	82	82
21.0–22.0 MHz (13 METERS)	20.5	0.9	0.9	1.0	68	470	56	68	68
25.5–26.5 MHz (11 METERS)	25.0	0.8	0.8	0.74	56	330	47	56	56
26.5–27.5 MHz (11-METER)	26.0	0.76	0.76	0.72	56	330	47	56	56

*SHOULD BE ADJUSTABLE −30 TO +50% OF VALUE SHOWN.
SEE TABLE 1 FOR SUGGESTED DIMENSIONS.
L1 HAS 2-TURN LINK AROUND COLD END FOR ALL VALUES.

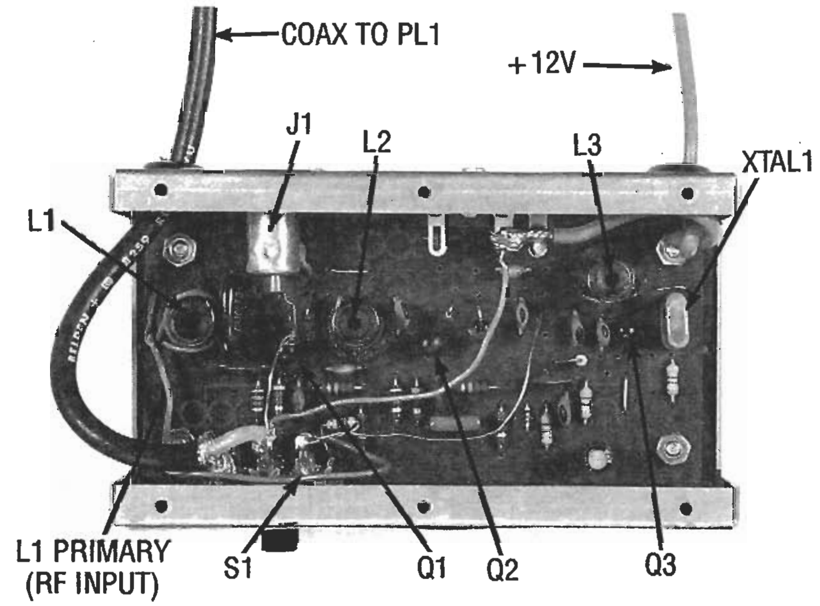


FIG. 3—THE AUTHOR'S CONVERTER is neatly assembled inside a metal case. Switch S1 and plug PL1 have been carefully installed, so as not to bump against any other PC-board components.

ground, wind two turns around L1 (that's the link), and then connect the other end of the wire to switch S1-a. Finally, position the link close to the grounded (bottom) side of L1.

- For inductors L1–L3, the author used IF coils taken from an old TV set. If preferred, standard ¼" diameter slug-tuned forms may be substituted. The PC layout has generous-size pads, so different-size coil forms can be accommodated; that simplifies construction for the hobbyist with a limited parts inventory.
- Resistor R14 should be installed off the PC board, between the PC board and S1-c.
- Figure 3 shows the completed project. The converter is housed in a metal box that can be mounted under a car's dashboard. The enclosure should be big enough to house the PC board, automobile plug, and switch; a suitable size might be 3-inches deep × 5-inches long × 1-inch high. Preferably, the 12-volt DC power lead should have a ½- or 1-ampere fuse.

Alignment and testing

Hook up a 12-volt bench supply and turn on the converter. Check for about +2 volts at the emitter of transistors Q1, Q2, and Q3. Check for +9 volts across Zener D1. For the rest of the converter test, you'll need a car radio or other AM-broadcast receiver with a shielded input. Connect the converter between the antenna and the AM radio. If a frequency counter is available, connect it across C13 and adjust L4 until the crystal oscillator begins operating. Now tune the radio over the AM-broadcast band; you should hear shortwave signals. Pick a weak signal you find interesting, and adjust L1 and L2 for best reception. There should be a definite point of maximum response; if not, add or subtract a turn from L1 or L2 as required, and try again.

In the shortwave broadcast bands between 6 and 15 MHz, plenty of signals should be heard whether day or night. The lower frequencies (5–15 MHz) are best at night, while the higher frequencies (15-30 MHz) are best during daylight hours; however, that is not always the rule. If no signals are head, re-check your wiring and solder connections.

That completes the alignment and testing of the shortwave converter. If you desire different frequency bands, a rotary switch can be used to switch in various values of components and crystals, but it is probably easier to build several converters, and simply switch the power and signal leads.

Operating tips

The shortwave converter makes it very easy to tune in stations, because it spreads the 1-MHz portion of the shortwave band across the entire AM radio's dial. That provides you with lots of "room" to tune in each individual station.

Another thing to keep in mind is the fact that it will be easier to tune in a station on an AM car radio that has manual tuning, as opposed to a radio with digital tuning. That's because regular AM stations are spaced 10 kHz apart from each other, and a digitally tuned radio is set up so that the tuner advances in precise 10-kHz increments with each "turn" or advancement of the dial.

Shortwave stations may be found anywhere on the dial, as they are not spaced with any kind of order. A manually tuned radio will allow you to adjust each station for best reception. A digitally tuned radio can be used, but the reception of some stations may not be perfect. It's also possible that you may not be able to tune in some stations at all on a digital radio, that you could actually receive on a manually tuned radio. **R-E**