how it works

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Straight Talk on Dipoles and Doublets

Surely the most all-around popular antennas used by amateurs near and far, especially those on limited budgets, are classic dipoles and doublets. They have been made from light wire, heavy wire, bare wire, and insulated wire; hidden under house eaves; strung between trees; installed horizontally, vertically, sloping, and at various heights. They always seem to work out fine. This month's column looks at these versatile skywires—their similarities, differences, and general "how it works" concept of operation.

A number of "old pro" antenna wizards probably will critique every word in this column (antennas are the most continuously debated subject in amateur radio), and to those critics I say, "Relax and chill out." This article is not a technical analysis of antenna design and theory, but rather a simple compilation of plain-language notes to help newer amateurs feel more comfortable with antennas.

As an opening point of view, I suggest visualizing the radiation of RF energy from an antenna element like light emanating from a long neon tube (fig. 1). An unusual analogy? Not really. Both light and radio waves are electromagnetic radiation. Light is just higher in frequency—above the microwave range, to be more precise. In both cases, maximum radiation emanates broadside and all the way around the element/tube with minimum radiation off the ends.

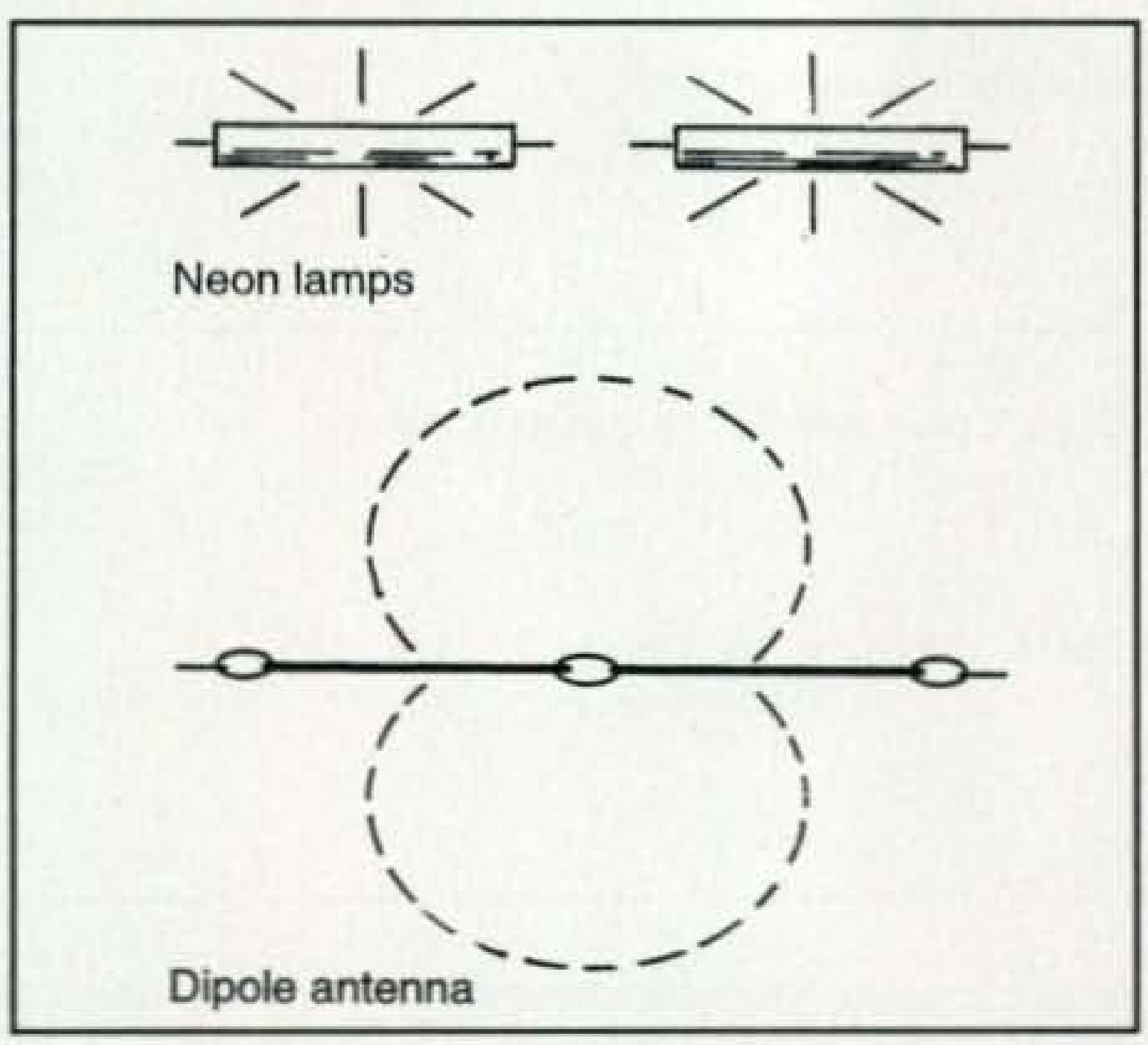

Fig. 1– Radio waves emanate from the wires or elements of an antenna similarly to the way light waves radiate from a long neon tube—evenly along the full length with minimum radiation from the ends. Placing a reflector behind it (like in a Yagi or beam antenna) directs more energy forward. Mounting it closer to a quasi-reflector (such as earth/ground) directs more energy upward rather than outward toward distant stations.

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Now consider how your antenna should be positioned to project the maximum amount of that radiation toward the lowest/most-distant point on your far horizon. Also, visualize the ground/earth beneath that antenna as a quasi-reflector with the amount of signal absorption determined by ground conductivity. These factors are important because an antenna installed a half wavelength above ground has a lower signal take-off angle than an antenna one quarter-wave above ground. The higher positioned antenna thus works out farther and has less ground losses and is less prone to signal blockage by houses and hills. You can devise a copy of this action with a light bulb and a mirror: The closer you place the light bulb to the mirror, the brighter its "opposite direction" reflection/illumination.

As a non-technical comparison here, a simple dipole installed at 80 feet may easily reach out better than a two- or three-element beam at 30 feet. Interesting, eh? Don't fret if you must opt for low height, however. Most of us are in that same boat. Just strive to install your antenna as high as feasible for your particular situation (preferably with an end pointed toward your station gear to minimize RF feedback) and enjoy the results. Getting on the air and enjoying our wonderful world of amateur radio is always the goal!

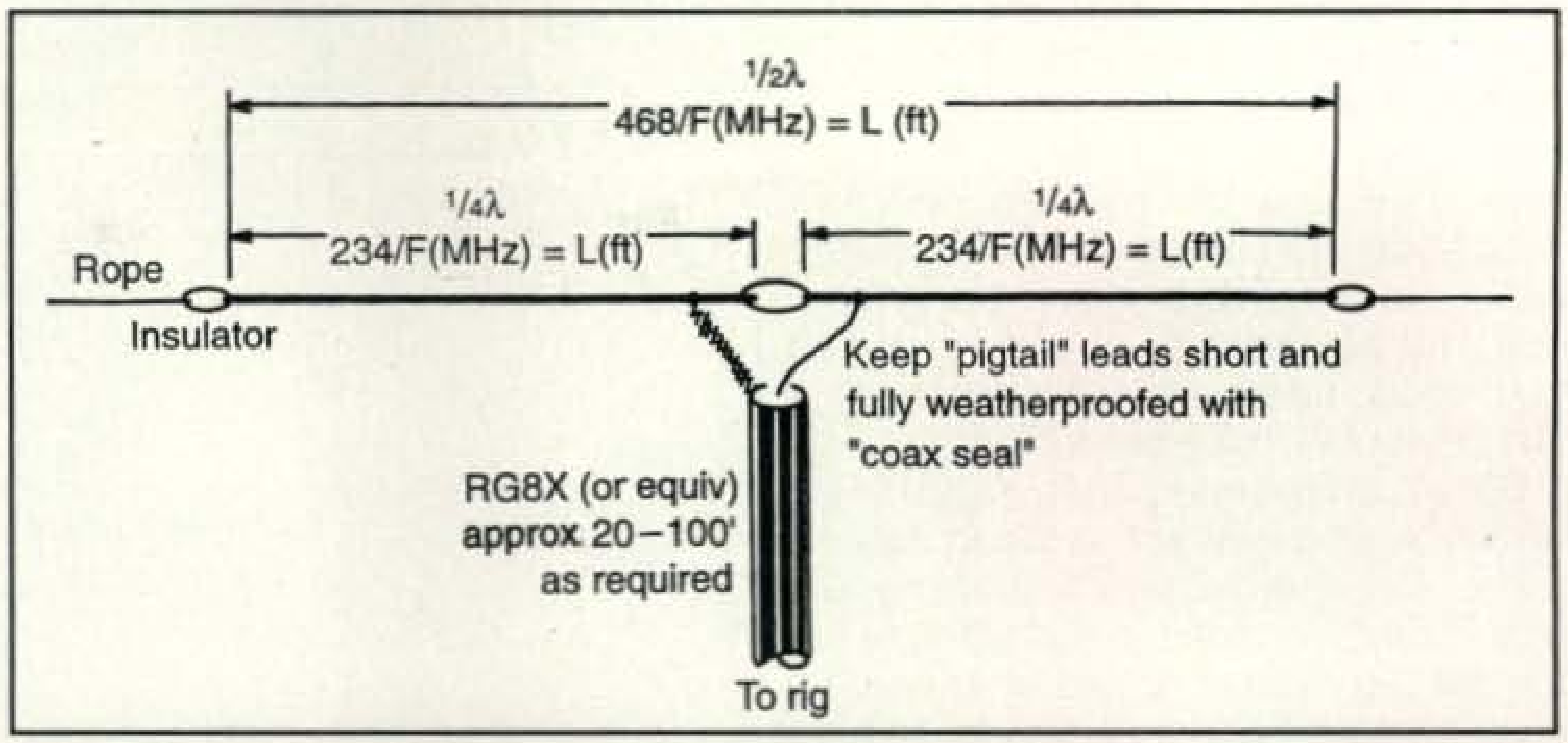
General Facts about Dipoles

As illustrated in fig. 2, a dipole is comprised of two equal-length wire elements that are each a quarter wave long and RF-fed in the middle with 50-ohm coax cable. The dipole is considered a resonant antenna, as it is cut for operation (and lowest SWR) on a particular amateur band. The antenna itself is also considered "balanced," as one side, or leg, is identical to the other and neither one is connected to ground.

Coax cable has one conductor inside the other. The outer conductor or shield usually connects to the station's ground, however. When directly connected to a dipole, it thus produces an unbalanced antenna. What difference does that make? Radiation from an unbalanced antenna (dipole) is usually different on each side and typically produces a less than theoretically ideal radiation pattern. Radiation can also occur from the coax feedline. There is nothing frightful here unless the dipole is part of a beam or Yagi antenna. In that case, signal directivity can be altered. If the dipole's feedline radiates, it can also cause RF feedback (blinking dial lights, distorted transmit audio, a "hot" mic, etc.). On the "up side," installing a balun at a dipole's feedpoint usually changes the unbalanced system into a balanced system, improves the radiation pattern, and minimizes or eliminates RF feedback.

Two other points warrant mention here. Standard SO-239 connectors such as those used on the rear

Fig. 2– Outline of the ever-popular dipole. The length of each side is a quarter wave and calculated as 234/F(MHz) = L(ft.). Overall, or end-to-end, length is a half wave and calculated as 468/F(MHz) = L(ft.). Transmission-line length depends on how far the antenna is located from the station gear and is usually between 20 and 100 feet. A 1:1 balun may be added/included at the feedpoint to maximize antenna radiation and minimize feedline radiation.



panels of modern transceivers (and many antenna tuners) are your clue that it has unbalanced/coax output. Twin wire connectors (often screw- terminal type) are your clue that it has balanced/"ladderline"-type output. Second, the built-in automatic antenna tuners in many modern transceivers work fine for matching transceivers to (unbalanced) antennas with SWRs up to 2:1 or 3:1. They are especially appreciated when you quickly install an antenna in biting-cold weather. You just press the "tune" button and "whirr-whirr, click-click"; your rig sees a low SWR and comfortably delivers its full output to the antenna. Nice!

General Facts about Doublets

Like a dipole, the doublet is also comprised of two equal-length wire elements that are RF-fed in the middle (fig. 3). It differs, however, in that it is fed with 450-ohm ladderline, it is a balanced and nonresonant antenna, and it operates on several HF bands with the aid of a balanced-output antenna tuner. The doublet's flat top section is usually cut to an overall or end-to-end length of a half wave on the lowest desired band of operation. On that band, the 450-ohm ladderline acts as a low-loss transmission line. On higher bands (where the antenna is various multiples of the operating frequency), the feedline radiates just like it is part of the antenna. The impedance (and SWR) between the flat top section, the 450-ohm ladderline, and the tuner may be any unusual value from 50 ohms to 2500 ohms, but the tuner converts and transforms that strange impedance to 50 ohms, so the transceiver delivers its full output power. The signal is then effectively radiated by the feedline and the antenna.

Since the impedance of a doublet varies from band to band, a balun is not used. The "why" of that statement relates to the distribution of voltage and current along a wire (or antenna). It is a technical discussion, but the simplified bottom line is that feedpoint impedance of a quarter-wave wire is near 50 ohms, the feedpoint impedance of a 3/8-wave wire is near 1300 ohms, and the feedpoint impedance of a half-wave wire is near 2500 ohms. Even if a 30:1 ratio balun was available, it could only be used for single-band operation—and that would defeat the doublet's attractive point of working several bands.

Some additional points regarding doublets also warrant mention here. Since 450-ohm ladderline/feedline is unshielded and radiates right along with the flat top section of the antenna on most bands, it should be positioned/spaced away from metal awnings, gutters, tower legs, etc. The doublet also works best when its feedline is approximately half the length of its horizontally flat top section. Typically, a 130-foot flat top with a 66-foot run of ladderline makes a good 80- through 10-meter doublet, and a 66-foot flat top with a 33-foot run of ladderline makes a good 40- through 10-meter doublet.

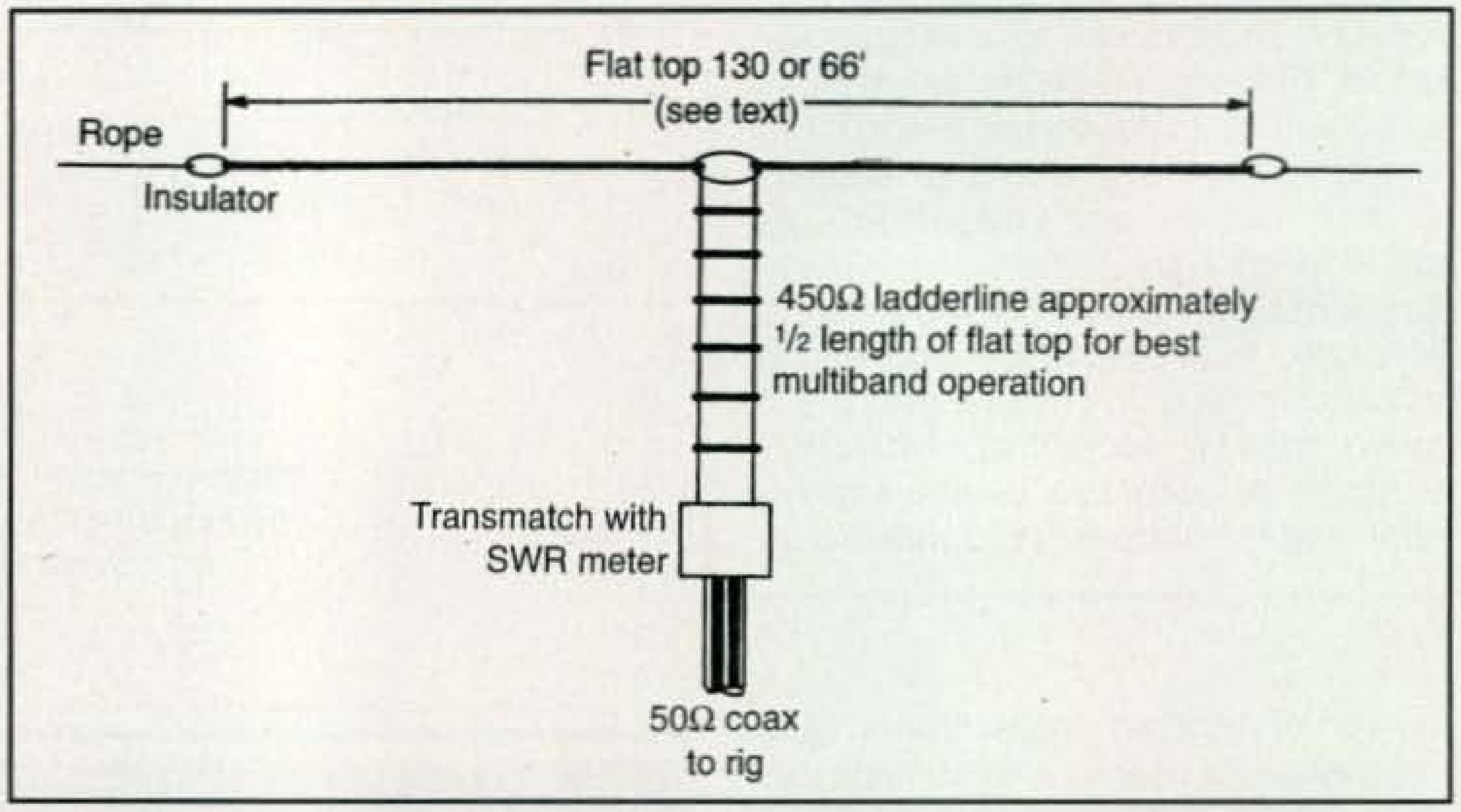


Fig. 3– Outline of the classic doublet. The antenna works several HF bands with the aid of a balanced-output tuner. Typical dimensions are 130-foot flat top section for 80–10 meter operation, or 66-foot flat top section for 40–10 meter operation, with 450-ohm "ladderline" cut to approximately half the length of the flat top section.

An attractive variation of the conventional doublet and a good wire antenna capable of delivering 3 dB gain on a single band is the Extended Double Zepp (fig. 4). The "EDZ" consists of two 5/8-wave top sections RF-fed with 450-ohm ladderline connected to an antenna tuner with balanced output. As an alternative, the 450-ohm ladderline can be cut to a specific length between 1/8 and 1/4 wavelength, a 4:1 balun installed at that point, and a non-critical length of 50-ohm/RG-8X cable routed from the balun to the indoor station. An antenna tuner is usually not required here. If one is necessary, a transceiver's built-in tuner works fine.

The previously mentioned "specific length" of 450-ohm ladderline where a 4:1 balun installs requires further "how it works" explanation. That is, the ladderline acts like an impedance-matching transformer to convert the flat top's high impedance to 200 ohms (4×50 ohms). The easy way to find that spot is to connect an MFJ-259B Antenna Bridge at various points along the line until you find the 4:1 SWR, or 200-ohm point, then insert the balun at that point.

You probably have noticed that an EDZ looks like a regular doublet and are asking if it too will work several bands. Yes, but it will work best on its "cut for use" band, and it also requires using a balanced output tuner (plus eliminating coax and balun from the feedline for multi-band operation).

If you are looking for an inexpensive and low-profile way to operate several bands or to pump out a superb signal on one particular band, a classic dou-

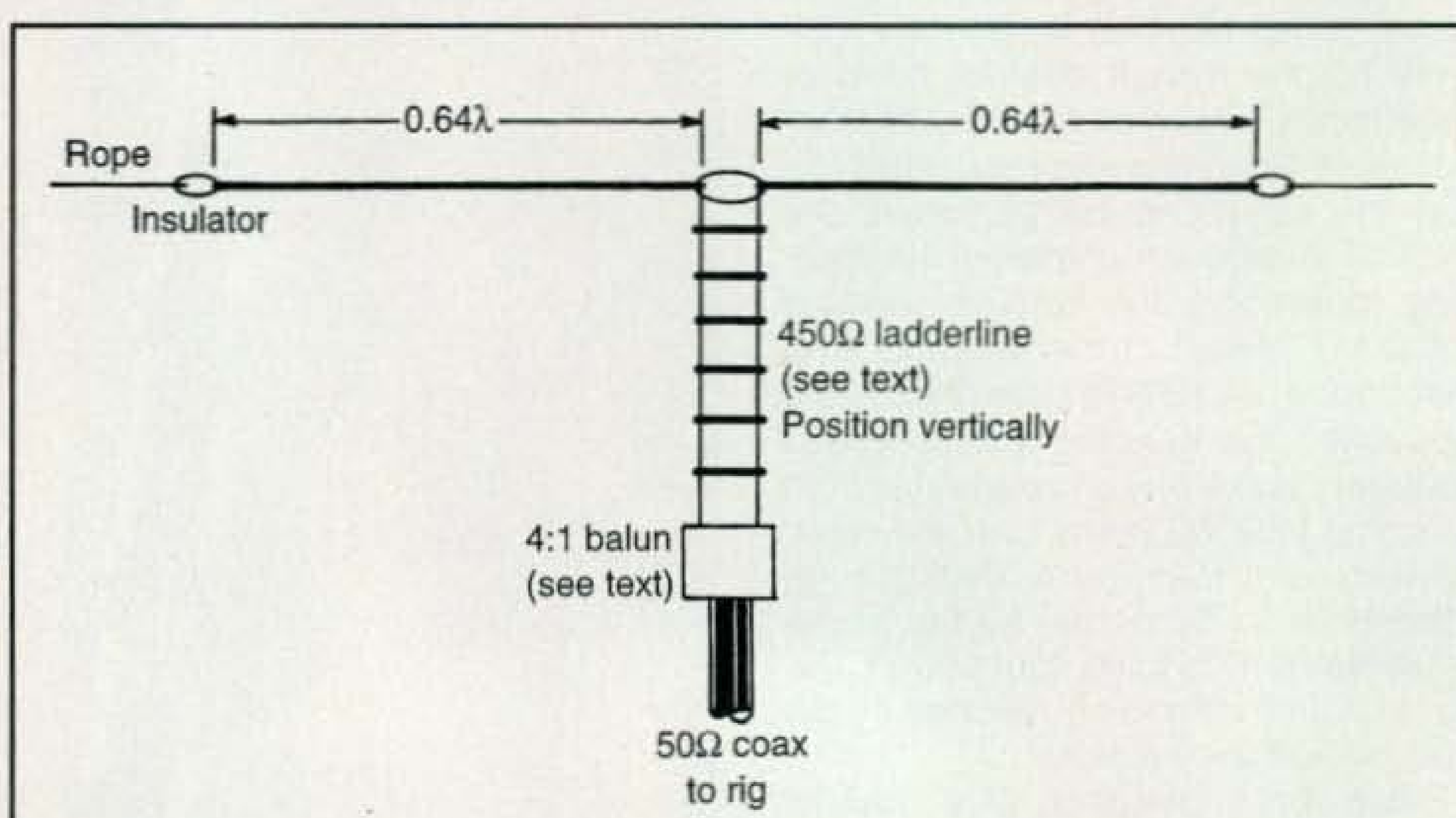


Fig. 4– A slight modification of the classic doublet results in an Extended Double Zepp antenna. Its flat top section is 5/8 wavelength on each side, and straight ladderline or ladderline with a 4:1 balun and 50-ohm coax cable may be used for feeding.

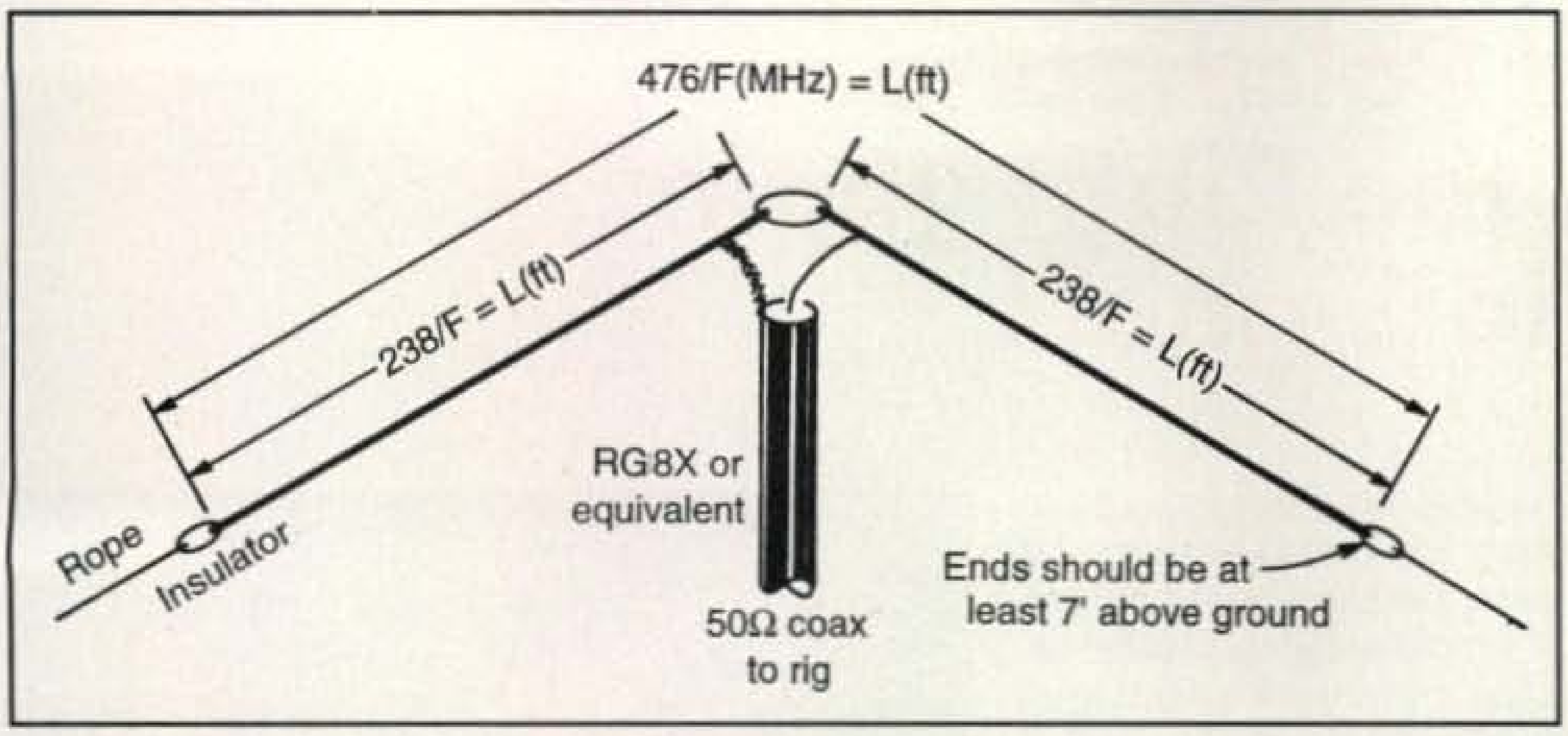


Fig. 5– Cramped for space? Limited on tall antenna supports? Consider installing a dipole or doublet in an inverted-Vee configuration. It requires only one tall support, and each leg or element can be oriented for maximum signal radiation in desired directions. Tip: Due to end effects, an inverted-Vee is usually 4 percent longer than a dipole. Cut it slightly long and trim it for lowest SWR.

blet or Extended Double Zepp may be the perfect answer!

Configurations and Heights

As previously mentioned, the overall performance of dipoles and doublets (indeed, any type of horizontal antenna) is directly related to their height above ground. What is a good height? Good question! I often say high enough to clear surrounding buildings and objects—to acquire a low signal take-off angle and minimize RF feedback from induction field radiation—but not high enough to attract lightning (I prefer maintaining a low profile).

When a horizontal antenna is installed at or below a quarter wavelength above ground, part of its radiated energy reflects off the ground below the antenna, returns, and re-enforces upward radiation, and causes a high signal take-off angle (remember our light bulb and mirror analogy?). You can visualize this same effect by holding a mirror near a light bulb. A high take-off angle is okay for near-in operations, or multi-skip DXing, but raising the antenna's height to a half wavelength above ground reduces ground reflections so you can reach out longer distances with fewer skips and a stronger signal level.

Finding three tall supports to install and orient a dipole or doublet for optimum radiation in specific directions often proves challenging, so many amateurs opt for an inverted-Vee configuration (fig. 5). This design requires only one tall support, and the ends can be positioned for north-south or east-west coverage as desired. Just strive to keep the Vee angle above 45 degrees (a 60-degree Vee is good), keep the ends at least 7 feet above ground for safety (so the neighbor's dog doesn't get fried), and enjoy HFing to the max!

Conclusion

That fills available space for this month, friends, but watch for more helpful "how it works" notes and details on wire-type antennas, transmission lines, support ropes, and connection sealers next time. Meanwhile, remember the real glitz and glamour fun of amateur radio is operating HF. Go for it, and may the force of good signals be with you.

73, Dave, K4TWJ