Giant Box Fan Antenna
MFJ-1784

INSTRUCTION MANUAL

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DISCLAIMER

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1 RADIO-FREQUENCY RADIATION

Radio-frequency (RF) radiation is one type of electromagnetic radiation. Electromagnetic waves and associated phenomena are described in terms of energy, radiation, and fields. Electromagnetic radiation is defined as waves in electric and magnetic fields moving together, or radiating, through space (Figure 1). These waves are generated by the movement of electrical charge. For example, the movement of charge in a radio station antenna creates electromagnetic waves that are radiated away from the antenna. The waves then induce charge motion in the receiving antenna, which is detected and converted into signal by the radio. The term electromagnetic field refers to the electric and magnetic environment existing at some location due to a radiating source such as an antenna.

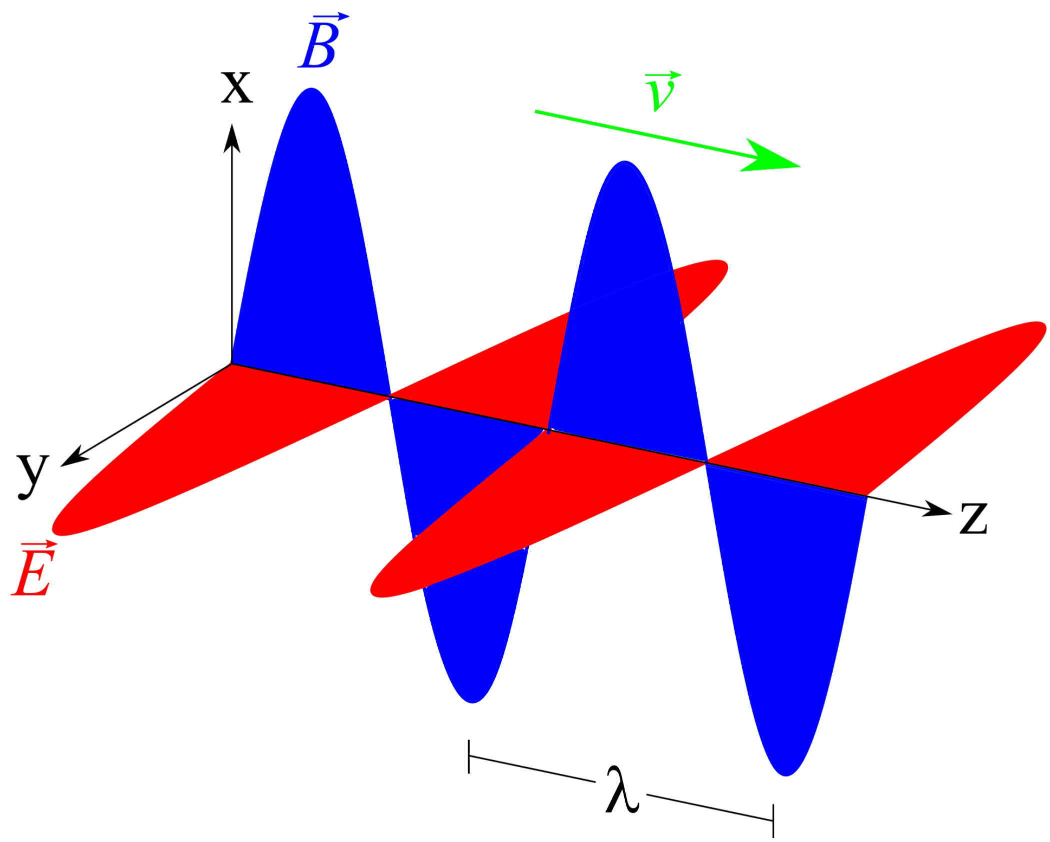


Figure 1: Horizontally-polarized Electromagnetic Plane Wave

An electromagnetic wave consists of oscillating orthogonal electric ($\vec{E}$) and magnetic ($\vec{B}$) fields. These fields propagate together with direction and velocity $\vec{v}$. In a vacuum (and only a 0.0003% lower in atmosphere) this is the speed of light, c. The two defining characteristics of an electromagnetic wave are its wavelength (λ) and frequency (f). The wavelength is the distance between two adjacent peaks in the wave, and the frequency is the number of peaks passing a given point in space during a second. Wavelength and frequency are reciprocal with the speed of light ($f\lambda = c$), so if you know one quantity, you can easily find the other. For example, a typical radio wave transmitted by a 2-meter VHF station has a frequency of about 145 MHz. Dividing the speed of light ($\sim 3 \times 10^8$ m/s) by the frequency in Hz, we find that the wavelength in atmosphere of the signal from our station is 2.06 m. Since wavelength and frequency are reciprocal, an increase in wavelength corresponds to a decrease in frequency, hence, the 160 m band has a much lower frequency of 1.8 MHz.

The electromagnetic spectrum (Figure 2) includes all of the various energies of electromagnetic radiation ranging from extremely low frequency (ELF) ranges (with very long wavelengths) to all the way up to x rays and γ rays, which have very high frequencies and correspondingly short wavelengths. In between these extremes lie radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, and the entirety of the FCC spectrum allocation chart. The RF part of the electromagnetic spectrum is generally defined as that part of the spectrum from about 3 kHz to 300 GHz.

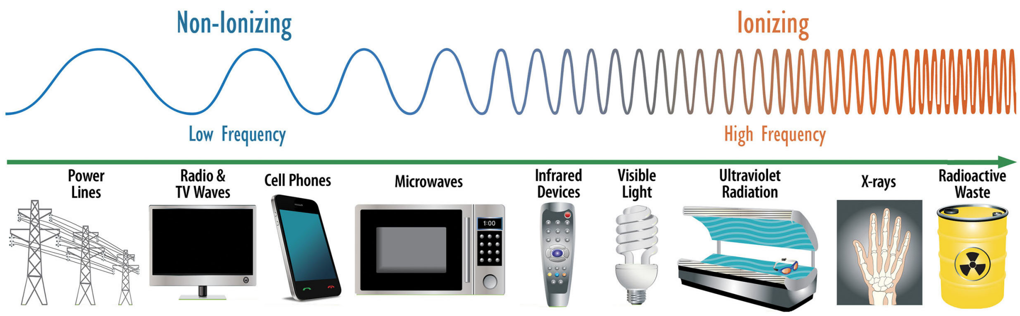


Figure 2: The Electromagnetic Spectrum

2 THE MFJ-1784

2.1 INTRODUCTION

The MFJ-1784 *Giant Box Fan Portable Loop Antenna*™ is the next step in box fan antennas. Adding four feet to the circumferance and fine tuning the physical dimensions for the perfect inductance has created an antenna that functions on more bands than its predecessor while still being slim enough to fit just about anywhere. Covering from 7 MHz to 22 MHz, this is the best-performing portable antenna available to amateurs today with the same form factor as a 3×3 foot box fan. It has a convenient carrying handle and features remote tuning control. All tuning and control voltages are coupled to the antenna through the coaxial feedline for a simple, neat, single-cable installation. You can take it with you anywhere: a hotel, camp site, or any other location. You can place the antenna on a picnic table, wooden table or any other non-metallic convenient place, and you are ready to start operating. The MFJ-1784 requires no tuner and is self tuned across all of its rated bands with an SWR less than 1.5. The driven element is constructed from rugged aluminum sheeting. Every current-carrying joint is welded to eliminate high-impedance pressure contacts that reduce efficiency. Finally, the MFJ-1784 is matched by a superb, welded, low-resistance, high-current, butterfly tuning capacitor.

WARNING

- Keep this antenna out of reach of adults, children, and animals. Any contact with this antenna while transmitting, even at low power, will cause severe RF burns and contact with lethal voltages.
- Never place this antenna or its feedline close to electric power lines or utility wires.
- Do not stay near the antenna if you are transmitting more than 10 Watts of power.
- The MFJ-1784 is not weather proofed and will be damaged if exposed to water and moisture.
- Never operate this antenna near RF sensitive medical devices such as pacemakers.

2.2 THEORY OF OPERATION

A magnetic loop antenna is one that is characterized by low-noise reception, working well even when mounted at ground level, and a circumference of less than 1/3 wavelength. The ideal small transmitting antenna would have performance equal to a large antenna, and the MFJ-1784 approaches that performance. Bandwidth is quite narrow due to the extremely high-Q of the tuned-circuit configuration when paired with a capacitor.

The components in a resonant transmitting loop are subjected to high currents and voltages because of the large circulating currents in the high-Q tuned circuit formed by the antenna. It is very important that the capacitors used in this antenna have a high RF current rating. Even a 100W transmitter develops currents in the tens of amperes and voltages across the tuning capacitor above 10 kV. This consideration also applies to any conductors used to connect the loop to the capacitor. Therefore care must be taken when choosing materials in the loop. The best electrical connections possible are those using soldered or welded joints.

The heart of the MFJ-1784 is the “Butterfly” loop-tuning capacitor, which has no rotating electrical contacts. Coupling this capacitor to a low-resistance loop, such as the welded aluminum used in the loop’s construction, creates a high-efficiency transmitting loop.

The efficiency of the MFJ-1784 increases with its height above ground. When traveling, a room above the ground floor above ground level makes for a better portable operation experience with the MFJ-1784. At very low heights, close coupling to the ground causes detuning and losses due to the twin factors of current induced into a mirror image of the loop below the surface and the resistance of the image loop proportional to soil resistance. Another loss component is due to current flowing in the soil via capacitance between the loop and soil surface. These are all reduced by increasing the height of the MFJ-1784 above the ground as measured from the bottom of the box. An operational height equal to ½ the diameter of the loop antenna is recommended to prevent detuning and excess ground losses when using the MFJ-1784.

In practice, ground losses are rather low above 14 MHz, so it is acceptable to operate close to the ground on these frequencies. However below 14 MHz, ground losses become significant and will noticeably degrade performance if the MFJ-1784 is placed close to the ground. If elevating the

MFJ-1784 is not an option, the loop should be mounted vertically (Figure 3).

2.2.1 PATTERNS, POLARIZATION, AND LOCATION

The Box Fan loop antenna can be used to provide either vertical or horizontal polarization (Figure 3). For vertical polarization the loop should be placed standing up on its edge, and for horizontal polarization the loop should be laid flat on its side over a non conductive surface.

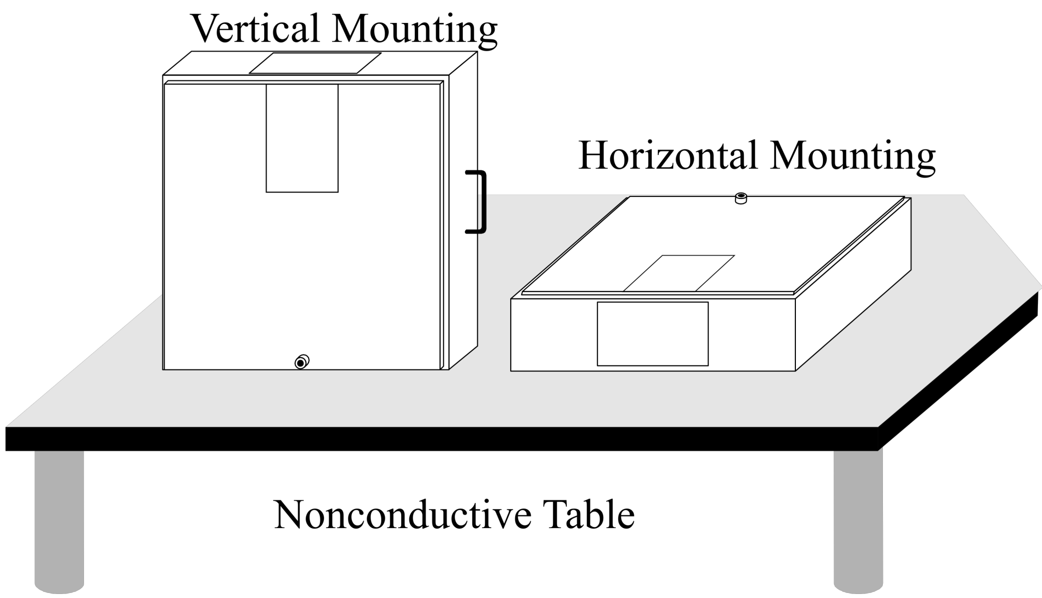


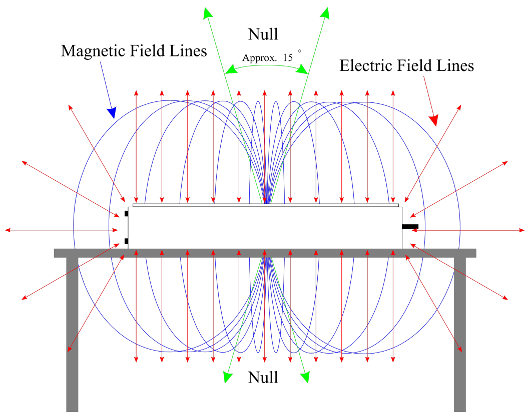
Figure 3: Various Mounting Orientations

The radiation pattern of a small loop antenna is essentially omni-directional with the exception of two 15° nulls along the axis of the loop (Figure 4a). If you visualize the loop as a wheel, the nulls are in the same directions that the wheel's axle would run. Signals will be attenuated more than 10 dB if they arrive within this region.

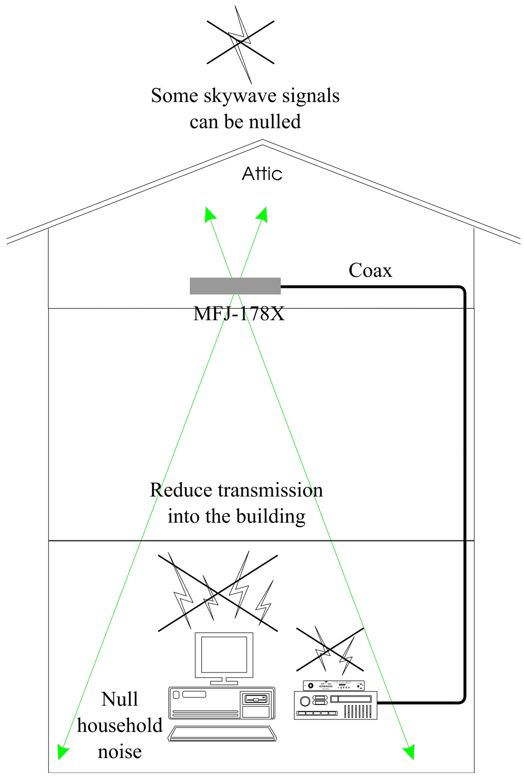
This antenna, like most others, should be placed as far away from and as high above other objects as possible. The null be placed along the direction that you do not want to transmit or receive. If the loop can not be placed more than fifteen feet above ground level the best placement arrangement will be with the loop oriented vertically. Otherwise, it is possible to mount the antenna horizontally.

In the vertical position, the Box Fan loop nulls can be used to reduce interference from undesired directions if the unwanted signal is coming from a fixed direction and wave angle, or to minimize interference (if transmitting) caused by the antenna itself to other household electronics equipment.

Other examples of using the null can be understood if we consider a loop antenna placed horizontally on a second or higher floor of a building (Figure 4b). Since the null is positioned directly below the antenna, clever placement of the antenna helps receiving by reducing the noise pick-up from devices in the building and helps transmitting because energy is not coupled into the building's lossy structure. RFI in the building will also be reduced because the signal transmitted into the building is significantly weaker.



(a) Magnetic and electric field lines



(b) Signal Nulling

Figure 4: Field and Null Patterns

VERTICAL POLARIZATION When the loop is oriented to provide vertical polarization the pattern is vertically polarized in line with the loop element. There will still be a large amount of horizontally polarized radiation broadside to the loop, especially if the ground under the loop is less than perfect or if the loop is placed some distance above the ground.

The broadside horizontal radiation that occurs in a small vertical loop is mostly between 10° takeoff angles and extends straight above the loop and to the opposite 10° elevation point. True vertical polarization occurs only in line with the loop. As you move around the loop towards the sides, the pattern skews and eventually becomes completely horizontal broadside to the loop.

Unlike linear verticals, small vertically-polarized loops also radiate straight up and down from the antenna. This high-angle of radiation can be used to cover short distances by sky wave. The high-angle horizontal radiation in a vertically polarized loop antenna occurs because the ground below the loop is either too far away or is not a good enough RF reflector to cancel the horizontal radiation component of the vertical loop.

HORIZONTAL POLARIZATION Horizontal mounting of the loop antenna results in an omni-direction, horizontally-polarized antenna pattern that has a null straight up in the air and straight below the center of the antenna. This means that any ground reflection will tend to cancel the radiation along the horizon and low takeoff angles unless the loop is mounted some distance above ground.*

Since ground-wave signals only propagate well along the earth when they are vertically polarized, a horizontally-polarized loop may not respond to some local noise sources. Like all other antennas, a small loop is generally a quieter receiving antenna when horizontally polarized. This also means that a horizontally polarized loop is not a good choice for local ground wave communications. It is an excellent choice for medium to long distance sky wave communications, however.

2.3 FEATURES

- **Air-variable Butterfly Capacitor:** The 213 pF capacitor can handle 15 kV
- **Welded Aluminum Construction:** Aluminum segments are welded to maximize conductivity
- **Single-cable Control:** RF and DC sent along a single piece of coax
- **Foldable Fiberglass Feet:** Feet are designed to rotate out of the way for mounting
- **Convenient Carry Handle:** An ergonomic aluminum handle makes carrying the MFJ-1784 a breeze

3 SYSTEM SETUP & OPERATION

Figure 5 shows a simple layout for a portable station using the MFJ-1784. Connect the controller, either the standard one or the Deluxe Loop Controller, between the radio and the MFJ-1784. Key the radio at low power (<10W) and adjust the antenna to match using the either radio's SWR meter or a simple one such as the MFJ-818.

> WARNING
>
> Do not install any devices between the controller box and the loop antenna. If anything causes a low DC resistance or short between the center conductor of the coax and ground, the control box or power supply will be damaged.

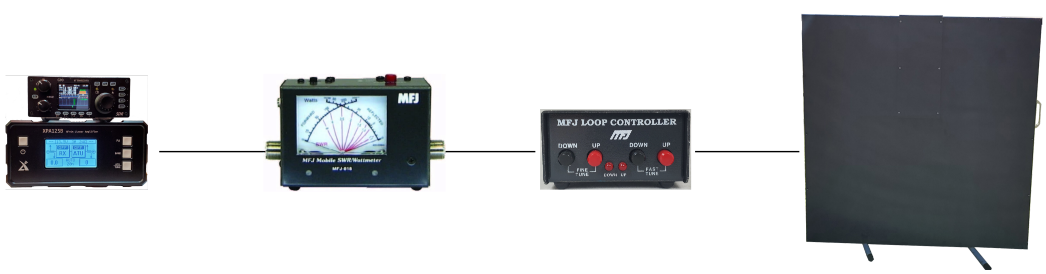


Figure 5: Typical Station Setup

*Do not expect the best results if you mount this loop antenna horizontally less than 15 feet above ground.

3.1 CONTROLS & CONNECTIONS

The controller box (Figure 6) can be installed at any position that allows easy access to it and the transceiver. The coax line between the controller and antenna should be good quality 50Ω cable and be kept as short as practical to reduce losses. If you use quality low-loss cable the exact lengths used are not important and will not effect the operation or SWR of the system. If you are using a lossy cable between your antenna and controller and have problem tuning, the easiest way to correct the problem is to get better quality cable. The MFJ-1783 controller box requires an 18 VDC 500 mA, ungrounded power supply. The power jack accepts a 2.1 mm coaxial plug with the center conductor positive. The provided DC power supply will supply the correct power to the controller box. There is also an internal battery bay with space for two 9V batteries. If you chose to use a different power supply than the one provided, the power supply must not share a common ground with anything else in your radio system.

Figure 6: Super Hi-Q Loop Remote Control

The controller supplies the control signals to the loop antenna through the coaxial feedline. These signals are low voltage and low current so that the length of the coaxial line does not affect the operation of the motor. It is important that the feedline remain water-free and that there are no short circuits between the center conductor and the shield of the feedline.

The controller box has seven buttons and two LEDs on the front panel. The first three from the left are Power, Meter Range, and lamp toggle. The remaining four buttons are assigned to UP and DOWN labels that correspond to the frequency of the SWR minimum. The button groups are as follows: FAST TUNE and FINE TUNE. The FAST TUNE group is used to quickly reach the approximate tuned position. The FINE TUNE group slowly pulses the motor to allow for minute adjustments. The SWR notch is very narrow, especially at lower frequencies. The control unit has the added funtionality of an automatic fast search. When either the UP or DOWN fast buttons are pressed, the unit begins an automatic search for the SWR minimum. Once found, the unit disengages the motor to allow for final adjustments with the fine-tune buttons.

The MFJ-1874 control box can be installed at any position that allows easy access to the controls of the unit and the transceiver. The coax line should be kept as short as practical to reduce losses. Good quality 50Ω coax, such as MFJ's Messi & Paoloni line, should be used as low-loss cable will allow longer lengths of coax to be used, increasing the standoff distance between you and the antenna. If you are using a lossy cable between your antenna and controller and have problem tuning, the easiest way to correct the problem is to get better quality cable.

You must only use the MFJ-1312D supply or eight AA batteries to operate this unit. If you chose to use another supply to power this unit, the power supply must not have a common ground with anything else in your radio system.

3.2 TUNING

Tuning the MFJ-1784 is easy.

Step 1: Place the MFJ-1784 on a raised nonconductive surface or pole.
Step 2: Assemble your station as shown in Figure 5.
Step 3: Turn on the control box and apply low power (<10W).
Step 4: Note the SWR, then press either the UP or DOWN button.†
- **Step 4a:** If the SWR improves, continue holding the button you pressed until you pass the minimum, then release.
- **Step 4b:** If the SWR degrades, switch to the other button. Hold it until you pass the minimum, then release.

Step 5: Once past the SWR minimum, press and hold the opposite FINE TUNE button until the SWR is matched.
Step 6: The MFJ-1874 is now ready to operate at full power.

3.3 OUTDOOR & INDOOR USE

The best outdoor location for the MFJ-1784 or any other antenna is high above ground and away from metallic objects and trees. However, if a clear location is not available try to maximize the distance between the loop and other objects.

Even though Figure 4b shows that this antenna can be effectively used inside a wooden or other nonconductive building, care must still be taken when this antenna is used indoors. Despite the significant null along the central axis, this antenna still generates strong electromagnetic fields everywhere else. These fields can induce considerable RF currents into wiring and other metallic items. If operating with the antenna inside, use only the minimum power necessary and pay close attention to the FCC RF exposure guidelines and whether RF energy is getting into expensive electronics. If the antenna must be used indoors, possible locations include a balcony, porch, atop of a small nonconductive table, or in the attic. It can also be placed on the roof if a flat surface is available.

†The butterfly capacitor is equipped with limit switches to prevent it from rotating so far that it damages itself. If while making adjustments one of the direction indicators stops illuminating use the other to back off the limit switch and move in the opposite direction.

4 TECHNICAL ASSISTANCE

If you have any problem with this unit first check the appropriate section of this manual. If the manual does not reference your problem or reading the manual does not solve your problem, you may call MFJ Technical Service at (662) 323-0549 or the MFJ Factory at (662) 323-5869. You will be best helped if you have your unit, manual and all information on your station handy so you can answer any questions the technicians may ask.

You can also send questions by mail to MFJ Enterprises, Inc., 300 Industrial Park Road, Starkville, MS 39759; by Facsimile (FAX) to 662-323-6551; or by email to techinfo@mfjenterprises.com. Send a complete description of your problem, an explanation of exactly how you are using your unit, and a complete description of your station.

USER NOTES