HISTORY:

In the 1930's and 1940's, a **Multi-Band HF Antenna** need only cover the 80/40/20/10m bands. These bands are harmonically related, specifically, *even harmonics* of the lowest band (80m).

Although some people consider the 160m to be an HF band, it is actually at the top end of the **M**edium **W**ave band, which is why it is called "Top Band".

The 15m band was added in the early 1950's. It was again an even harmonic of the lowest band. Thus, a multi-band hf antenna at the time need only cover 5 bands. The higher bands were all even harmonics of the 80m band.

This remained unchanged for 30 years until the three WARC bands (**W**orld **A**dministrative **R**adio **C**onference) were introduced in the early 1980's, increasing the HF bands count to 8. These new bands were all close to being an odd multiple harmonic (i.e., 3rd harmonic, 5th harmonic, 7th harmonic) of 80m.

It took almost another 30 years (2017) until the next addition added the 60m amateur band. This band has no harmonic relationship to the 80m band.

In terms of quarter wavelengths, the impedance at even multiples repeats (approximately). At odd multiples of the quarter wavelength the impedance inverts (i.e., a high impedance becomes low or low impedance becomes high). This characteristic is very important when designing multi-band antennas.

TODAY (2022):

The HF Band Count is now 9 bands.

Solutions which worked well many years ago do not necessarily work well today. Antenna articles written 50+ years ago may have sounded good then, but may not be so good today. A lot of things have changed.

Other Changes:

- The bands are not all even harmonics of each other, and some of the neighboring bands are quite close together, which may cause interaction between them with certain types of antennas.
- Although our band-count has increased, the mass migration of the population from rural areas to metropolitan cities has resulted in space available for antenna farms to become smaller and smaller.

- Component Technology has changed. The past 50 years has brought significant additions and improvements in the material available for building antennas. Indeed, Plastic, Teflon, Copper-Weld, Ferrite, fiberglass, Kevlar, Dyneema, etc., have enhanced our ability to build lightweight antennas at relatively low cost.
- Public Opinion: “RF Smog” . . . (Need I say more?).
- Home Owner Associations (HOA’s), with their stringent restrictions on antennas.
- Households full of consumer devices, which radiate RFI to our receivers and are easily disturbed by RFI from our transmitters.
- A trend to portable/field operation, rather than operation from the home QTH (due to all of the above).

When considering which multi-band HF antenna to build, all of the above must be taken into consideration.

Few ham radio operators have the space for a well-equipped antenna farm. Indeed, most of us are lucky to be able to erect just one good antenna at our home QTH. As a result, there is a strong demand for antennas that work as many bands as possible.

There are several multi-band antennas to choose from. Each has its own set of strengths and weaknesses. Which one each of us chooses depends on our own unique set of criteria *at the specific site* where the antenna will be erected.

THE MULTI-BAND ANTENNA CANDIDATES:

Pg.	ANTENNA
4	The Morgain antenna
5	The W3DZZ and G8KW antenna
6	The Trap Dipole
7	The Fan Dipole
9	The G5RV and ZS6BKV antenna
11	The End-Fed antenna (random-non-resonant length and λ/2)
13	The Double-Zepp (Openwire Fed Dipole/Doublet) antenna
15	The Off-Center-Fed Dipole ("OCFD"; sometimes called "Windom")
17	The Current-Sums Antenna (“CSA”)

This chapter takes a brief look at each of these antennas and introduces the **CSA antenna**, an improved Off-Center-Fed Dipole, which will be explained in detail in later chapters of this book.

All of these antennas listed here are usually mounted horizontally. A key factor in efficiency for all horizontal antennas is *height above ground*.

HEIGHT = MIGHT

The biggest limiting factor for obtaining height is weight. Unless one owns a very tall tower, weight must be an important considerations when selecting a multi-band antenna.

Other important considerations include complexity and cost, as well as all of the points listed above under "OTHER CHANGES."

For portable use, ease of erecting the antenna is also important.

The author is a dedicated follower of the "KISS" philosophy:

KEEP IT SIMPLE, STUPID.

This is reflected in his personal opinions, which follow the descriptions of each of these antennas, **beginning on the next page.**

"YOUR" MILEAGE MAY VARY!

DISCLAIMER:

The drawings below are for the purpose of discussing their advantages and disadvantages. Most drawings show concept (only).

The author takes no responsibility for the accuracy, nor content.

They should not be used as plans for building these antennas.

DO YOUR OWN DUE DILIGENCE!

The "Morgain" Antenna

The Morgain is a dual-band antenna, primarily used on the low bands; i.e., either 160/80m, 80/40m or 40/20m. It is kind of a folded dipole whose overall length is approximately the same as a dipole for the higher of the two bands.

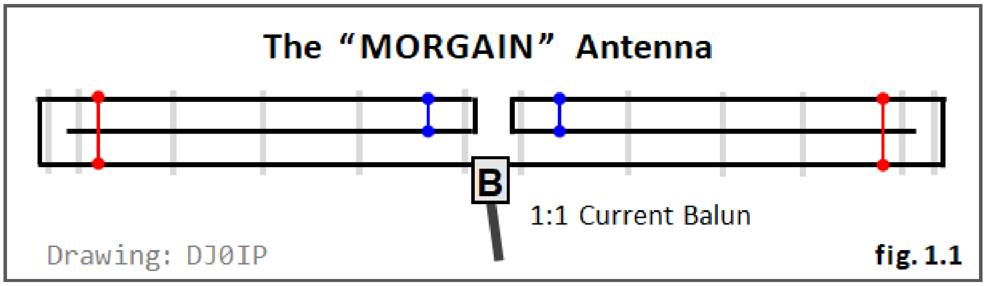


fig. 1.1

Advantages: This is a simple and cheap antenna consisting of only wire, a balun, and spacers. There are no traps or coils required. It requires just half the space of that of a full-size dipole for the lower of the two bands.

Disadvantages: It only covers two bands and the two bands must be adjacent harmonic bands. It has reduced bandwidth on the lower band. It is also a bit cumbersome to build.

OPINION: For the author, the construction of this antenna is too complex for covering just two bands. It takes a lot of handwork to construct. If higher bands are not required and space is limited, it is worth considering. If enough space is available, a full-size dual-band "Fan Dipole" is a better solution.

The "W3DZZ" and "G8KW" Antennas

The W3DZZ antenna is a simple 80m trap dipole with just two traps. It was claimed to cover all hf bands; albeit, before the WARC bands were allocated. People often used it without a balun, but like any (and every) dipole, it is better to use a balun.

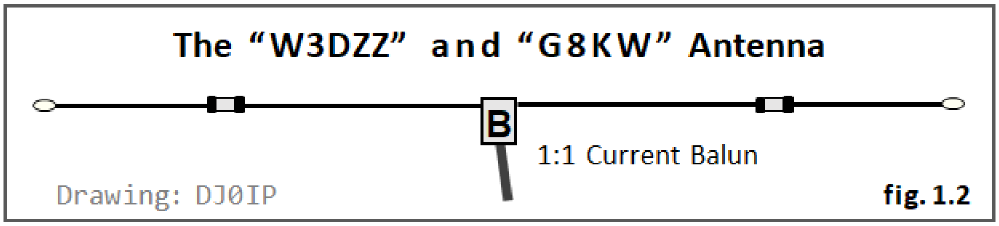


fig. 1.2

Advantages: The W3DZZ has a single radiator wire. It does "work" on most bands, although it will require an antenna matchbox on some bands. It was very popular as just an 80/40m antenna. It is about 6½ meters (ca. 20 ft.) shorter than a full-size 80m dipole, which is useful when space is limited.

Disadvantages: The dimensions used in the original US version were better suited for Region-2 operation, where the 80m privileges include the 75m band. It resonates above the ham band on 10m.

G8KW later designed a similar antenna with dimensions better suited for Region-1 operation. It resonates at the top end of the 10m band.

Like all 80m antennas that are used for working higher bands, the radiation lobes of both antennas on the higher bands split into multiple, smaller lobes, with deep nulls in between the lobes.

Unfortunately, traps, especially high-power traps, add a lot of additional weight. Thus, thicker (heavier) wire is required. Most traps tend to degrade after several years of use, causing losses to slowly increase.

OPINION: The author used this antenna for a few years, 50 years ago, but only for 80/40m. An antenna matchbox is required for covering the entire 80m band, but this is true, even for a standard 80m dipole. In order to run higher power, large heavy traps are required, which is counter-productive for use with today's low-cost, lightweight telescoping fiberglass poles. In the author's opinion, this is its biggest disadvantage, because **HEIGHT = MIGHT**.

The "Trap Dipole" ANTENNA

The Trap Dipole antenna was once a very popular multi-band antenna, especially when only 2 or 3 bands were required. It is similar to the W3DZZ and G8KW antennas, but has a separate pair of traps for each hf band.

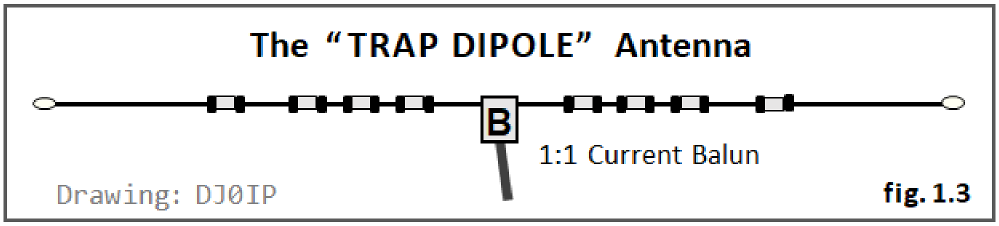


fig. 1.3

Advantages: Theoretically, it can cover as many bands as you like; again, as long as you have a pair of traps for each band. The resonance of each band may be adjusted independently of the other bands.

Unlike other multi-band antennas based on an 80m dipole, the radiating lobes of the higher bands do not split up into multiple smaller lobes. It has the same radiation pattern as a standard dipole on all bands. In some cases this can be a big advantage.

Disadvantages: The most obvious disadvantages can be seen just by looking at it; complexity, weight, and cost. In addition, it is narrow banded, especially on 80m. Traps have loss, and the more traps in the antenna, the more loss you will have. Traps often tend to degrade over time, and losses increase.

Though popular before the WARC bands were issued, trying to cover ALL hf bands now days requires 14 of traps! This is very expensive, and dreadfully heavy.

OPINION: The glory days of the Trap Dipole are gone. Unless one only needs to cover two or three bands, it is simply too complex and too heavy.

Exceptions are Trap Dipoles built with lightweight Teflon-insulated coax traps; i.e., the **Kelemen Dipole**. However, it is still narrow-banded, and expensive.

The "FAN DIPOLE" ANTENNA

The Fan Dipole is a very popular multiband antenna, *with mechanical and cosmetic issues*. It consists of multiple dipole antennas, one for each band, each fed by a common feedline (preferable through a 1:1 current balun).

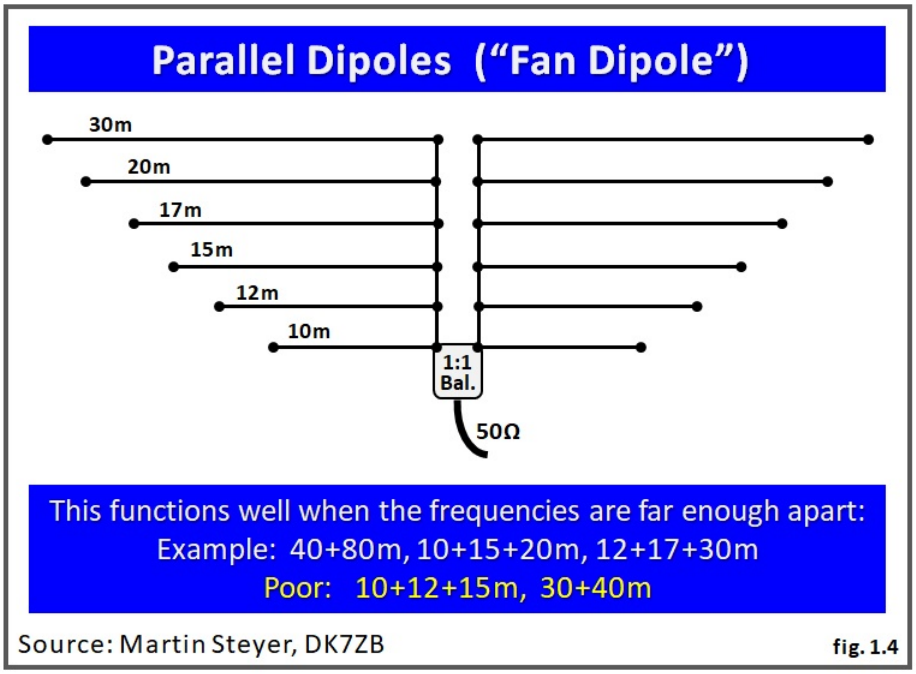
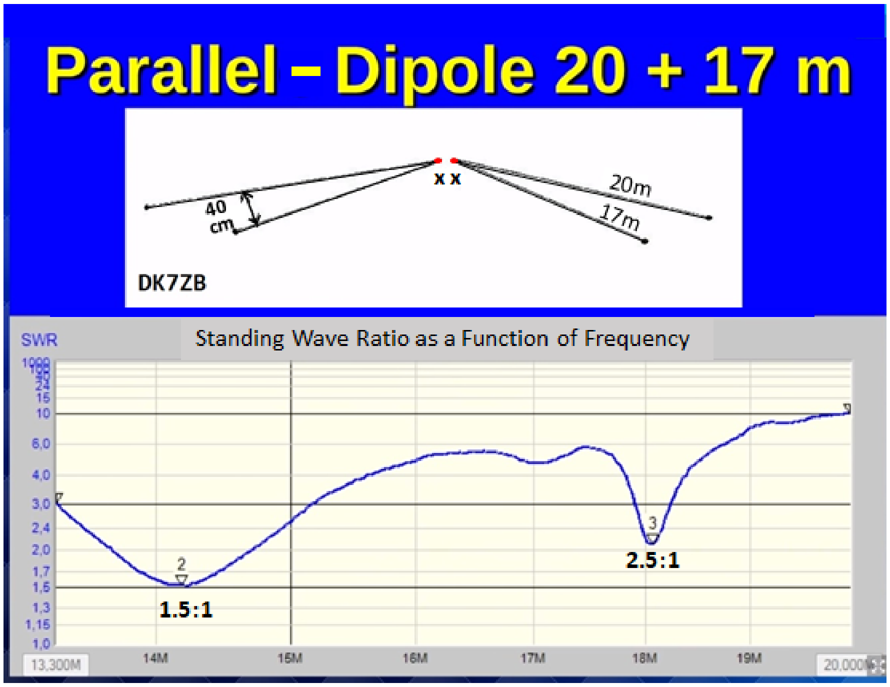


fig. 1.4

Advantages: Each band has its own dedicated half-wave dipole; each dipole radiates just like a standard dipole (at the same height). The radiation pattern is the typical "figure-8", broadside to the radiator wire.

Apparent Disadvantages: Whenever several bands are desired, it requires an awful lot of wire. This can be a real eye-sore for neighbors and even your own family members. When several bands are required, it is quite complex.

Hidden Disadvantage: Whenever any two bands are too close together, there is interaction between them, causing one of the two bands to have higher than normal SWR. An example with a 20m and 17m fan dipole are shown below (on the next page):



Source: Martin Steyer, DK7ZB **fig. 1.5**

Normally, both dipoles should have about the same SWR (i.e., 1.5:1). When the two frequencies are too close together, interaction between the two antennas often degrades the SWR on one of the antennas, as seen in fig. 1.5 above. This characteristic limits the flexibility when using Fan-Dipoles, although it is not serious; 2.5:1 is still an efficient antenna, albeit, you may need to use the transceiver's built-in ATU, or an external antenna matchbox.

OPINION: Technically, this is a good solution, provided no two bands are too close together. This is definitely not a KISS solution when several bands are desired. It requires a lot of wire if you want to cover lots of bands.

It is also impractical as a portable antenna, due to its complexity. However, I have often used a two-band fan dipole when only two bands were needed.

The "G5RV" and "ZS6BKW" Antennas

Although Louis Varney, G5RV is credited with having developed this antenna in 1946, and publishing it in 1958, its roots actually date back to 1936. This antenna is described on pages 22 & 25 of *The RADIO ANTENNA HANDBOOK*."

At the time G5RV described this antenna, 75 Ohm coax was popular, and transmitters had tubes with a Pi-Network output.

The idea was to provide an antenna having a small amount of gain on 20m and at the same time, be useable on the other bands, albeit with the help of an antenna matchbox.

In 1985, ZS6BKW (G0GSF) published his improved version of the G5RV in *Radio ZS* magazine. His version had several changes, enabling it to be fed with 50 Ohm coax and be used on several bands without an antenna matchbox, even with transistorized transmitters. 80m requires a matchbox.

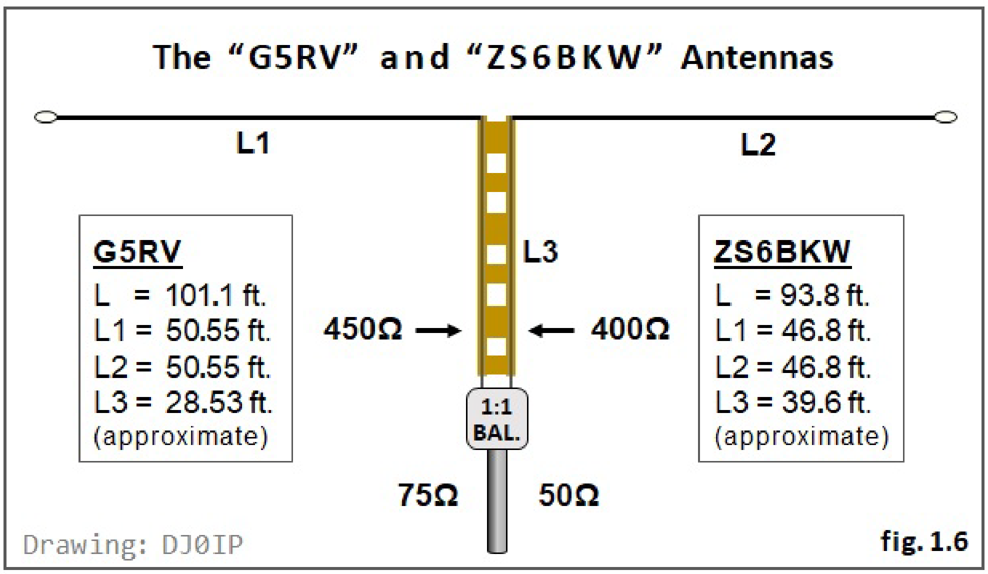


fig. 1.6

The ZS6BKW version is about 7 ft. shorter than the G5RV, but requires an 11 ft. longer openwire feedline. The G5RV required a balun; it was "claimed" that the ZS6BKW *'usually' did not* need a balun. That was perhaps OK in 1985 but today, a good current balun should always be used.

Advantages: Both antennas have a single radiator wire, and are quite a bit shorter than a full-size 80m dipole. They are simple, and low cost. The heavy balun can be mounted/supported a good distance below the radiator – an important feature when mounting on a telescoping fiberglass pole. they work most hf bands, albeit, an antenna matchbox will be required on some bands.

There is no need to run the openwire feedline all the way to the shack. In many cases, running coax cable is more convenient/desirable.

Disadvantages: Both have slightly reduced performance on 80m, though it is claimed that the G5RV works slightly better than the ZS6BKW on that band. Although the ZS6BKW is claimed to work several bands without an antenna matchbox, apparently this is only true when fed with a long coax.

More important, **all dimensions are critical**. The length of the radiator wire must be changed if you do not use the identical wire as shown in the plans. Thicker wire will require the radiator to be longer, thinner wire requires it to be shorter. The length of the feedline will change if you do not use the identical feedline that the author used (i.e., THE WIREMAN "Model 544").

Published velocity factors for different feedlines are not always accurate. Suppliers change, or their procedures change and velocity factors change. It may require a lot of trial and error to adjust the antenna for these changes.

L.B. Cebik wrote of this antenna, "There are too many situational variables for me to do much more than mislead someone." See link under "Resources" below.

OPINION: Clearly the ZS6BKW is the better choice than the G5RV. However, unless you can replicate the antenna using the identical radiator wire and feedline, the antenna will not work as designed, thus requiring a lot of pruning, or the use of an antenna matchbox.

I tend to agree with L.B. Cebik. There are too many variables in the design to be able to predict the exact results. ***Tryer Beware!***

Finally, when running openwire feedline, I prefer to just run it all the way to the shack and straight to an antenna matchbox.

Resources:

- "The RADIO ANTENNA HANDBOOK", 2nd Edition, p. 22 & 25, published by the engineering staff of "Radio Magazine" in 1936.
- The G5RV Antenna System Re-Visited (Part 3) – by L.B. Cebik
  - http://www.k2ck.us/g5rv.pdf
- ZS6BKW vs G5RV, by Larry James LeBlanc, W5DDL
  - https://www.w5ddl.org/files/Zs6bkw_vs_G5rv_20100221b.pdf

The "End-Fed" Antenna

Currently one of the most popular multi-band antennas.

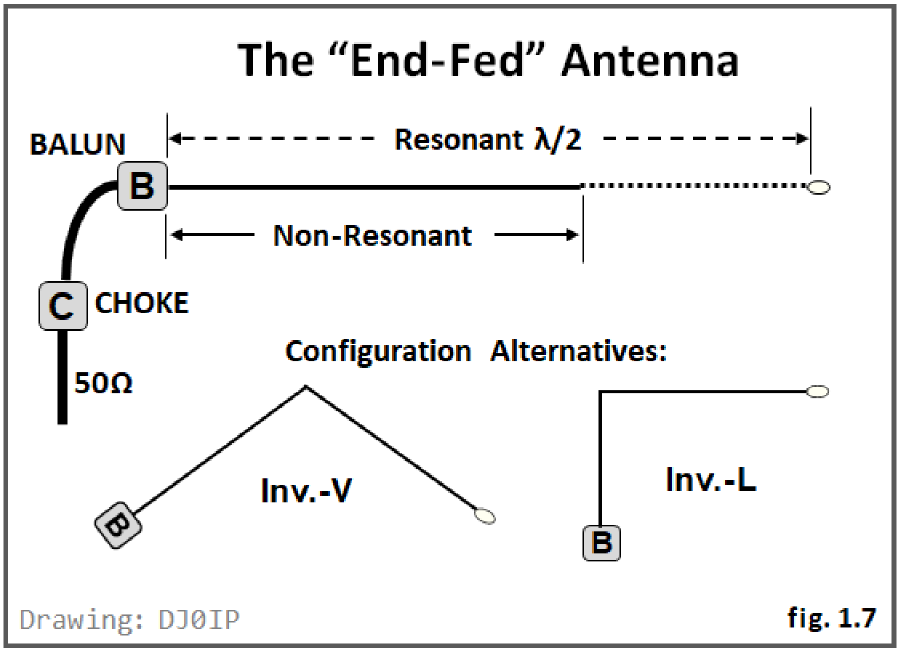


fig. 1.7

Pictured in fig. 1.7 above are three typical configurations for End-Fed Antennas. Each has its own set of advantages and disadvantages.

A counterpoise (not shown in the drawing) is always required, although there are different ways of implementing this.

Fundamentally, there are FIVE types of end-fed antennas:

1) a random, non-resonant length of wire fed through a balun with a high transformation ratio (i.e., 9:1),
2) a resonant half-wavelength of wire, fed through a balun with a high transformation ratio, (i.e., 49:1 or 64:1),
3) a resonant half-wavelength of wire, fed through a tuned circuit (also known as the "Fuchs" (Eng. "Fox") antenna); but this is typically just a mono-band antenna,
4) a resonant half-wavelength of wire, fed through a quarter wavelength of openwire feedline – (also known as a "Zeppelin" Antenna).
5) a resonant half-wavelength of wire on the lowest band to be covered, matched with a high-impedance antenna matchbox (i.e., L-Network).

All share some of the same advantages and disadvantages.

Advantages: Probably the simplest form of multi-band antenna there is. It is low cost, simple to build (just buy a balun and attach a wire), simple and rapid to erect: tie a rope to its middle and throw the rope over a tree branch. In many cases, they do not even need an antenna matchbox to work many/most bands. You might say it's "idiot-proof."

Disadvantages: There are three disadvantages of all of these antennas:

1) Although the radiator is efficient, there are often high losses associated with the impedance matching.
2) Due to feeding at its highest possible impedance, there are very strong electric and magnet fields near the feedpoint. This can play havoc with consumer devices in your house and in the neighborhood, even at moderate TX power levels.
3) Receiver Noise! Grounding and using RF chokes may help a little, but usually fail to eliminate this noise.

Although QRP users swear by this antenna, mainly for its simplicity, running high power with it with the feedpoint near the house will tear up every consumer device in the house. The operator sometimes incurs RF burns.

The only thing that helps issues 2 and 3 above is to move the feedpoint as far away from the shack as possible. **If you can do this, then you can probably erect a much better antenna instead of this one.**

OPINION: For home use, this is one of the worst antennas you can choose, unless nothing else works at your QTH – i.e., you live several floors up in a large apartment house and can only run a wire to a tree.

There are many variables affecting the installation, thus affecting the potential for RF issues in the shack. Just because a few users claim they have no problems, that does not mean these problems do not exist.

Although a few users brag about the DX they have worked with this antenna, that doesn't mean it is efficient. After all, *Everything 'Works'*.

I have three commercial End-Fedz antennas (resonant half-wavelength) which I sometimes use for portable work – in the field, far away from consumer devices. I use these because they are convenient . . . and I am lazy.

Resources:

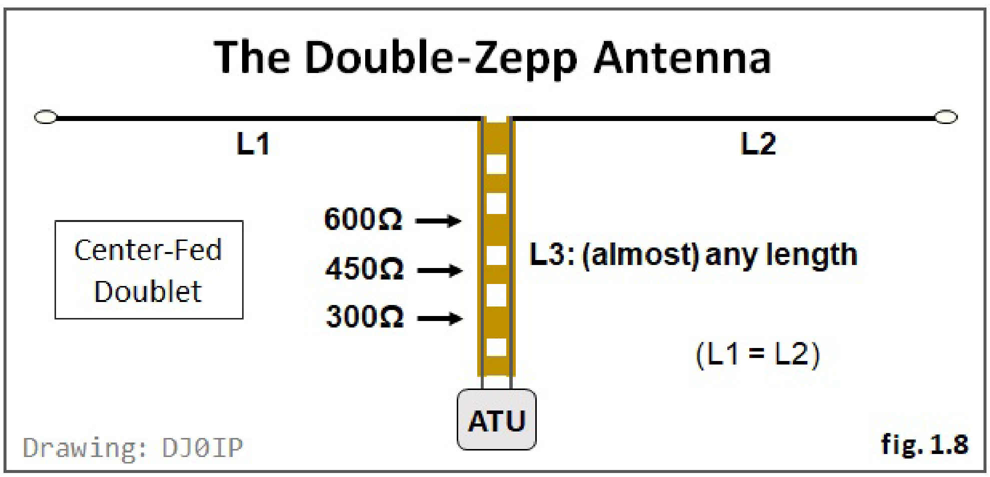
- Tom Rauch, W8JI . . . on "End Fed Halfwave"
    - https://www.w8ji.com/long_wire_antenna.htm

The Double-Zepp Antenna (D-Z)

Although this is its most popular name, many people find is a misnomer. It is more correctly called an "Openwire-Fed-Doublet", or "Openwire-Fed-Dipole." Some people simply call it a "Doublet", assuming everyone knows it is openwire fed. This is confusing to old timers; 60+ years ago, dipole antennas were typically called doublets.

The Double-Zepp antenna was one of the most popular antennas in the first half of the 20th century. It later fell out of favor with the ham radio community, perhaps because the price of coax cable dropped and at the same time, E.F. Johnson ceased building their famous Viking K.W. Matchbox.

When the WARC bands (30/17/12m) were allocated in the late 1980s, increasing the number of hf bands, the Double-Zepp seems to have arisen from the ashes and once again become one of ham radio's favorite multi-band antennas.



The most popular version of this antenna was the λ/2 doublet, fed in the center. It is basically a dipole fed with openwire, rather than coax. It does not require a balun at its feedpoint.

Advantages: ALL-BAND coverage with a single radiator, albeit, a <u>very good</u> antenna matchbox is required on every band. This was especially useful once the 3 new WARC bands were allocated giving us a total of 8 hf bands.

It is lightweight (no heavy traps, baluns, or coax), enabling it to be erected high on lightweight push-up fiberglass poles. It is also inexpensive, easy to build, and easy to erect. Its single radiator wire, when kept thin, is nearly invisible to the neighbors. Because the antenna is fed in the center, common mode current issues are lower than with off-center fed antennas.

Disadvantages: Its biggest disadvantage is the requirement to use an antenna matchbox on all bands, compounded by the need to match a very wide range of impedances. Although the feedpoint impedance is about 50 to 70 Ohms on its fundamental frequency, its second harmonic band can have an impedance of 3k or 4k Ohms. Higher harmonic bands have somewhat lower impedance but are still in the kilo-Ohm region. This is further complicated by transmission line transformation (TLT) which, depending on frequency and feedline length can transform the impedance very high or very low. In other words, the impedance can be (and is often) all over the map with this antenna. Thus, "choice of antenna matchbox" is key to the success of all-band operation.

A potential mechanical disadvantage is, openwire transmission line does not function properly when lying on the ground, nor can it come in contact with anything metal. This sometimes prohibits using the Double-Zepp antenna.

Occasionally, with some feedline lengths, some bands will fail to find a good match. In that case, you must add more feedline to the antenna system. Typically, λ/8 to λ/4 additional feedline (on the band with high SWR) is enough to bring the impedance into matching range.

Like all multi-band antennas that are a half wavelength long on a low band, the horizontal radiation lobes on higher bands will split up into multiple, smaller lobes, with deep nulls in between the lobes.

COMMENT: It has been proposed by several users to shorten the antenna somewhat, thus lowering the impedance on the higher harmonic bands. Shortening the overall length by 20% reduces the impedance matching requirements significantly, with very little loss of signal on the fundamental band. Reducing by 30% works as well, but with slightly higher losses. Both solutions usually place the impedance matching requirements of the antenna within the range of nearly all manual antenna matchboxes and many auto-tuners.

OPINION: This was the author's "go-to" all-band antenna for 50+ years. As long as it is used with an antenna matchbox having a wide matching range, and large enough components to be efficient, it will usually work well on all bands; albeit, you may sometimes need to adjust the length of the feedline when one or more of the bands do not find a good match.

This need to re-tune the matchbox with each band-change is the main reason I now prefer the OCFD antenna. Also, at my current QTH, I was unable to run openwire feedline through the air – for cosmetic reasons.

The Off-Center-Fed Dipole (OCFD)

The OCFD antenna is often [falsely] called "Windom", even by some commercial vendors of this antenna. The Windom was a single-wire-fed Hertz antenna dating back to the 1920's.

This half-wave dipole is fed off-center with coax, through a balun. Traditionally, it was fed 33.33% from either end. Different commercial vendors offer versions fed at a slightly different feedpoint, but very near the 33.33% position.

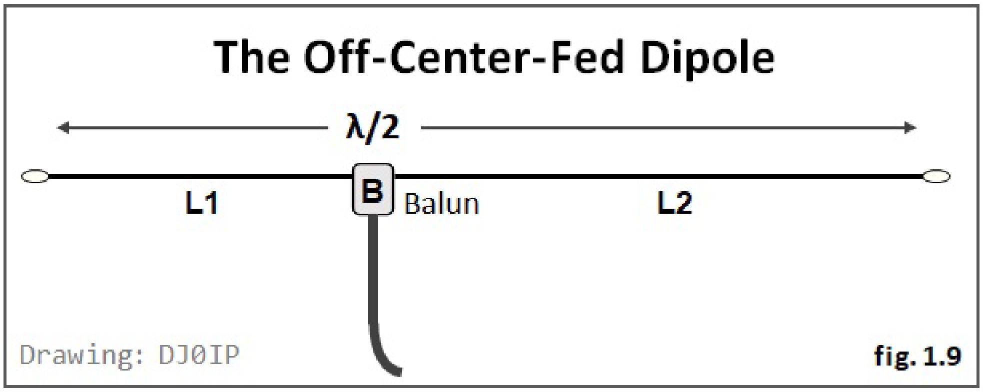


fig. 1.9

Advantages: This is a very simple multi-band antenna that is relatively simple to build, albeit, care must be taken to use the correct balun. Because it has no traps or coils, it may be built very lightweight, enabling it to be mounted high onto lightweight telescoping fiberglass poles.

HEIGHT = MIGHT!

Disadvantages: The biggest disadvantage of this antenna is, the Internet is full of bogus information about how to build them, especially concerning the balun. This will be discussed in detail, later in this book.

As a result, most OCFD antennas use a poor balun, resulting in common mode current flowing on the outside of the coax. This skews the resonance and the radiation pattern of the antenna, and often causes RFI havoc in the neighborhood.

An additional disadvantage of the traditional design (i.e., feedpoint = 33.33%) is that the antenna does not cover 30m nor 15m. At this specific feedpoint, the RF current on 30 and 15m bands crosses the zero axis. Thus, the impedance is sky-high, resulting in very high SWR. Operating the antenna on these two bands with the assistance of an antenna matchbox is inefficient, and often results in damaging the balun.

Further, these antennas are highly prone to generating common mode current, especially when the installation is less than perfect. Surrounding objects or a feedline run diagonal to the antenna can cause serious common mode current issues. For this reason, choice of balun is so very important, yet that is what most people, even commercial vendors, usually get wrong.

Finally, like all other low band dipoles, the radiating lobes on higher bands split into multiple, smaller lobes with deep nulls in between them. Although this sounds bad, in real-life, due to most antennas being low to the ground and reflections from houses and other objects near the antenna, the nulls tend to fill in somewhat, making communications between the lobes possible.

OPINION: This has all the potential of being an outstanding multi-band antenna, “if” it is built properly. “How to build it properly” is the main subject of this book, and suggested in the “CSA” below.

The Current Sums Antenna (CSA)

An improved Off-Center-Fed Dipole antenna.

The Current Sums Antenna is a concept developed by Karl H. Hille, DL1VU (SK), and described in his German-language book, entitled *Windom- und Stromsummen-Antennen.* (ISBN 3-910159-14-1)

This version of the OCFD is well known among German-speaking ham radio operators, but little known among non-German-speaking hams. Indeed, it is also described in the popular *Rothammels Antennenbuch* – (see References below).

The **Current Sums Antenna** is to the OCFD antenna, what the ZS6BKW is to the G5RV antenna; a newer, better design that works more bands without the need for an antenna matchbox.

Its main differences are the position of the feedpoint such that RF current on any desired band is not crossing the zero axis at that point, and careful selection of a balun and choke combination.

When it is properly designed, it will usually cover 6 or 7 of the hf bands without the need for an antenna matchbox, and the SWR is low enough on the other hf bands that it may be used on these with an antenna matchbox without damaging the balun.

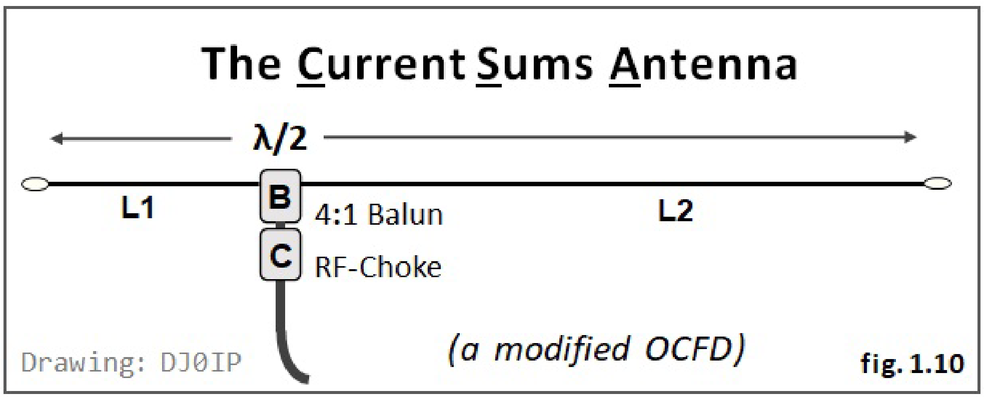


fig. 1.10

Advantages: The main advantage was stated above in the description of the antenna. It has a low SWR on the 15m band, which is very important for contesters and DXers. Some feedpoints have a also have a low SWR on 30m.

By carefully choosing the feedpoint such that none of the bands have their RF current crossing the zero axis at that point, the antenna may be used with an antenna matchbox on bands having higher SWR without damaging the balun.

Its single radiator, when kept relatively thin, makes this multi-band antenna nearly invisible to non-hams.

It can be built extremely lightweight, enabling it to be mounted high onto a lightweight telescoping fiberglass pole. **Remember: HEIGHT = MIGHT !**

Disadvantages: There are several good feed points to choose from, each having advantages and disadvantages. Which one the user should choose depends on which bands are favored most. This is a complex decision, best made by consulting antenna modeling data – published in monster-size Excel spreadsheets. OR… by simply by reading the rest of this book, where all of this will be explained in detail. In other words, users must inform themselves before choosing.

Some of the feedpoint positions (in percentage from the end of the antenna) that work well for 80m OCFD do not work well on a 40m OCFD, and vice versa. This is unknown or ignored by many first-time builders, leading to poor choices.

Finally, *and this is for many people the hardest part*, when building the antenna, the user must **follow directions exactly**, as per lengths, feedpoint position, and choice of balun/choke. **WHY** this is important will be explained in later chapters of this book.

OPINION: After using the Double-Zepp (D-Z) for 50+ years and the CSA for 10 years, the CSA is now the author's favorite multi-band antenna when a single antenna covering as many bands as possible is required. Several other hams have switched from the D-Z to the CSA and all agree.

The main difference between the D-Z and the CSA is, the CSA does not require an antenna matchbox on most bands, whereas the D-Z requires a matchbox on every band. In some cases, feeding with coax rather than openwire is advantageous.

The only time it makes sense to return to using the D-Z is when there is not enough space for installing a full-size antenna. Whereas the D-Z works well at 80% of full-size and even fairly well at 70%, the CSA always requires a full half-wavelength on its fundamental band.

Resources (English):

- **Funkamateur Magazine** review of the Aerial-51 Model 807-L (CSA) antenna.

  - https://www.aerial-51.com/model-807-xx/magazine-reviews/funkamateur/

- **RadCom Magazine** review of the Aerial-51 Model 404-UL (CSA)
  - https://vk5pas.files.wordpress.com/2013/05/radcom-test-of-aerial-51-model-404-ul-s.pdf

- **QST Magazine review** of the Aerial-51 Model 404-UL (CSA)
  - http://www.arrl.org/files/file/ProductReviewsForDeb/2016/pr052016.pdf (you must be a member of ARRL to view this)

Resources (German):

- ***Windom- und Stromsummen Antennen***, Karl H. Hille, DL1VU.
  - ISBN 3-910159-14-1

- Any recent issue of ***Rothammels Antennenbuch***
  - 12th edition, page 227.
  - For other editions, see index for the correct page in your specific edition.

CONCLUSION:

The good news is, hams now days have many options to choose from. Modern material used in components (i.e., thin Copper-weld wire, Teflon insulation, plastic, fiberglass, etc.) enable building multi-band antennas that are low cost, lightweight, nearly invisible to non-hams, and may be erected high into the air – provided one chooses the right multiband antenna.

There are no winners or losers among the antennas presented here. Each has its own set of strengths and weaknesses. Different users will have different winners.

Therefore, it is important that operators carefully define their requirements, then considers all of the advantages and disadvantages of each antenna listed above.

The CSA is the newest addition to this group of antennas. The following chapters of this book will show the logical progression from the classic OCFD to the CSA, and describe in simple terms, why it works like it does and how to **d**o-**i**t-**y**ourself, rather than buy one.