Welcome to the

Aug 10, 2022

issue of

Radio World Engineering Extra

FUTURE

Flared skirts offer options for grounded tower feeds

Dawson and Cox on umbrella-spoke feed for grounded medium-wave antenna towers

Writers

Benjamin F. Dawson III
P.E.
Hatfield & Dawson Consulting Engineers LLC

Bobby L. Cox II
Ph.D.
Kintronic Laboratories Inc.

This paper was presented in the 2022 NAB Broadcast Engineering and IT Conference. Proceedings are available at *https://nabpilot.org/beitc-proceedings/*.

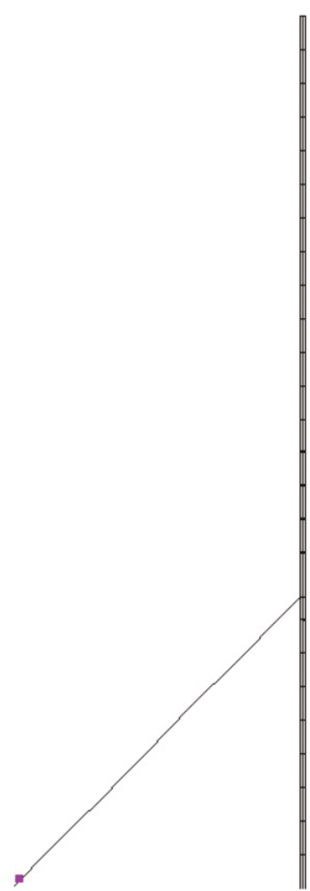
The increasing use of single antenna systems for multiple frequencies and use of medium-wave antenna structures for mounting antennas for other uses has led to the exploration of alternative methods for feeding grounded towers.

While the simple skirt feed with multiple parallel wires insulated from the tower is fairly common, other methods such as slant-wire feeds and skirts with other geometries offer substantial advantages.

The simple skirt feed has shortcomings that can be eliminated by the use of flared skirts, which extend from at or near the tower top to a location near midpoint on a guy wire and then back to a common connection near the tower base. The advantages are that the skirt wires need not add substantial compression load to the tower or be supported by multiple insulators, and that in general their impedance bandwidth is excellent. The flared skirt also has less long-term maintenance concerns and is less obstructive to tower climbers and to installations of other services on the tower.

Flared skirt systems exhibit vertical radiation patterns that are essentially the same as base-fed antennas of the same height, and do not generate excessive horizontally polarized radiation.

Right
Fig. 1: Traditional skirt feed geometry



Far right
Fig. 2: Slant wire feed geometry

Antenna Tower Feed Systems

While the base-fed monopole tower has been the most common medium-wave antenna since the 1930s, antenna towers grounded at the base have also been employed in many installations. Grounded tower antennas have essentially the same electrical behavior (pattern characteristics) as base-fed antennas of the same electrical length.

Straight Wire Skirt Feeds Parallel to Towers

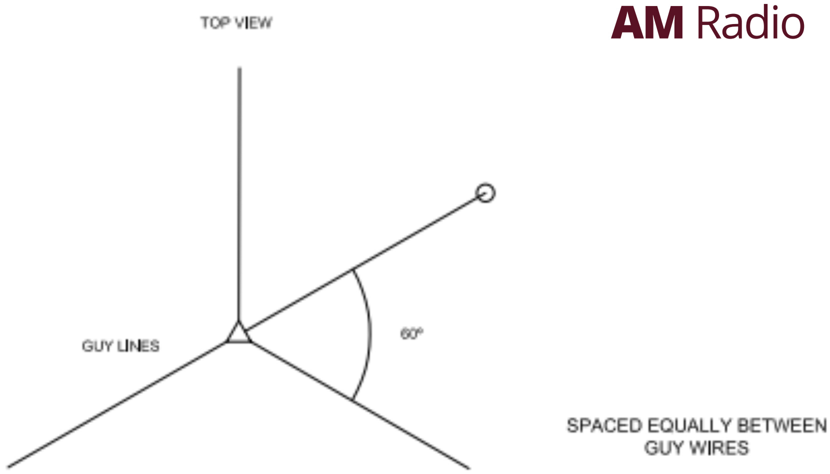
The most common method of feeding the grounded tower employs wires connected to the tower at an elevated location, most commonly a skirt of several wires, roughly parallel to the tower face, as shown in Fig. 1.

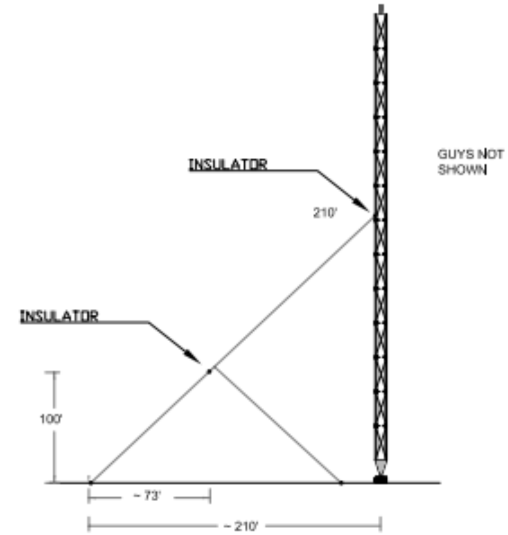
Traditional skirt feeds have several unfortunate characteristics. The skirt must be kept at a constant spacing from the tower to avoid impedance changes in windy conditions. This can require the use of numerous insulators between the skirt and the tower, or substantial tension on the skirt wire. The wire tension adds additional compression load on the tower legs. The use of insulators adds weight and wind loading, and can obstruct other installations on the tower.

They can also be a maintenance issue, requiring periodic cleaning, and they can obstruct tower climbing.

The spacing of the skirt from the tower and the number of skirt wires are critical for impedance bandwidth. In some cases the design can result in poor performance because of inappropriate choice of insulator length or tuning stub location.

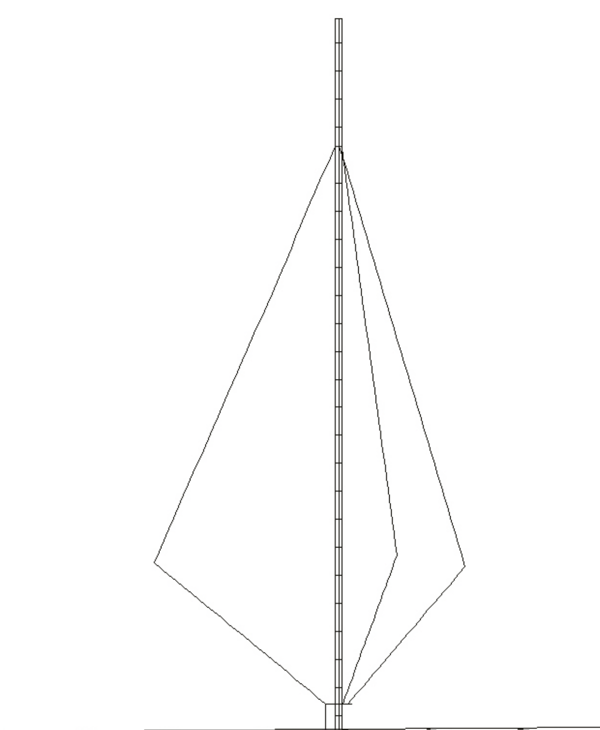
A particular concern often caused by insufficient spacing between the skirt wires and the tower is impedance changes caused by icing. Even a very small skin of ice can result





Above, left and right
Fig. 3: STA antenna using single umbrella-spoke skirt wire

Below
Fig. 4: The flared skirt feed



in considerable impedance change under some conditions.

Slant Wire Feeds

Slant wire feeds, which have been used since the 1930s, are a simple feed system solution for grounded towers in the quarter wavelength range.

They are simple to install, and structurally minimal. However, for towers much over 120 degrees in height they result in high angle radiation pattern distortion. They also have a ground level high voltage point, at their feed location, distant from the tower base area, as shown in Fig. 2 on page 6.

They are the most economical method of feeding a grounded tower. Their only complexity is in high-power installations where the slant wire needs to be a ribbon or bundle to reduce surface voltage gradients well below corona levels.

Single Parallel Wire Feeds

A single wire, extending along the tower structure, connected at the top and insulated from the tower as it descends (like one wire of a conventional skirt), can also be used to drive a grounded tower. It can be visualized as one half of a folded dipole, with unequal diameters.

This design can be a good emergency antenna but generally will have relatively narrow bandwidth impedance characteristics.

Single Wire Umbrella-Spoke Feeds

The single wire "umbrella spoke" feed is sometimes used as an emergency or Special Temporary Authority ("STA") antenna and is a good solution for that purpose, such as shown in Fig. 3.

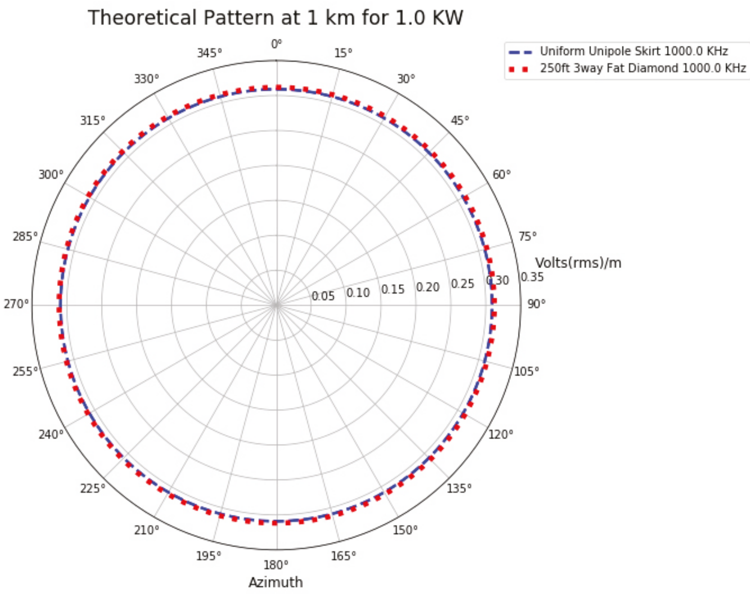
Examples have also been constructed with the geometry carefully modeled so as to have a purely resistive input impedance. Others have used guy wires on HF curtain antennas or have been supported by grounded FM towers. But this feed arrangement suffers from high angle radiation pattern distortion if used with taller towers, and can produce non-circular horizontal radiation patterns.

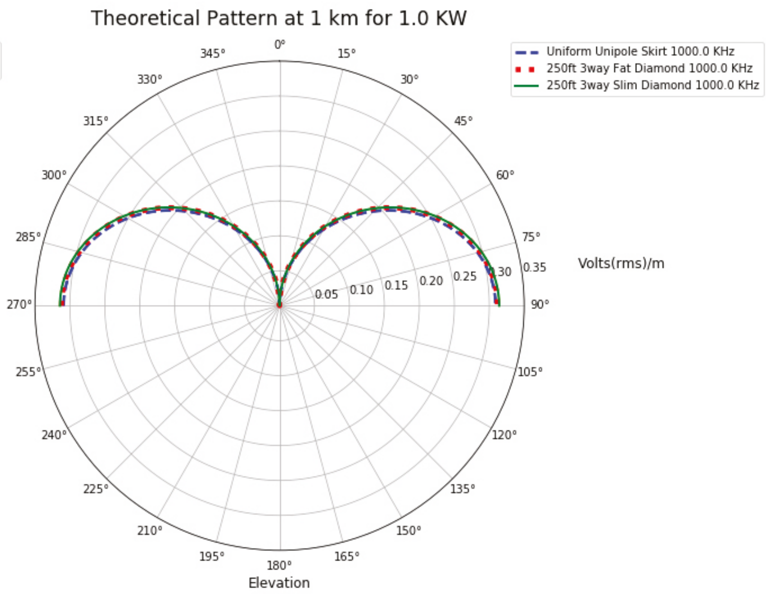
Flared Skirt or Umbrella-Spoke Feeds

The flared skirt with multiple wires, usually three for triangular towers and four for square ones, has significant advantages over all other methods of feeding a grounded tower as an efficient wide-bandwidth radiator.

The flared skirt, as shown in Fig. 4, does not require tower attachment except at its top and (if mechanically convenient) bottom ends. It can be configured so that it's used as part of one of the uppermost guy levels. Its additional structural load is largely just the weight of the necessary cables, with no extra compression load on the tower legs. Because there is no requirement for intermediate support insulators, there is easier access to other antennas and hardware on the tower, and maintenance is reduced.

One minor disadvantage is that the skirt wires need to be "clocked" from the primary guy wire directions to avoid contact with the lower guy levels. Intermediate azimuths 60 degrees from the adjacent guy orientations can be used, but much smaller offsets of just a few degrees are also possible. This requires additional anchors, but unless the skirt support is also used as a primary upper-level guy, this anchor is far less substantial than the anchors for the main guy cables.





Above left
Fig. 5: Horizontal plane pattern

Above right
Fig. 6: Vertical patterns

Frequency Allocation Considerations

While the RMS efficiency of an MF or LF antenna (directional or non-directional) is a significant characteristic in determining the value of the antenna, the radiation pattern, both vertical and horizontal, is of critical importance in its fit to the allocation requirements for operation.

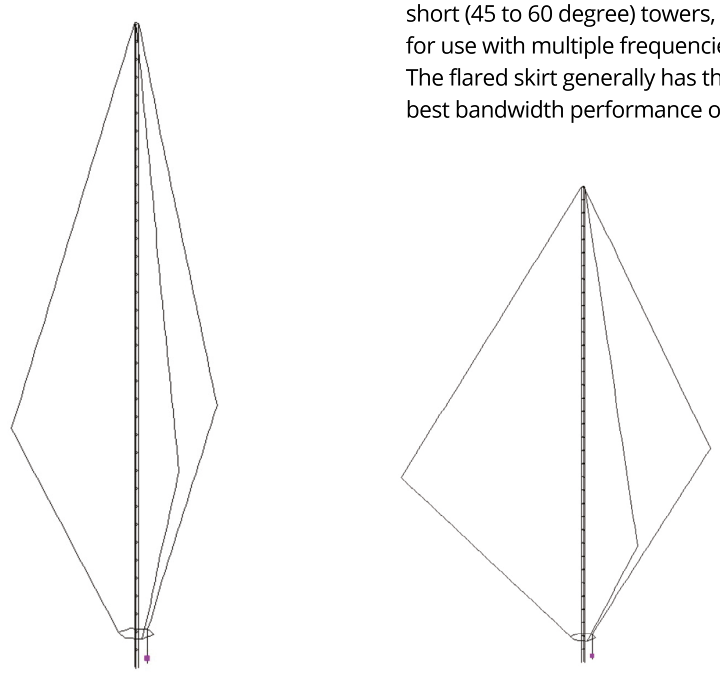
The horizontal plane circularity of flared skirt antennas is generally well within ±1 dB or less, which is within the accepted definition of omni-directional operation [see 47CFR1.30002(a)]. Vertical pattern characteristics of a flared skirt antenna or of multiple tower directional antennas employing flared skirts are nearly indistinguishable from the patterns of base fed antennas of the same electrical height.

Impedance and Bandwidth Characteristics

Electrically, the significant advantage of the flared skirt is superior impedance bandwidth characteristics. This is of substantial value for very short (45 to 60 degree) towers, or for use with multiple frequencies. The flared skirt generally has the best bandwidth performance of any feed system for short towers and has significantly better impedance characteristics than conventional vertical wire skirts.

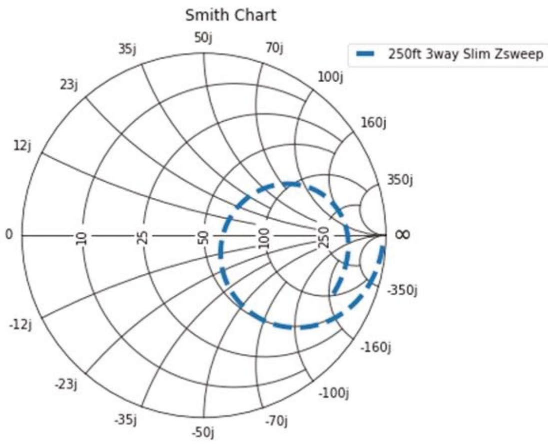
Two examples of flared skirt antennas are shown in Fig. 7. The example on the left is a "Slim" flared skirt and the one on the right is a "fat" flared skirt. The enhanced bandwidth qualities are more pronounced with the wider flared skirt.

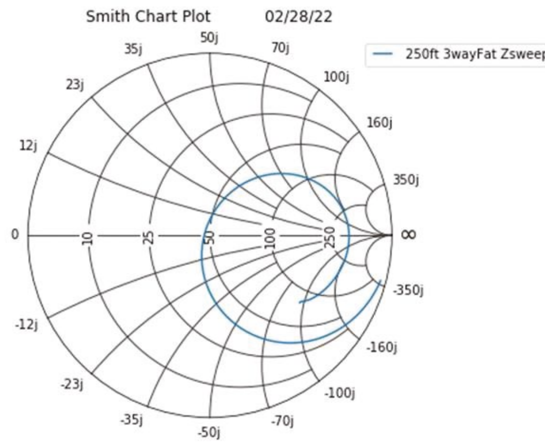
Note that as the skirt is made more and more slim, the design

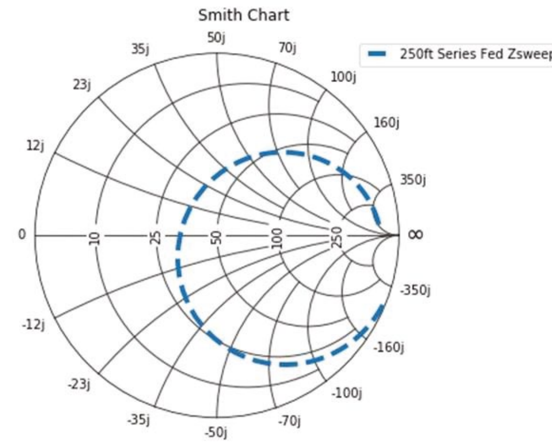


Below left
Fig. 7: Small and large angle of skirt and tower

> **The flared skirt with multiple wires has significant advantages over all other methods of feeding a grounded tower as an efficient wide-bandwidth radiator.**







approaches the case of the traditional straight skirt fed "folded unipole" antenna, and the wideband characteristics diminish significantly.

A good proportion for a wide flared skirt antenna is to have the individual folds of the antenna form roughly a 3-4-5 triangle with the tower being the longest length of the triangle, the upper half of the skirt being the "4" and the lower half of the skirt being the "3" of the triangle. This wide flare can be achieved using anchors for the cables that tension the skirt elements placed no further from the tower than the uppermost guy anchors.

If this wide flare is not achievable, then the more narrow flare is still a significant improvement in bandwidth characteristics over the traditional skirt fed system.

The midband VSWR values for the flared skirt are several percent better at ±10 and 15 kHz than that of the conventional unipole.

Examples of typical impedances for several feed arrangements are shown in Figs. 8 and 9. The fat skirt definitely works well over the full band for the 250-foot tower height used as the example. The example tower's electrical height ranges from 49° to 147.7° over the frequency range. The series fed tower is too short to be desirable at the lower end of the band for that tower height. The slender skirt is a bit in between, but still quite a bit better than the series fed.

Above
Fig. 8: 530–1695 kHz impedance plots for small and large angle of skirt and tower as well as base-insulated and series-fed tower, all at 250-foot height

Right
Fig. 9: Comparison of normalized impedance characteristics for 250-ft. tower fed with three methods for example frequencies across the AM band

Below
Fig. 10: Calculated vs. measured impedance for a typical flared skirt antenna

Freq. (kHz)	Series Fed Impedance	VSWR	Slim Flared Skirt Impedance	VSWR	Fat Flared Skirt Impedance	VSWR
535	7.7 – j 244.4	4.243	350.9 – j 1403	4.600	43.2 – j 359 .0	3.066
540	7.9 – j 240.2	2.694	283.6 – j 1230	2.838	41.8 – j 341.6	2.121
545	8.0 – j 236.1	1.671	236.3 – j 1093	1.693	40.6 – j 325.4	1.453
550	8.2 – j 231.9	1.000	201.6 – j 982.2	1.000	39.5 – j 310.4	1.000
555	8.4 – j 227.9	1.613	175.3 – j 890.6	1.651	38.6 – j 296.4	1.430
560	8.5 – j 223.9	2.523	154.9 – j 813.6	2.595	37.8 – j 283.3	1.992
565	8.7 – j 219.9	3.756	138.7 – j748.0	3.843	37.0 – j 270.9	2.702
885	28.6 – j 22.9	1.319	58.7 – j 12.2	1.181	57.8 + j 34.4	1.159
890	29.1 – j 20.2	1.200	59.5 – j 8.9	1.115	58.9 + j 37.1	1.103
895	29.6 – j 17.6	1.096	60.2 – j 5.7	1.056	60.0 + j 39.8	1.050
900	30.1 – j 14.9	1.000	61.0 – j 2.5	1.000	61.2 + j 42.5	1.000
905	30.6 – j 12.3	1.091	61.8 + j 0.7	1.055	62.3 + j 45.2	1.048
910	31.1 – j 9.7	1.189	62.7 + j 3.8	1.111	63.6 + j 47.9	1.099
915	31.7 – j 7.0	1.297	63.5 + j 6.9	1.169	64.8 + j 50.6	1.151
1235	98.9 + j173.0	1.118	245.3 + j 157.4	1.080	300.3 + j 130.6	1.076
1240	100.8 + j176.2	1.077	251.7 + j 157.3	1.053	306.6 + j 126.6	1.050
1245	102.8 + j179.5	1.037	258.3 + j 156.9	1.026	312.7 + j 122.2	1.025
1250	104.8 + j182.7	1.000	265.0 + j156.4	1.000	318.7 + j117.4	1.000
1255	106.9 + j186.0	1.038	271.8 + j 155.5	1.026	324.6 + j 112.3	1.025
1260	109.0 + j189.3	1.076	278.7 + j 154.4	1.052	330.3 + j 106.7	1.050
1265	111.1 + j192.6	1.115	285.8 + j 152.9	1.080	335.8 + j 100.8	1.076
1585	484.8 + j404.0	1.080	187.4 – j 211.8	1.107	128.4 – j 141.3	1.102
1590	497.5 + j404.2	1.053	181.4 – j 210.3	.071	124.9 – j 139.3	1.067
1595	510.4 + j404.0	1.026	175.6 – j 208.6	1.035	121.5 – j 137.2	1.033
1600	523.7 + j403.6	1.000	169.9 – j 206.8	1.000	118.2 – j 135.1	1.000
1605	537.3 + j402.7	1.026	164.5 – j 205.0	1.035	115.0 – j 132.9	1.034
1610	551.1 + j401.3	1.053	159.2 – j 203.0	1.071	112.0 – j 130.7	1.068
1615	565.3 + j399.5	1.080	154.1 – j 200.9	1.110	109.0 – j 128.4	1.105

Frequency	Calculated Impedance	Measured Impedance
540 kHz	39.3 + J 41.8	43.8 + J 40.8
702 kHz	116.4 + J 83.9	139.8 + J 78.2

Below
Fig. 12: Base region geometry of a six-wire flared skirt, upper image, and a flared skirt replacing conventional skirt due to instability in icing conditions, bottom image.

Above
Fig. 11: Temporary installation, left, and high-power installation, above.

The example shows that the usable portion of the band is widest with the fat skirt, and that it has noticeably wider bandwidth than a series fed configuration.

The low resistances of the series fed case on the low end of the band are especially troublesome for multiplexing.

Comparisons with measured data show that the NEC impedance calculations for the flared skirt antenna are quite accurate. As an example, see Fig. 10 at the bottom of page 10.

Examples of some real-world flared-skirt installations are shown on this page. Umbrella-spoke towers perform equally well in directional arrays.

Conclusions

The flared or "umbrella-spoke" feed arrangement for grounded towers employed as radiators in medium- and long-wave antennas is both physically practical and electrically advantageous. Numerous examples of both temporary and permanent installations shown in this discussion have performed reliably.

The vertical and horizontal radiation patterns are essentially the same as conventional parallel skirt fed antennas or base driven antennas. They exhibit drive impedance characteristics that make them very desirable for multiple-frequency installations, particularly when the frequency spacing is large.

The flared skirt has proven to be a valuable tool to make multiplexed scenarios practical when no other tower feed method would do so. They are no more mechanically complex than conventional skirt feed arrangements and exhibit fewer undesirable effects from adverse weather conditions. RW