Chapter 27

Various Feed Systems
How To Do It

This is where you get a great benefit. After working on new driver cells and matching systems for several years, plus seeing them in the field for close to 20 years, here it is for you. Please also see the appendix for more drawings.

The open sleeve feed system is the most efficient and simple method to feed multi-band Yagis that are designed for a common feed cell. The lowest band in the design is the one fed directly with the coaxial feed line. We will call this driver element the "center driver." The other band(s) are excited via coupling to adjacent driver elements.

The general guidelines for open sleeve driver cells is that the feed impedance for the higher frequency bands is determined by:

- the spacing of the adjacent driver elements from the center driver;
- the relationship of the tapers between the adjacent drivers and the center driver;
- the length of the adjacent driver elements;
- the length of the center driver will have little affect on the frequency of the adjacent driver elements and their frequency band;
- the length of the adjacent driver elements will tend to only affect the frequency of their respective band(s).

Adjusting an Open Sleeve, 2-Band Yagi

Make use of the wonderful computer modeling we have available. Follow these guidelines to achieve an open sleeve feed:

____ design the lowest band Yagi with 2 elements so that it has a feed impedance close to 50 ohms. It is possible to have more than 2 elements, although this is an exhausting, complex design process, as the directors will be interlaced with the higher band Yagi. The most complex ever achieved is the C-49XR with 24 elements;

____ be sure the model is placed above ground, not in free space;

____ the feed point is the driver element of the lowest frequency Yagi;

____ design the higher band Yagi so that its feed impedance is also close to 50 ohms, although it is possible to adjust an open sleeve for lower and higher impedances;

____ overlay the second Yagi using the examples 2-band forward stagger Yagis as a guide, placing the driver in the general area of the center driver for the lower band Yagi;

____ enter the elements into the computer model using the exact tapered section diameters and lengths that will be used in the antenna;

____ remember to model the element mounting plates properly, otherwise the lengths will be incorrect in the real world (most likely too high in frequency);

____ add open sleeve driver elements on each side of the center driver, spacing them a few inches away. "Each side" means one to the rear and one to the front of the center driver on the common boom;

____ set the model for the desired frequency in the lower band;

____ adjust the length of the center driver for close to resonance in the band, working towards approximately 42-50 ohms, which is an acceptable range. Remember that not being a perfect 1:1 VSWR does not mean it is not an excellent performer;

____ next, set the frequency for the higher band Yagi, keeping the feed point on the center driver;

____ make a chart where you can write the spacing, length and resulting impedance;

____ adjust the spacing between the center driver and both drivers for this band, changing one at a time and noting the change in feed point impedance for each run on the model;

____ when you get the closest to 50 ohms as possible (might be 70 ohms), change the length of this driver element and note the change;

____ continue on making adjustments to the length and spacing of this driver element until it comes within 40-60 ohms and some reactance is acceptable;

____ construct the antenna and mount it about 12' above ground;

____ test the antenna for VSWR and note how it tracks to your model;

____ make small adjustments to the driver elements, one change at a time, to achieve the desired results;

____ depending on the frequency bands of the antenna, it will shift a certain amount as it is raised from the test height.

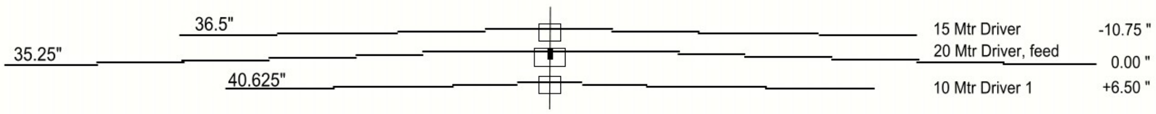
Designing an Open Sleeve for 3 Bands

The following is a procedure for designing and adjusting a 3-band open sleeve cell for 20-15-10 meters. It can be used as is for a 3-band, full size dipole. The elements can be mounted vertically on a single mast, or on a short boom mounted horizontally:

____ design a dipole for the lowest band, using the anticipated tapered section diameters and length, plus accounting for the mounting plate;
____ remember that the feed impedance of a full size dipole can be higher than 50 ohms, depending on its height above ground;
____ adjust the dipole length for resonance at the desired frequency;
____ add open sleeve driver elements for each band, one on each side of the center driver, using the actual tapered section diameters and lengths, plus the actual mounting plates. Space the elements a few inches away, either vertically or horizontally – the model will function the same in either case;
____ set the model for one of the other frequencies, keeping the feed point on the lowest band dipole;
____ make a chart where you can write the spacing, length and resulting impedance;
____ adjust the spacing between the center driver and the driver for this frequency, changing only the spacing or length (not both) and noting the change in feed point impedance for each change (run on the model);
____ the feed impedance should be able to be close to 50 ohms (40-60) on the model, which indicates it can be successfully built;
____ change the model frequency to the third frequency and make adjustments to it, just as you did for the prior band;
____ go back and check each of the drivers to be sure they are still as expected, making small adjustments if required – keeping notes as you go;
____ mount the antenna at a convenient height and note how it tracks to your model;
____ make small adjustments to the driver elements, one change at a time, to achieve the desired results;
____ depending on the frequency bands of the antenna, it will shift a certain amount as it is raised from the test height.

3-Band Open Sleeve Driver Cell for 20-15-10

1 MHz Coverage on 10 Meters



Element	mtg plate	1"	.875"	.750"	.625"	.500"	.375"
		Tubing diameters and lengths per side (not total tip-to-tip)					
15 driver	3" x 6"			24" *	33"	45"	a/r
20 driver	4" x 8"	48"	21"	33" **	33"	33"	a/r
10 driver 1	3" x 6"			6" ***	12"	45"	a/r

* 48" center piece, double walled with 24" of .625" at center
** split driver for feed point, 48" x 1" double-walled with 36" x .875", .750" x 8" fiberglass at center
*** 12" center piece double-walled with 36" of .625"

Element tips for 15 and 10 meters might need to be adjusted for the desired band coverage.
If adjustments are made at a low height (i.e. 12'), antenna will rise in frequency as it is raised.

The lines representing section lengths are the exposed lengths, as specified in the chart. Inserting 3” into the next-larger tubing size is sufficient to hold it in place, so a 33” exposed length implies an overall length of 36”. When setting up the model, allocate the equivalent diameter for the mounting plate. A 3”x6” plate will be 1.93” and a 4”x8” plate will be 2.55” diameter. Half the plate length is used for the length. The first section in each element half will start with a diameter of 1.93” x 3” for a 3”x6” plate and start with 2.55”x4” for a 4”x8” plate. Be sure to subtract the length from the first actual tube section, which means a 48” first section of 1” tubing mounted on a 4” x 8” plate will be: 2.55”x4”, then 1”x44”.

A single open sleeve driver for a wide amateur band like 10 meters will probably not cover the band in full. The addition of a second 10-meter driver element will be required:

____ follow the same steps as in the previous example for the closest driver of a pair, then;
____ make small adjustments to the “forward” driver element, one change at a time, to achieve the desired results;
____ it is certainly acceptable to go back and change particularly the spacing, to the closest driver, since the forward driver will alter the coupling;
____ make adjustments to the elements last to achieve the best / closest computer solution to 50 ohms;
____ remember to keep notes.

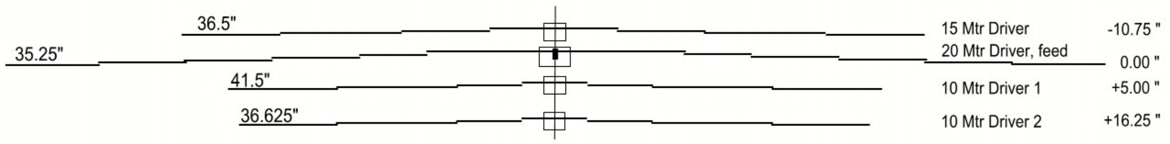
The drawing of this implementation follows.

Using a 3-band **Open Sleeve** has additional features to offer:

You can break all the elements at the center and feed them separately so that you can
- run SO2R with one antenna;
- be on 1, 2 or all 3 bands simultaneously. Be sure to have adequate receiver filtering in the front end!
- match each band independently if necessary.

3-Band Open Sleeve Driver Cell for 20-15-10

Full Coverage on 10 Meters



Element	Tubing diameters and lengths per side (not total tip-to-tip)						
	mtg plate	1"	.875"	.750"	.625"	.500"	.375"
15 driver	3" x 6"			24" *	33"	45"	a/r
20 driver	4" x 8"	48" **	21"	33"	33"	33"	a/r
10 driver 1	3" x 6"			6" ***	12"	45"	a/r
10 driver 2	3" x 6"			6" ***	12"	45"	a/r

* 48" center piece, double walled with 24" of .625" at center
** split driver for feed point, 48" x 1" double-walled with 36" x .875", .750" x 8" fiberglass at center
*** 12" center piece double-walled with 36" of .625"

Element tips for 15 and 10 meters might need to be adjusted for the desired band coverage.
If adjustments are made at a low height (i.e. 12'), antenna will rise in frequency as it is raised.

The lines representing section lengths are the exposed lengths, as specified in the chart. Inserting 3” into the next-larger tubing size is sufficient to hold it in place, so a 33” exposed length implies an overall length of 36”. When setting up the model, allocate the equivalent diameter for the mounting plate. A 3”x6” plate will be 1.93” and a 4”x8” plate will be 2.55” diameter. Half the plate length is used for the length. The first section in each element half will start with a diameter of 1.93” x 3” for a 3”x6” plate and start with 2.55”x4” for a 4”x8” plate. Be sure to subtract the length from the first actual tube section, which means a 48” first section of 1” tubing mounted on a 4” x 8” plate will be: 2.55”x4”, then 1”x44”.

The "closed sleeve" matching system

The term, "closed sleeve" was coined when the biggest, trap-less tri-bander was being modeled. It had already been used to feed the smallest trap-less tri-bander, the C-3SS.

The C-3SS stands for "C-3S short", as the antenna is mostly a blueprint of the C-3S, but with shortened 20 meter elements. This makes a much different feed scenario than when you have a full size 20-meter element for a driver (main driver, where the coax attaches).

The main point is that the shortened 20-meter driver will not excite the adjacent open sleeve driver elements. Right – it won't. A secondary issue is that the 20 Yagi, with its shortened elements, is less than 50 ohms, making a marketing issue, as the market likes low VSWR. How do we accomplish this closed-sleeve feed system?

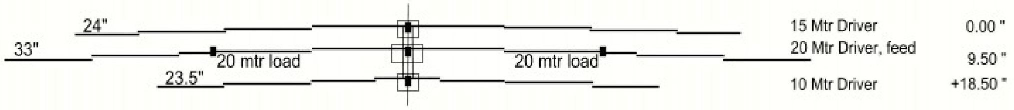
How about modeling it on a computer? Unless you are extremely competent and talented with modeling, it cannot be done with any meaningful results. The method used when designing and building the C-3SS was the old way: a lot of time trying different techniques in real time and making detailed notes.

The result of those efforts is the closed sleeve feed design. In this case, the middle band (15 meters) is fed directly with the coax feed line through a 1:1 balun (of course). This implies that it is a 50-ohm direct feed Yagi. From there, the shortened 20-meter driver is fed via parallel feed wires. The spacing of the feed wires is approximately 1½" and the wire size is #12. The screws through the split driver elements used to connect the feed wires are spaced at this dimension. It is important to have these wires

3-Band Open Sleeve Driver Cell for Loaded 20, Full-size 15-10

1 MHz Coverage on 10 Meters

All 3 drivers parallel fed, wires spaced approx 1.5", 20 meters receives coax feedline through 1:1 balun



Element	Tubing diameters and lengths per side (not total tip-to-tip)						
	mtg plate	1"	.875"	.750"	.625"	.500"	.375"
15 driver	3" x 6"			36" *	33"	33"	a/r
20 driver	4" x 8"	36" **	33" & 12"		33"	33"	
10 driver	3" x 6"			12" ***	24"	33"	a/r

* split driver for feed point, 36" x .750" double-walled with 24" x .625", .500" x 8" fiberglass at center
** split driver for feed point, 36" x 1" double-walled with 24" x .875", .750" x 8" fiberglass at center
.875" sections joined with .750" x 8" fiberglass for loading system
.875" outer section has a short inner liner of .750" to reduce it for .625" next section to .500" tip
*** split driver for feed point, 12" x .750" double-walled with 36" x .625", .500" x 8" fiberglass at center

Loads for 20 meters can be high-Q coils, or linear loading.
The shortened 20 meter elements cause the 20 feed to below 50 ohms and
the parallel feed lines from 20 to 15 act as a step-up matching transformer for 20.
Note that the parallel feed lines add to the length of the 15 driver and also the 10 driver.

Element tips for 15 and 10 meters might need to be adjusted for the desired band coverage.
If adjustments are made at a low height (i.e. 12'), antenna will rise in frequency as it is raised.

The lines representing section lengths are the exposed lengths, as specified in the chart. Inserting 3" into the next-larger tubing size is sufficient to hold it in place, so a 33" exposed length implies an overall length of 36". When setting up the model, allocate the equivalent diameter for the mounting plate. A 3"x6" plate will be 1.93" and a 4"x8" plate will be 2.55" diameter. Half the plate length is used for the length. The first section in each element half will start with a diameter of 1.93" x 3" for a 3"x6" plate and start with 2.55"x4" for a 4"x8" plate. Be sure to subtract the length from the first actual tube section, which means a 48" first section of 1" tubing mounted on a 4" x 8" plate will be: 2.55"x4", then 1"x44".

straight and this is accomplished by first having them the right length and then twisting the elements in their mountings to snug up the wires.

The 10-meter driver is fed similarly. The same type of wire is run from the 20-meter driver to the 10-meter driver and spaced the same.

All three drivers are now fed directly, but they interact with the parallel driver wires and also somewhat with each other through the air, like a typical open sleeve. Its really not possible to have close-spaced elements that do not "see" each other. The key is to be sure that they work together and enhance each other as compared to being destructive to each other.

The length of the 15-meter driver is physically shorter than in an open sleeve. The parallel lines from the 20-meter driver that act as a matching system increasing the feed point on 20 meters adds to the length of the 15-meter driver. The 10-meter driver is also affected by the lengths of the parallel driver wires and is physically shorter than it would be in an open sleeve.

The "closed-open sleeve" matching system

Overlaying mono-band Yagis for 20-15-10 makes a compact, high performance antenna. Designing a matching system to service all three drivers can be an issue. The answer lies with combining the open sleeve and the closed sleeve matching techniques.

The design process generally:

____ be sure to use the actual tapered diameter sections and lengths;

____ overlay the Yagis on the computer model so that the 10-meter driver is in front of the 20-meter driver, being sure it has adequate performance for you;

____ design the 10-meter Yagi for a feed impedance close to 50 ohms;

____ the space between the 10-meter and 20 meter drivers should be at least 15", preferably more. This can be tested by moving the 10-meter driver forward and back to see if it is affected much by the 20 driver, or by other elements in your design;

____ locate the 15 meter driver so that it resides to the rear of the 20 meter driver and follow the procedure for setting it up as an open sleeve driver. Adjusting the spacing to 20 and the length should get the match close to 50 ohms. Don't be surprised if that for close spacing, the taper schedule on 15 will be the same as the 20;

____ run the computer model on each of the bands, specifying the appropriate driver for the band being run;

____ check the patterns for each band to be sure the energy is going in the directions you expect;

____ the 20-meter Yagi can be less than 50 ohms and matched with a simple hairpin coil across the feed points;

____ the parallel wires attaching to the 10-meter feed point (where the coax attaches through a 1:1 balun) and gong to the 20-meter driver are made from jacketed house wiring with the third wire in the jacket (the bare copper wire) removed. Strip just enough from each end of the jacket to expose the ends and attach lugs. This technique keeps the wires close together (less than ½"), protected from weather and they cannot move. The characteristic impedance of this parallel wire is about 70 ohms and does not add appreciable length (if any) to the 20-meter Yagi driver element;

____ place a hairpin across the 20-meter driver if its impedance is less than 50 ohms;

____ place a jumper across the 15-meter driver if it was built as a split element.

____ make final adjustments with the antenna elevated as high as practical.

Using a 3-band **Closed Sleeve** or **Closed-Open Sleeve** feed system has more features to offer:

You can break all the elements at the center and feed them separately so that you can

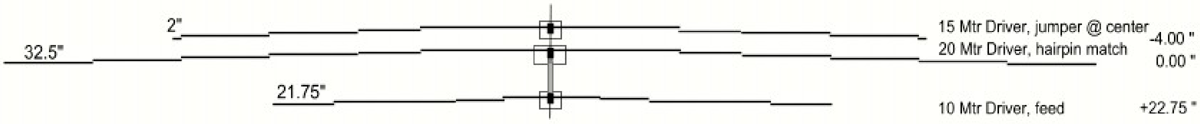
- run SO2R with one antenna;
- be on 1, 2 or all 3 bands simultaneously. Be sure to have adequate receiver filtering in the front end!
- match each element independently to suit your desires.

This is an amazingly flexible feed system for 3-band Yagis using overlay designs. Most any practical Yagi feed impedance can be matched on all 3 Yagis while using only one feed line.

3-Band Closed Sleeve Driver Cell for 20-15-10 overlay Yagi designs

>1 MHz Coverage on 10 Meters

The 10 and 20 drivers are parallel fed using close-spaced wires in a jacket. 15 is an open sleeve with 20.



Element		Tubing diameters and lengths per side (not total tip-to-tip)					
	mtg plate	1"	.875"	.750"	.625"	.500"	.375"
15 driver	4" x 8"	48" *	21"	33"	33"	a/r	
20 driver	4" x 8"	48" *	21"	33"	33"	33"	a/r
10 driver	4" x 8"			18" **	18"	45"	a/r

* split driver for feed point (20 and 15), 48" x 1" double-walled with 36" x .875", .750" x 8" fiberglass at center

** split driver for feed point to coax, 18" center piece double-walled with 36" of .625"

The 20 meter element is less than 50 ohms and is matched by a hairpin coil across its feed points.
Note that the parallel feed line from the 10 to the 20 is close-spaced inside a jacket, with a character impedance of about 70 ohms.

Element tips will be close from th emodel, except possibly 15, so plan on adjusting those tips.
If adjustments are made at a low height (i.e. 12'), antenna will rise in frequency as it is raised.

You can also decide to use different combinations of feeds:

1) 1 feed line "standard" for 20-15-10;

2) 2 feed lines, one for 20 and 10, a second for 15 meters. In this case, the 15-meter driver can be moved to the rear if space permits and probably will require a hairpin matching coil on 15;

3) 2 feed lines, one for 10, a second for 20 and 15. In this case, the parallel feed lines between 10 and 20 are not used. If 10 meters is less than 50 ohms it can be matched in this configuration;

4) 3 feed lines, one for each band. In this case, the parallel feed lines between 10 and 20 meters are not used and the 15-meter driver can be moved to the rear if possible;

5) when the 15 driver is in close proximity to the 20, the two elements must be secured with a spacer so that the spacing is retained in the wind. A simple device is a 2" wide x ¼" thick strip of ABS that spans the elements. Cutting slots in the ABS will allow for compression clamps to secure the spacer to the elements.

Overlay designs can be very time-consuming. For example, the C-49XR was designed after having the C-31XR in production. The C-31XR development spanned close to a year. I was over in Finland as a guest speaker at their big convention and decided to make the biggest tri-band Yagi ever. It would be equivalent to a trio of large mono-band Yagis.

I started on the design while in Finland and 15 months later, we built the first one. Yes, 15 months. That design required a major invention, which was how to pass energy on 10 meters through 20-meter elements. When you look at the design, you will see the multiple 10-meter elements surrounding some of the 20-meter elements.

It looks simple now, but as my favorite saying goes, "nothing is obvious."