Yana Dongles

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These notes elaborate some items described in the Build notes, and add some more dongles enhancing Yana.

Every effort has been exerted to save on the cost of accessories for Yana. Pin headers are cheaper than sma connectors so that the various dongles are made with pin headers and plugged into a couple sma connectors. I decided that if a dongle has one connection (i.e. no forces act on it to pull it loose) or has two connections and is rarely used, then pin headers are the right connectors. If a dongle has two connections and is used often, the it can fall out from the pulling of the two connections, therefore sma connections were used. The bridge is used as if it were part of Yana so it can experience some pushing and pulling. Pin headers would continually come loose. Therefore, it is recommended that the bridge be made with sma connectors so that it attaches securely to Yana.

For RF wiring everyone learns to keep the leads short and wire over a good ground plane. This admonition works pretty well at 40 meters and below, but progressively gets more difficult as the frequency increases (amplifiers oscillate and oscillators make all kinds of frequencies in addition to the desired one). There are even more fundamental rules at work here. First, any piece of wire is an antenna. And second, any two wires (or a ground plane and a wire) make a transmission line. Antennas radiate, and transmission lines couple frequencies between the two conductors. As the frequency increases, these two principles begin to dominate all RF wiring. These principles can louse up all kinds of attempts to measure what is happening. I dispair that I am mostly unsuccessful with a high impedance probe on my oscilloscope while probing RF circuits with fast rise times. My probe mucks up the circuit. So I try to stick to a 50 ohm environment where I understand the mucking up.

The dongles for Yana are built on perfboard with male pin headers. These headers are plugged into a female header on a male sma plug. This means there are necessarily leads of short length. This presents little or no problem at 40 meters and below, however, it can be significant as the frequency increases toward 70MHz. I have measured the performance of the various dongles with an N2PK VNA and you can see the results.

A. Calibration

The three instruments (SNA, SWR, PWR) in Yana need calibration.

1. SNA Calibration

Two attachments are needed:

a. short sma jumper, and

b. a 28.64db attenuator.

a. The jumper

I purchased two 10cm sma male to male jumpers, one of which is used for (a). Ideally, the generator should be directly connected to the detector. Instead, the short sma jumper is connected from the Yana Generator to the Detector. Because the generator and detector are matched to 50 ohms, the short 50 ohm coax jumper does not unduly louse up calibration. Thus Yana can read the maximum output from the generator. This output is read at 50KHz, 100KHz, 1MHz, 10MHz 20MHz, 30MHz, 40MHz, 50MHz, 60MHz, and 70MHz. The values are stored in EEPROM. For values between these, linear interpolation is used to compute an offset.

These offsets are used to normalize the response of the SNA so that, for example, maximum generator output (a direct connection from the generator to the detector) is always read as 0db, even though the output is falling above 10MHz.

b. The attenuator

Normalization is not enough. Yana must know the value of a 1db decrease. A 28.64db attenuator is connected from the generator to the detector and the result is read at 10MHz and stored in EEPROM. From this value, the step for 1db can be determined and used for all frequencies and amplitudes.

Commerical precision switched attenuators contain steps no larger than 20db. The recommended step attenuators in ARRL publications also use steps no larger than 20db. The reason is that for larger attenuations, it is very difficult to remove leakage from the input to the output. My own experience bears this out with single Pi attenuators of 30db: they did not have flat frequency response and this response was a poor approximation to 30db.

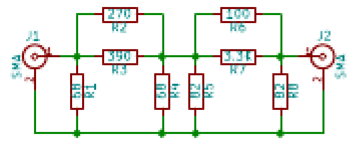
Therefore, the Yana 28.64db attenuator is built up from a 16.33db and a 12.31db attenuator. In the design section it was determined that attenuation of about 30db could be used to accurately calibrate Yana's SNA. For simplicity, the attenuators are built from standard 10% value resistors. Further, the parallel resistor should be a standard value to minimize the number of resistors placed in parallel. A search of possibilities indicates the only choices adding up approximately to 30db are 16.33 and 12.31.

For a given resistance of 50ohms and an attenuation, say, of 20db, the parallel and series resistors of a Pi attenuator are uniquely determined. It is also true that if the resistance of 50 ohms is fixed and a value greater than 50 ohms is chosen for a parallel resistor, then there is a unique choice of series resistor that will give a 50 ohm Pi attenuator of some attenuation. In other words, a standard value resistor can be chosen for the parallel value from which the series value and resulting attenuation can be computed. This is the method that was used to determine the attenuation values. Of course, these attenuation values cannot be expected to come out to be decade or other integral values. Thus, the oddball numbers: 16.33 and 12.31.

The attenuators are as follows:

Attenuation	R series	R parallel
16.33db	270 || 390	68
12.31db	100 || 3.3K	82

The 200, 2K, and 20K ranges were used on my Harbor Freight free DVM. I shorted the probes, waited about 5 seconds for the reading to settle, then recorded the resulting resistance. The recorded value is subtracted from a reading to give the correct resistance. This step removes the resistance of the probes (which is added to the resistor value) from the reading.



For example, on the 200 ohm range the value settled at 1.2 ohms. A resistor which settles at 69.7 ohms would have a resistance of 68.5 = 69.7 – 1.2. Taking half a dozen 68 ohm resistors, I selected the two closest to 68 ohms. I selected all other resistors in the same way.

It is handy for test purposes to have a 10db attenuator. The 12.31db attenuator is close enough and easy to build, so one was made to be used for test purposes. Together the 28.64 and 12.31 db attenuators serve most test situations (in addition to calibration).

c. The SNA calibration

Yana asks for the jumper and records the values, then asks for the attenuator and records the value. Finally, Yana asks if the calibration should be saved. If it is saved, then these values are saved in EEPROM and adopted for the present and future runs of Yana. This final step allows you to check calibration without committing to the results. The raw ADC calibration values are listed on the screen so you can see them. The result can be accepted or rejected. The actual voltage may be calculated using Voltage = 5 x (Raw ADC) / 1024.
E.g. a reading of 538 would be a voltage of 2.63 = 5 x 538 / 1024 volts. A more accurate computation can be obtained by checking the actual 5v regulator voltage and using that number for 5 in the formula.

2. SWR Calibration

SWR calibration requires:

a. The bridge attached to Yana.
b. A 0 ohm load (short) to attach to the bridge.

a. The Bridge

The bridge is described in the build notes for Yana. It is a standard 50 ohm resistance bridge.

b. The Short

The short is described in the build notes for loads. A sma to pin header adapter is attached to the bridge and a pin header short is plugged into the adapter. Care must be taken to be sure the center pin of the short is not plugged into the center pin of the adapter. There would be no connection in that case.

c. SWR Calibration

Yana asks that the bridge be attached with a short installed. After obtaining and showing the calibration values, Yana asks if you wish to skip or save the values. If skipped, nothing happens. If saved, the values are stored in EEPROM and taken as the current values.

B. Measuring Attachments

1. 40db Taps

Taps are used to measure transmitter output power. A 40db tap will reduce the power of a 100 watt transmitter to 10dbm. Yana was tested to show that the Detector remains db-linear to 10dbm. Thus, the taps here will measure powers up to 100 watts.

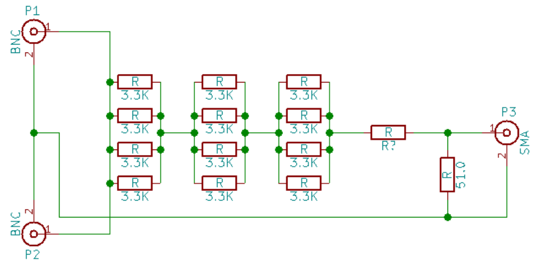
a. Resistive 40db Tap

Hayward and Larkin (QST, June 2001) in the article which presented the detector for the PHSNA and Yana, also described a 40db tap.
http://www.qsl.net/sz1a/download/build%20an%20rf%20power%20meter.pdf
This tap is based upon a very nice observation, namely, a 40db Pi attenuator has end parallel resistors very close to 50 ohms. There is a calculator at
http://chemandy.com/calculators/matching-pi-attenuator-calculator.htm
which shows that a 40db attenuator has parallel resistance 51.01 ohms and series resistance 2499.75 ohms. The attenuation is so large that most of the power of a transmitter is dissipated on the input parallel resistor. Therefore, this resistor can be a 50 ohm dummy load of the right power rating.

Hayward and Larkin used three 820 ohm ½ watt resistors in the series arm and a 51 ohm resistor in the output parallel arm. The 2460 ohms in series with the 51 ohms is called the “tap.” When a 50 ohm load is connected, the 2460 + 25 ohm divider serves at a 100:1 voltage divider giving an attenuation of 40db. One half watt resistors create a tap that will handle about 60 watts. Increasing to 1 watt, accommodates a 100 watt transmitter.

Hayward and Larkin include some capacitive compensation so that the tap works right up to 500MHz. No attempt was made to compensate the current tap. It still works fine up to 2 meters where the detector of Yana is still accurate. Kicad

The schematic for the tap for Yana is shown at the right. I have a number of dummy loads. Of course, there is Yana's precision 50 ohm load. At powers up to 100 watts my load of choice is an Oak Hill RFL-100. For high power measurements, the transmitter connects to the tap input, the output of the tap connects to the dummy load, and the tap point connects to the Yana detector.



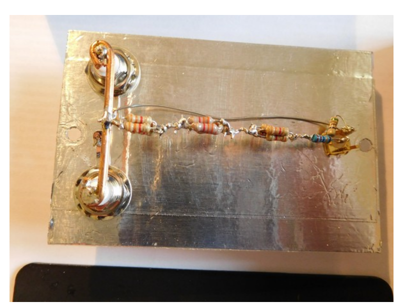
The series arm should be about 2500 ohms. I used carbon film (metal film may be a better choice) ¼ watt resistors. Four 3.3K 1/4w resistors in parallel give 825 ohms at 1 watt. Three of these packs in series gives 2475 ohms. After the three packs are placed in series, the result is measured. Measure by checking each pack then adding the resistances. Adding one of an 18, 22, or 27 ohm ¼ watt resistor will bring the series value very close to 2500 ohms. Several 51 ohm resistors were measured and the closest to 51 ohms was chosen. I used my free Harbor Freight DVM and as will appear, obtained an excellent result.

A shallow single outlet electrical box was used as a case. A cover (box lid) of clear acrylic plastic was cut to size for a cover. The through transmitter to dummy load connections are female BNC connectors. The tap for Yana is a female sma connector.

The cover (box lid) is layered with aluminum foil duct tape with significant overlap between the two strips of tape necessary to cover the box lid. The connectors pass through the box lid from the conducting (tape side). The entire circuit is built on this box lid. The picture at the left shows the tap.

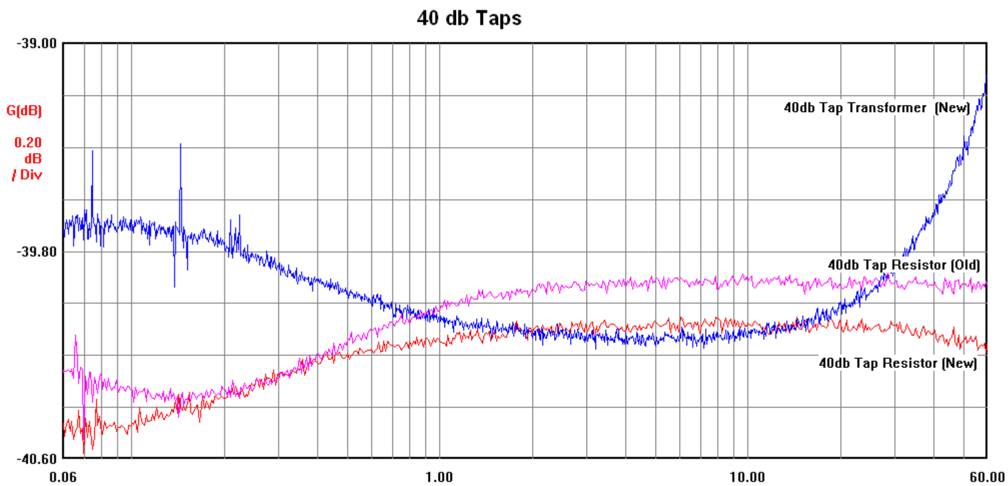
Even though aluminum is an excellent conductor, it does oxidize immediately and the oxide is a good insulator. Therefore, I never depend upon aluminum foil as a circuit conductor. I connected the two BNC grounds and ran a wire from them to the sma ground.

A short bare piece of heavy copper wire connecs the two BNC center conductors. The resistor chain: (4x3.3K)+(4x3.3K)+(4x3.3K)+22 runs from the center of the BNC copper wire to the center of the sma connector. The 51 ohm resistor runs from the sma center conductor to the sma ground.



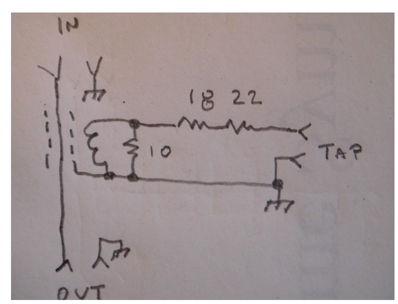
The outlet box is lined with aluminum foil duct tape with significant overlaps. The glue on the tape is not conductive, so layers must provide good capacitive coupling to make a good shield. The tape is applied in single strips which overlay the edge of the box. Thus, when the cover is installed, a good mechanical electrical connection is made from the cover to the box. The whole combination makes a good inexpensive shielded box that looks nice.

The tap was checked with my N2PK VNA and the results are shown below. This graph shows both the resistive and the inductive 40db taps. The third plot is for my build of the orginal Hayward-Larkin 40db tap made when the QST article first appeared. The inductive tap is the more curved plot. All three taps agree closely over the HF bands and are very close to 40db. The load for the VNA check was my precision 50 ohm calibration standard. If only one tap is built, it should be the resistive tap.

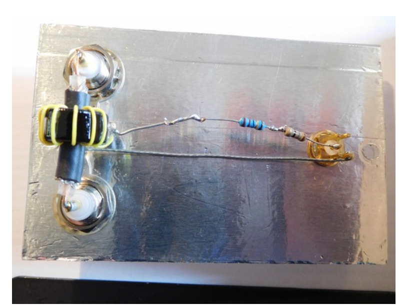


The **resistive tap** works by measuring the voltage on the coaxial line from the transmitter. The **inductive tap** measures the current in the coax. When the swr is 1:1 (as it is with a good 50 ohm dummy load) then both measuring methods give the same result for the power.

b. Inductive 40db Tap



Even when the swr is not 1:1, the taps are useful since the resistive tap senses line voltage and the inductive tap senses line current. The inductive tap involves a transformer so it has a more limited frequency range than the resistive tap. The VNA scan shows both taps as excellent over the HF bands. The graph also shows that above 30MHz the inductive tap begins to fade.



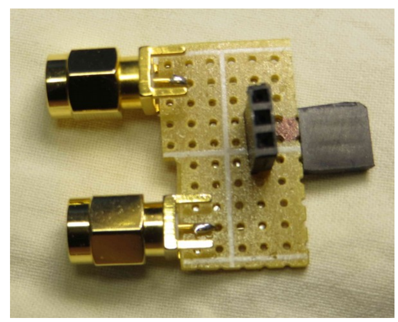
I used a 35T0501-10H toroid core (available from Digikey) for the inductive tap transformer. I chose a 10:1 current ratio (i.e. 10 turns wound on the core). A 10 ohm resistor shunts the secondary to take most of the current load. Alone, this would give only a 20db tap, so a further voltage divider is needed to match 50 ohms and to bring attenuation to 40db. A 40 = 18 + 22 ohm resistor runs to the output to Yana. The circuit is shown at the right. RG-58 coax connects the input to the output through the core. One side of the ground braid is grounded to the coil and 10 ohm shunt.

The 2012 Radio Amateurs Handbook shows the tap in Figure 25.76. Design equations are given there. Other editions of the Handbook should have the same figure.

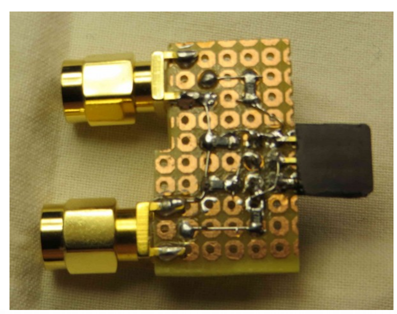
The tap is built the same way as the resistive tap. I used RG58 coax to connect the two BNC center conductors. The coax shield is connected to ground at one of the BNC connectors. The other end of the shield is left unconnected. This shield ensures tha the coupling between the line and the transformer is inductive (and not capacitive). The coax holds the core securely in place. I used coil dope on the 10 turn winding to hold the turns in place. (Sally Hansen, Hard as Nails, Hardener probably would work just fine if you don’t have coil dope.) The 10 ohm ¼ watt resistor connects the two ends of the 10 turn winding very close to the core. One lead goes to ground at the BNC connector and the other lead connects to the ¼ watt series of 18 and 22 ohms. The latter goes to the center conductor of the sma connector. Again, I ran a ground wire from the BNC grounds to the sma ground. The tap is shown at the left.

The previous VNA graph shows that over the HF range, this is a good 40db tap.

2. Resonance, L, C attachment

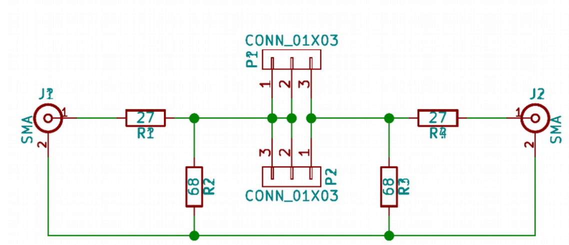


a. The attachment



The resonance attachment is built in the same way as a screw on 30db attenuator. Using smd 0805 resistors, the perfboard can be cut 7x11 holes giving a work area of 6x10 holes. A notch 1x6 is cut in the 10 hole side to accommocate the offset of the male sma connectors. I did not build a leaded resistor version, so a layout that is a bit larger must be determined before cutting the perfboard.

The parts are:
2 male PCB mount sma connectors.
2 3-pin female pin plug receptacles.
2 27 ohm resistors.
2 68 ohm resistors. Kicad



The circuit diagram shows the wiring. The photographs show my layout. A 27 ohm resistor comes off each center pin of the male sma plugs. These resistors are each connected to a 68 ohm resistor leading to ground. Each junction (27 ohm to 68 ohm) connects to an outside pin on the pin header. The two pin headers are in parallel. The same outside pin on each header connects to the center pin on the header. The standard and unknown connect between pins 1 and 3 or 2 and 3 of P1 and P2.

Be sure the sma connectors are screwed onto Yana before they are soldered to the perfboard to make sure the adapter is aligned with Yana. The circuit is a 10db T-attenuator broken in the middle. That is if the pin header is shorted, the result is a 10db attenuator. Off resonance, an SNA trace will be about -10db.

b. The inductance and capacitance standards

The parts are:
1 100pF C0G 0805 smd capacitor.
1 680pF 0805 smd capacitor.
1 1.2uH molded inductor.
3 3-pin male pin headers.

Plug a pin header into a female socket (breadboard) to prevent warping while soldering. Short the middle pin to an outside pin. Connect the component (capacitor or inductor) between to two open pins (smd parts) or between the two end pins (leaded parts). Keep leads as short as possible.

c. Calibrating Parts

As far as Yana is concerned, use the following procedure to determine the values of these standards. Let the 100pF part be labeled 100pF. Put the adapter onto Yana. More details are available in the Yana LC Measurement experiment.

1. Choose a 100pF standard capacitor.

As a percent deviation, the 0805 smd C0G (NP0) 100pF capacitor seems best according to the VNA readings. In measuring 10 samples I found variation among values to be smallest. Finally the values were closest to the nominal value of 100pF. Therefore, I decided that the best way to obtain standards is to bootstrap from a 0805 C0G 100pF capacitor. These are inexpensive on eBay.

Pick a 100pF capacitor and call it your 100pF standard. Short two pins of a 3 pin pin header and solder the 100pF capacitor between the remaining pins. If you have an accurate way to measure standards, by all means, use that way.

2. Choose a 1.2uH standard inductor.

In Yana SNL mode, set the C standard to 100pF (see Operation). Plug the 100pF standard into the adapter. Then plug 1.2uH inductors into the adapter's second port and write down the values for a collection of 1.2uH inductors. The dip on Yana will be about 14.3MHz. Select the inductor with value closest to 1.2uH and record the value given by Yana.

Short two pins of a 3 pin pin header then connect the 1.2uH standard between the end two pins of the pin header. Measure the inductance of the 1.2uH inductor in its mounting on Yana and record the inductance. This number (in nH) is the value of the 1.2uH standard.

3. Choose a 680pF standard capacitor.

I used a 0805 smd 680pF capacitor. Mount it on a 3 pin pin header in the same way as the 100pF standard is mounted. Measure the 680pF standard using the standard L value recorded in step 2. Write down the value of capacitance measured by Yana.

You now have three standards: 100pF, 680pF, and 1.2uH. The values to the left are nominal. The values used in Yana are the ones you wrote down. I don't think my 680pF is C0G (NP0). If you can, choose that type ceramic because it will be more stable. The values you obtained for 680pF and 1.2uH can be entered into the Yana code as L_STD and C_STD. Thus, they will always come up as default when Yana starts.

If you decide to use leaded parts, follow this procedure as closely as you can, both in building the adapter and making the standards.