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# SWR signal power within a coax cable

alastair underwood GW0AJU

There is much debate regarding the swr signal within a coax feed line, when attached to an antenna loading.

Some say the antenna will receive a full signal, others say that the cable swr signal is lost, and plays no part within the signal pathways. Some say that the swr match value does not indicate the antenna signal loss,, that is even if the match is a 10:1, the antenna still gets its full figure of transmitter power output.

However, if we view the antenna to cable connection as a source resistor impedance, with the antenna load a resistor potential divider circuit, then theory follows that for maximum signal transfer, the cable ohms must match the antenna ohms.

If the load  antenna ohms is however greater than the cable ohms, the rf signal will see a resistor divider circuit going up in antenna ohms, reducing the signal power transfer, while if the load antenna ohms is lower than the cable ohms, the rf signal will see a resistor divider circuit going down in signal, in both cases again reducing the signal power transfer to the antenna.

The graphs shown below, attempt to study the RF signals within the feedline itself, the feedline as a circuit part of the whole transmitter circuit, the radio then the transmission feedline finally to the radiating antenna.

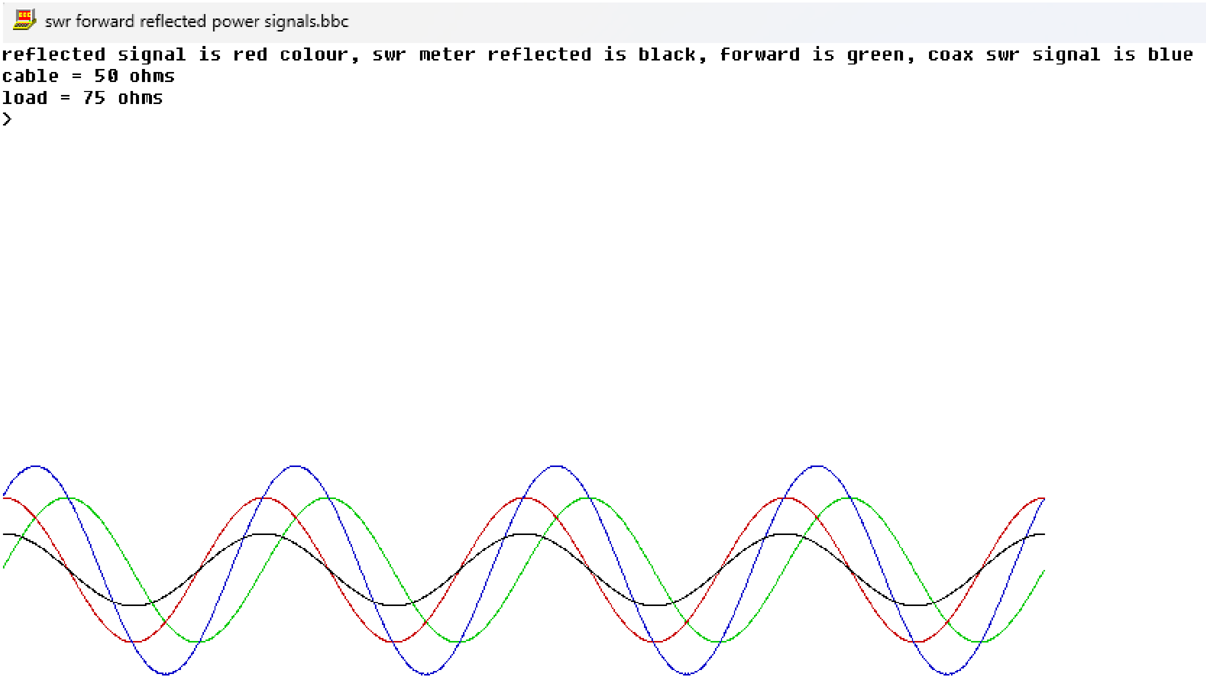
If some cases, a swr meter has two meter readings from two different meters displays. One the forward signal voltage reading, the second meter the reflected signal voltage meter reading.

Other swr meter designs use just one meter, showing the forward value to calibrate the forward circuit voltage, so when switched into measuring the reflected voltage, the voltage measured is a error signal value of the matching miss-matched feedline to the antenna. Some swr meters have double measure indication on one meter display, with calibrations lines to indicate the radio to antenna match via the feedline.

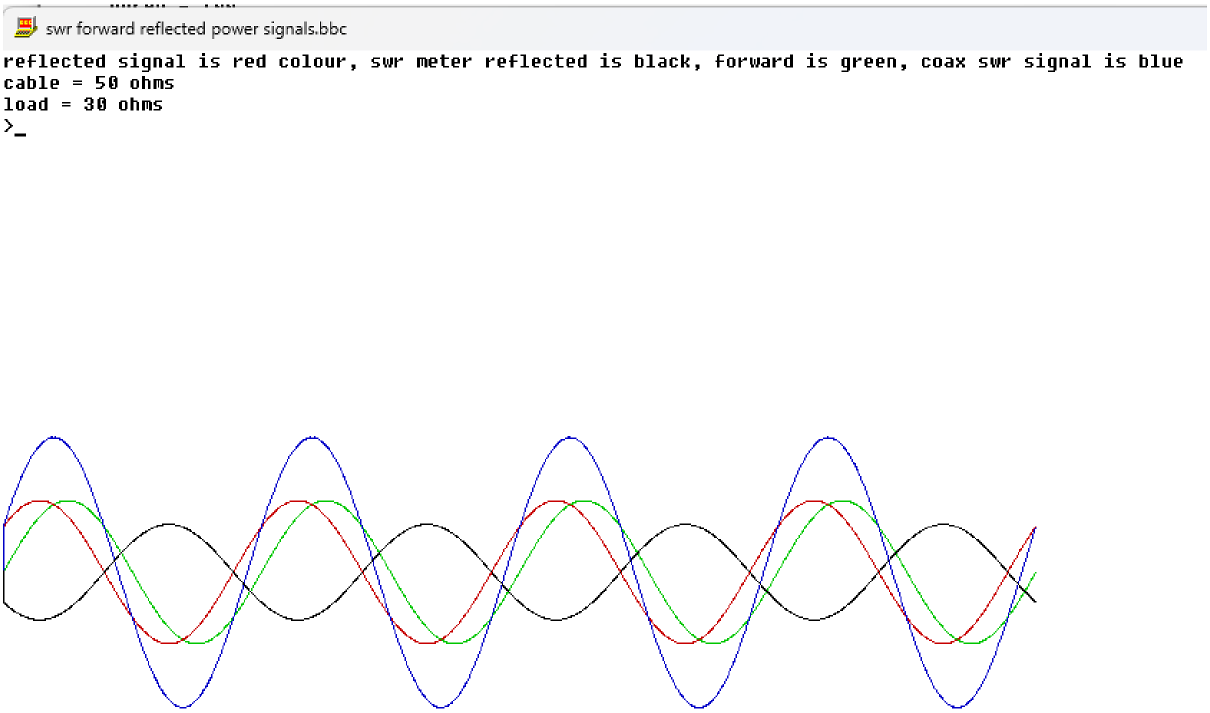
The graphs attempt to illustrate this measurement figures of both types of swr meter designs. The forward signal voltage is a green sinewave, while the reflected signal voltage sinewave is a red coloured plot. The blue sinewave plot represents the feedline signal voltage sinewave, while the black plot illustrates the miss-matching error voltage signal meter reading.

Firstly, an antenna can be high in impedance, hence an inductive reactance, or low in impedance and hence a capacitive reactance.

An inductive antenna signal of the forward and reflected signal with the vector the cable swr rf signal, looks as shown below:



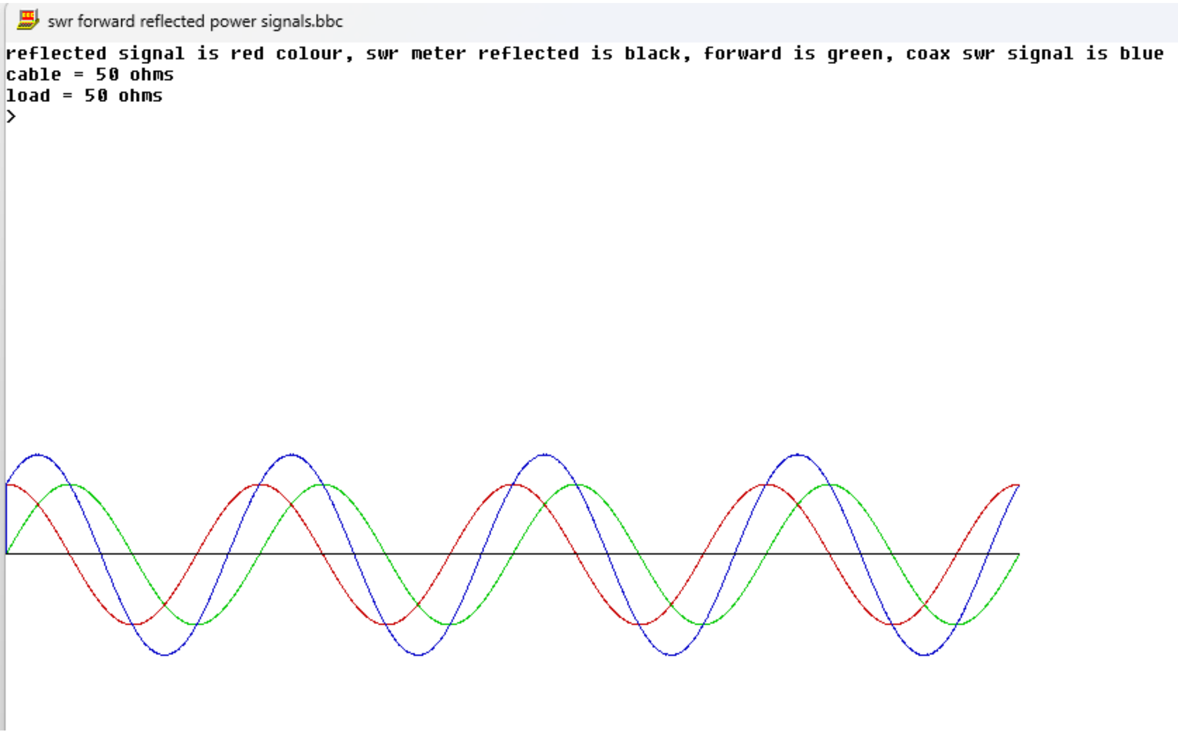

While a capacitive antenna loading signal looks as shown below:




Look to see that the forward and reflected signal are now in a near phase, whereas with an inductive antenna, the forward and reflected signal become out of phase. It is the reflecting and forward phase of the RF signals, that go to stress the coax cabling. Notice the phase signal voltage reversal of the miss-match error voltage between the inductive and capacitive loading.

The next question is what happens to the coax cable with an unmatched cable to an unmatched antenna loading.

For a 1:1 match, the signal look as follows, notice the miss-match error voltage is a straight line:

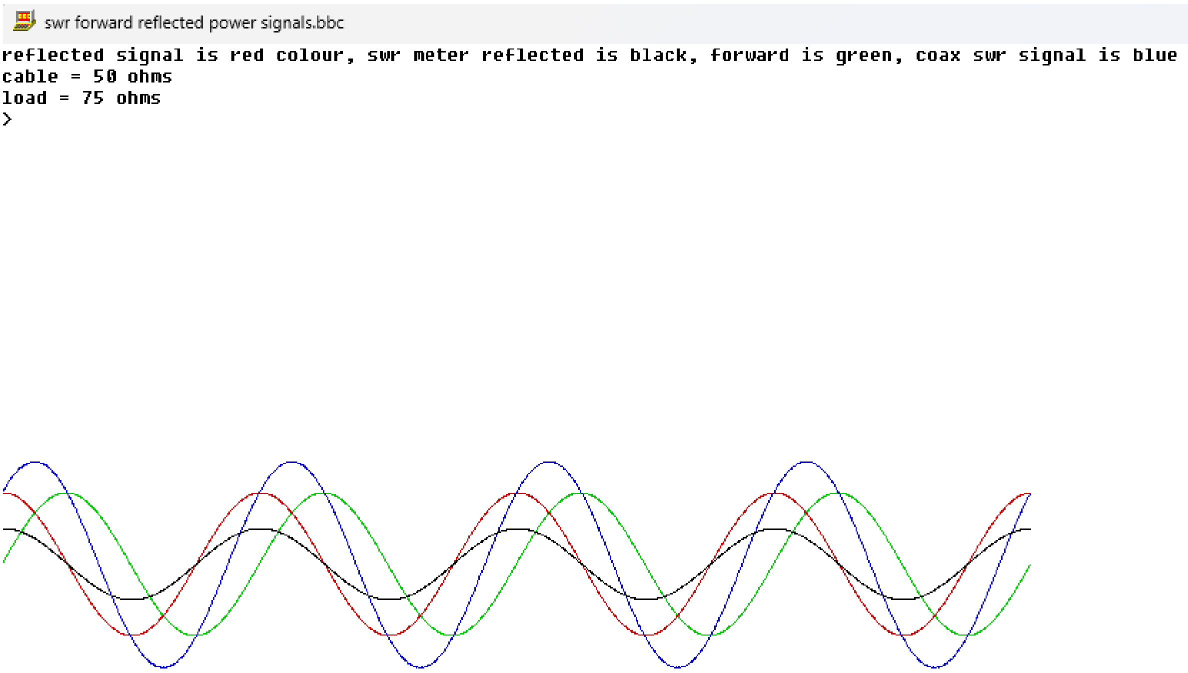



The cable a signal and the antenna signal, although matched to 50ohms, the antenna signal voltage reflects back down the coax at a 45 degrees offset angle. The blue line illustrates the signal power that is present within the coax feedline. The reason for this the following equation:

Tan angle = ( antenna load / cable impedance )

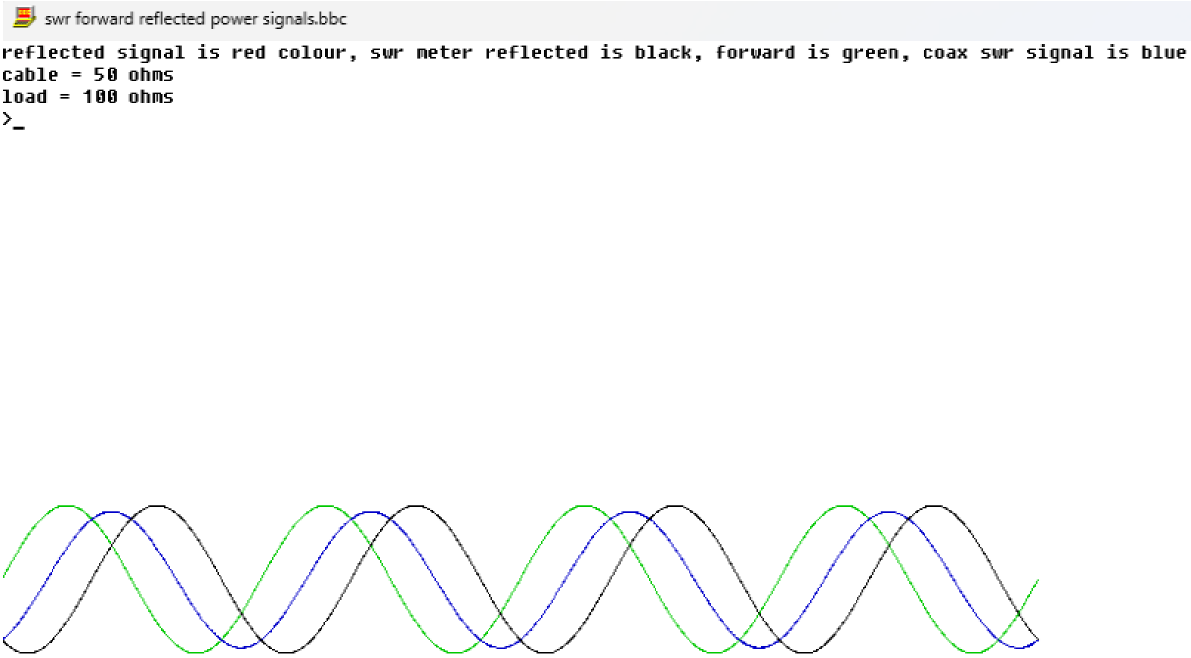
Reflected voltage phase angle = $\tan^{-1}(50/50) = 45$ degrees.

If we have a miss-match reading of "1• 5 : 1" match condition, the reflected voltage phase angle is a 56 degree phase shift, the signals look as follows :



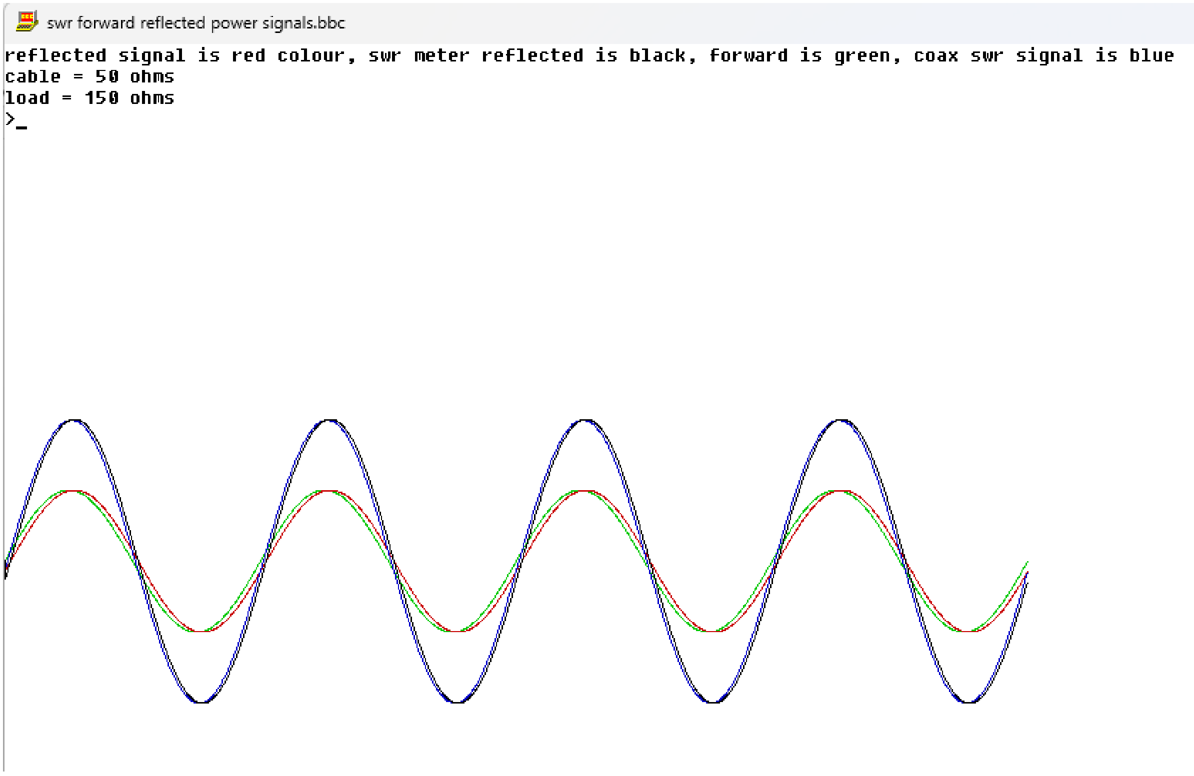
The cable signal, the blue line, although looks similar to the matched condition, does differ much to be noticed.

With a 2:1 swr matched condition, things look a bit different, with a 63 degrees phase shift upon the reflected signal voltage, as shown below:



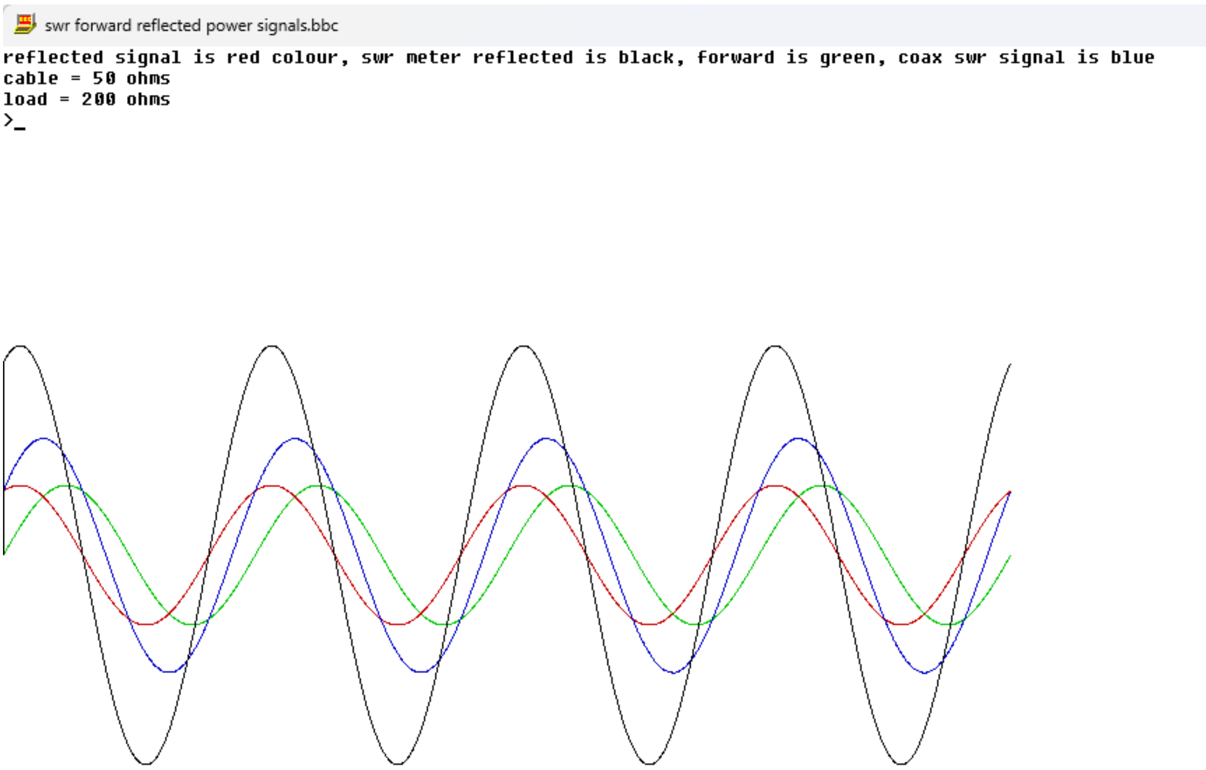

At this point of the cable to antenna matching, the feedline cables swr rf signal voltage is lower than each of the forward or reflected signals, but however the error miss-match voltage signal super imposes itself over the reflected voltage plot, normally the red colour plot, indicating a phase match between the two signal voltages.

However, things change again with a 3:1 match condition, with a 71 degrees phase shift, as shown below:



Here the reflected signal is in phase with the forward signal, hence the cable swr rf signal in blue colour peaking to a high point is also shadowed by the miss-match error voltage signal in black colour. The higher feedline voltages then stressing the coax insulation material.

With a 4:1 matched condition, with an 84 degrees phase shift, shown below:




The forward and reflected signal become out of phase, but the cables swr rf signal is still present, stressing the coax insulation materials, the error miss-match voltage signal in black indicating the degree of miss-matched antenna to feedline and radio.

While as the theory goes, for a maximum signal power transfer to the antenna, the cable and antenna loading impedances must be equal, the coax stress voltages exposed the need for cable specification is excess of the radio transmitter power output.

The feedline cable rf signal voltage is reflected back into the radio transmitter output circuit, although the coax feedline is a 1:1 match with the radio transmitter, as supposed to the feedline to the load antenna, the transmitter circuits may well generate additional heat due to the feedline voltages.

The ATU unit is itself a transmission feedline, so it would be thoughtful to consider the blue plot to be also the ATU signal voltages that a ATU design would need to contain within the components chosen for an ATU design.

The equations used to create the plots, assumes a voltage signal amplitude of 100 pixels, perhaps equate to a 100 Watt radio transmitter. It would be therefore reasonable to judge to the extent the feedline voltage, hence the required power rating of the coax feedline cable to accommodate the feedline voltages.

Below, is the listed BBC Basic for windows software to create the graph plots:

```
PRINT"reflected signal is red colour, swr meter reflected is black, forward is green, coax swr signal is blue"
DIM forward%(1440)
DIM reflected%(1440)
xprev = 1
yprev = 700
cable = 50
PRINT "cable = ";cable;" ohms"
load = 75
PRINT "load = ";load;" ohms"

REM forward signal power
GCOL0,2
FOR x = 1 TO 1440
  y = 100*SIN(x*3.14/180)+700
  forward%(x)=y
  MOVE xprev,yprev
  DRAW x,y
  xprev = x
  yprev = y
NEXT x

REM antenna match
return_phase = TAN((load/cable))
REM PRINT TAB(5,5); return_phase

REM reflected signal power
xprev = 1
yprev = 700
GCOL0,1
FOR x = 1 TO 1440
  y = 100*SIN((x*3.14/180)+return_phase)+700
  reflected%(x)=y
  MOVE xprev,yprev
  DRAW x,y
  xprev = x
  yprev = y
NEXT x

REM swr signal power
xprev = 1
yprev = 700
GCOL0,4
FOR x = 1 TO 1440
  y = (forward%(x) + reflected%(x))-700
  MOVE xprev,yprev
  DRAW x,y
  xprev = x
  yprev = y
NEXT x


 REM load reflected signal summation return
 summation = load/cable
 IF summation = 1 THEN  sum = 0
 IF summation > 1 THEN  sum = (load/cable) - 1
 IF summation < 1 THEN  sum = 1 - (cable/load)

 REM swr meter reflected
 xprev = 1
 yprev = 700
 GCOL0,0
 FOR x = 1 TO 1440
   y = (100*sum)*SIN((x*3.14/180)+return_phase)+700
   MOVE xprev,yprev
   DRAW x,y
   xprev = x
   yprev = y
 NEXT x
```