A SIMPLE SLOTTED LINE for STUB PLACEMENT

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This easily constructed line is used for matching and stub placement purposes. Download the supporting software RF2.XLS, is available on this site, and will totally automate stub placement calculation from the slotted line measurements. The workbook also gives you several alternatives to the way you could match.

The slotted line is generally considered a laboratory instrument. This simple version gives accuracy adequate for determining load magnitude and phase to sufficient accuracy which you will need for calculation of stub placement. It consists of a transmission line section, suitably slottedto allow a voltage probe to be slid along a reference scale, and voltages on the line recorded.

Basically, the use of the slotted line requires two sets of magnitude and distance readings to allow calculation of VSWR and phase angle after a 'shorted min' is found.

Initially, load is connected (as closely as practical to the slotted line), and a 'short' is established at the load or reference point. The detector probe is slid along the slotted line until a voltage minimum is located, and this position is noted on a suitable reference scale. A typical trace of the line probe gives 'sharpened' sine curve shown below. (The slotted line should be long enough to show two minimums at the working frequency, to allow all cases of phase to be established).

The short is next removed, and the probe again moved down the line, and voltage maximums and minimums noted. These positions are recorded as to their magnitude, and their position on the line. A representative trace of this probe movement appears below as the 'flatter' sine wave.

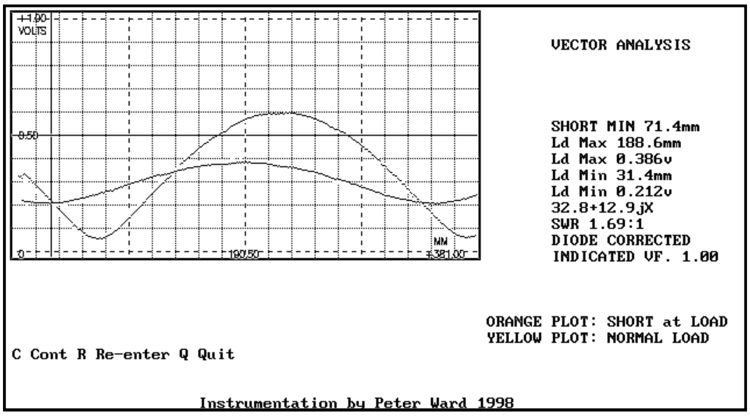


Fig 1:- This trace was recorded from the traverse of the carriage and probe on a HP 805C slotted line. In this adaptation cursors are used to mark the required maximum and minimums, and the load is calculated automatically.

The accompanying worksheets allow several methods to be used to analyze this data, including voltage from a diode detector, dBm from a calibrated receiver, or an attenuator technique. A study of the associated code and macros will allow the reader to come to grips with the associated calculations.

The detector used by this author is an ICOM R7000 with a calibrated RSSI curve, and a separate worksheet in RF4.XLS refers to the calibration procedure. This technique gives better accuracy than a diode detector with its non-linear detection curve, and is a great asset when used with a HP 805 bridge. If you have one of these bridges, and access to a calibrated signal generator, greater accuracy for your diode detector can be obtained by plotting a calibration curve for the diode, and producing an equation for the curve using a program such as T. Fahmey's 'XLSTAT'. (Calibrate your diode at frequency of use, and as closely as possible to the temperature of use, and with a nominated load.)

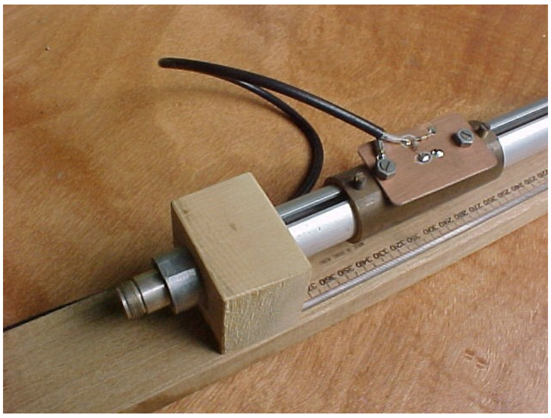
For home use, a simple slotted line is made by slotting one metre of 9.5 mm OD aluminum tube with a 1 mm slot extending to within 50 mm of each end. The inner core of 1 metre of RG213 is removed from its jacket and braid, and becomes the inner core for our slotted line. Where the 'N' connectors attach to the core, small sections of core material are sized and split, so as to fit snugly over the soldered section.

Fig 2:- The RG213 core is a snug fit in this aluminum tube, which retains our line impedance at 50 ohms. The far end of the tube can be terminated with a similar connector, but preferably the entire slotted assembly can become an extension of the feed-line. In this case, after stub placement is calculated, the antenna is re-assembled with new coax.

Effective VF of the line is calculated from the distance apart of two 'shorted minimums', and for this line is 0.72 at 477 MHz.

Fig 3:- The author's first attempt at building a slotted line, with its diode probe. Insufficient signal is available for diode operation, and the pickup of these simple lines is best fed direct to a sensitive receiver.

This line has an inner rod of 9.5 mm OD, and an outer tube of 19 mm ID, maintaining a close 50 ohm impedance. Designing a tapered transition at the end may be desired, and Worksheet # 9 on RF3.XLS includes a calculator to automate this for you.



Both voltage (Fig 4), and current probes (Fig 6) are pictured above, but the voltage probe is appropriate for slotted line use, (and avoids having to remember that current max is at voltage min!). The voltage probe is basically an extension on the end of a 50 ohm cable terminated with a 50 ohm resistor (a pair of paralleled 100 ohm chip resistors if you are clever). This probe extends to skim the inner core, and is fitted with a tiny sheath of teflon insulation from a piece of high temperature hookup wire, to ensure it runs without binding in the slot. The signal level from the voltage probe is too low to drive a diode detector, and a calibrated receiver is used.

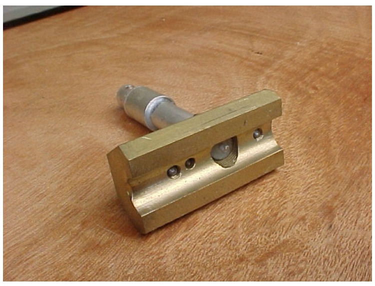
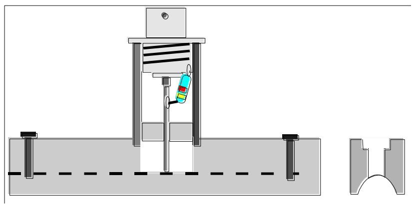


Fig 4 (Left) The voltage probe is a simple operation. If a mill is unavailable, drill the brass block and slit with a hacksaw.

Fig 5 (Right) Sketch shows line terminating resistor and probe.



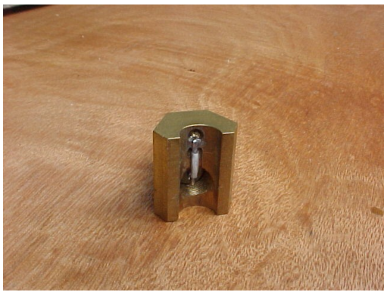


Fig 6 (Left) A current probe may be easier to build, but line readings have to be transposed.

Fig 7 (Right) Small dielectric sections are drilled and cut to minimise discontinuity at the connector

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The home brew slotted line is used in exactly the same way as the HP805 bridge and when used in conjunction with the accompanying spreadsheet, will calculate matching stubs automatically. Although the core of RG213 with a VF of 0.66 is used in this slotted line, the value of VF to be used in line calculations must be obtained after construction by measuring the distance apart of two nodes. The line pictured has an effective VF of 0.71 at 477 MHz.

Where a suitable receiver RSSI is not available, a 10.5 MHz IF output can be fed to a simple one chip detector based on a BAT114, or SA607. Both these chips have about 80 dB of RSSI range, but need care in design to avoid self oscillation. The author found the BAT 114 the simplest to use.

This last illustration shows adaptation of a ten turn pot as a displacement measuring aid on a HP805 bridge. The PCL818 Labcard in the computer reads the voltage from the pot., converts it to distance, reads the probe power from the ICOM R7000 and plots the curves as shown in Fig 1. Cursors then are moved over the required max. and min., locking them in, and all necessary calculations are fully automated. A particular advantage of using cursors is that routines in software can assist in finding the exact peak or trough of a shallow dip which is difficult to find using a meter or visual inspection of the trace.

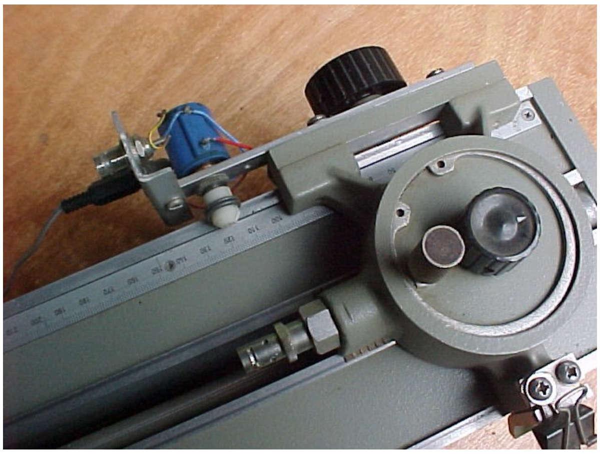

Fig 8:- The ten turn pot with 12 mm ‘o’ rings for friction grip mounted on the side of the bridge provide distance feedback. No modification is needed to the bridge metalwork, retaining its resale value.

The simple line described, used with spreadsheets in RF2.XLS will allow simple and accurate stub placement in all cases where a ‘short’ can be placed at the feed point to give us a reference point, and where reasonably short cables are used. Any error introduced by the simple line construction is compensated by small adjustments to stub lengths. Where broadband matching is required a bracket of readings should be taken, and the ‘Solver’ worksheet in RF2.XLS used.