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Measurement Aids for the UHF Amateur

In the development of assemblies for the UHF and VHF bands, the amateur usually has to make do without expensive measuring equipment. To make the work easier, we have designed two simple pieces of auxiliary equipment, which have already solved many measurement problems, namely an adjustable broad-band measurement amplifier and a divider operating up to 5 GHz.

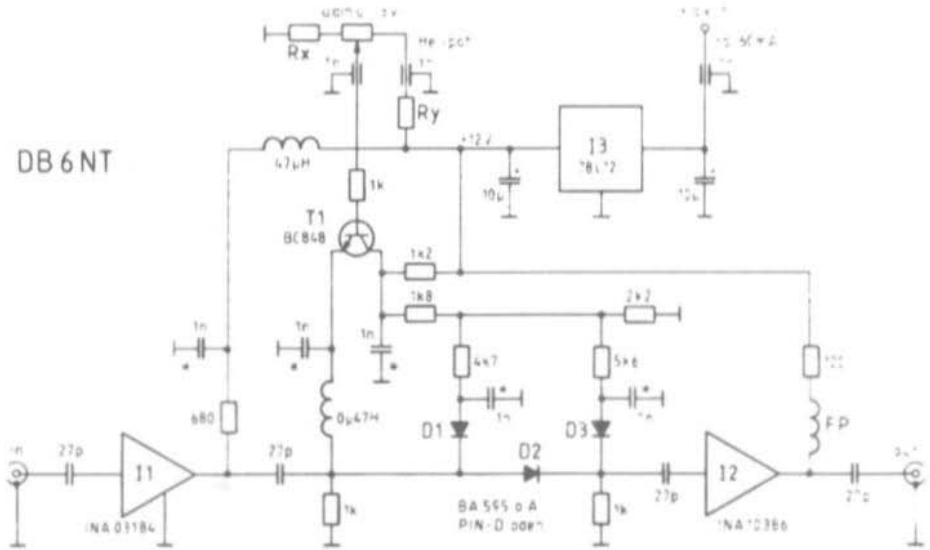


Fig.1: Broadband Measurement Amplifier: 100 MHz to 2.5 GHz

1. THE BROAD-BAND MEASUREMENT AMPLIFIER

1.1 Introduction

A broad-band and low-noise pre-amplifier with a band width going up to the 13cm. band can be used for many purposes, e.g. as:

- → Pre-amplifier for diode detectors in sweep measurements
- → Pre-amplifier for older spectrum analysers or microwave receivers
- → Makeshift aerial amplifiers

A few years ago, it would scarcely have been possible to produce such band widths on a repeatable basis using amateur resources, but nowadays integrated amplifiers are available at reasonable prices, which are a match, with regard to frequency response and noise factor with individually balanced discrete amplifiers.

1.2 Measurement amplifier circuit

Fig. 1 shows the result of the experiments: the first stage of the measurement amplifier is equipped with an INA 03184 MMIC (monolithic microwave integrated circuit) from Avantek/Hewlett-Packard. This module has an amplification of about 25 dB at band-widths between 0 and 2.5 GHz. The lower limiting frequency is determined only by the coupling capacitors at the input and output. The noise factor is below 3 dB.

The amplifier stage is followed by a PIN diode damping element in a PI circuit to adjust the amplification. This circuit will certainly be familiar to older readers from the television tuners of the pre-MOSFET age, and provides constant input and output impedances over the adjustment range. The BA595 SMD diode used, from Siemens, is especially suitable for damping elements in the frequency range between 1 MHz and 2 GHz.

The second amplifier stage is equipped with an INA 10386 from Avantek and

Fig.2: Measurement Amplifier frequency response

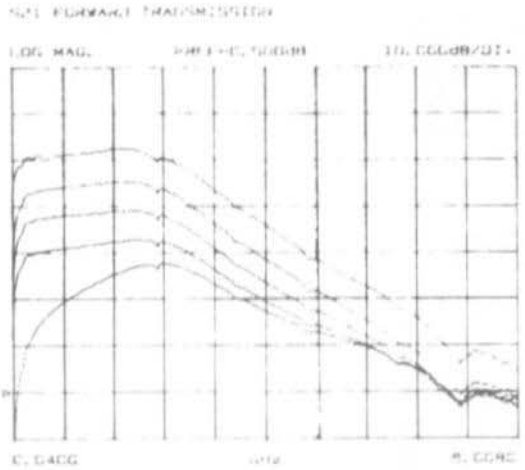


Fig.3:
Control behaviour of the PIN Diode regulator

supplies about 25 dB amplification. The remaining circuit elements merely set the operating points of the amplifiers and PIN diodes. A voltage regulator stabilises the supply voltage, which should lie between about 14 and 20 V. Higher voltage levels of up to 35 V are possible if the 78L12 is replaced by a 78M12 or 7812 and appropriately cooled.

1.3 Measurement results

The amplifier described produces an amplification of 50 dB in the frequency range between 100 MHz and 2 GHz. As Fig. 2 shows, an amplification of 30 dB can still be obtained at 3.5 GHz, and 10 dB can still be obtained at 5 GHz. The lower frequency limit of 100 MHz can be pushed down if necessary by enlarging the coupling capacitors by 27pF.

Fig. 3 shows the effect of the PIN diode damping element. The adjustment range covers more than 20 dB at frequencies of less than 2.5 GHz, which should be enough for most applications. The additional frequency response is negligible at damping levels below 20 dB.

Measuring the noise factor using an Eaton 2075 noise factor meter yielded values of 2 dB at 100 MHz and 3 dB at 2 GHz.

1.4. Assembly and parts list

A DB6NT 001 printed circuit board made from 0.5 mm thick RT Duroid 5870 forms the basis for the assembly of the measurement amplifier. Fig. 4 shows the layout. For assembly as per the components diagram (Fig. 5), proceed as follows:

First make the holes for the connectors (SMA or SMC flanged types), carefully producing a clearing hole on the earth side of the printed circuit board. The connectots can then be soldered in from the earth side. The flange should be soldered cleanly to the earth surface. Check carefully to make sure there is no copper swarf causing a short-circuit.

Then through-hole plate the earth connections of I1 and I2 in the usual way using thin brass foil and solder on the remaining assemblies (the order of operations is not critical here). But you should respect the basic rules when working with components where there is any danger of electros-

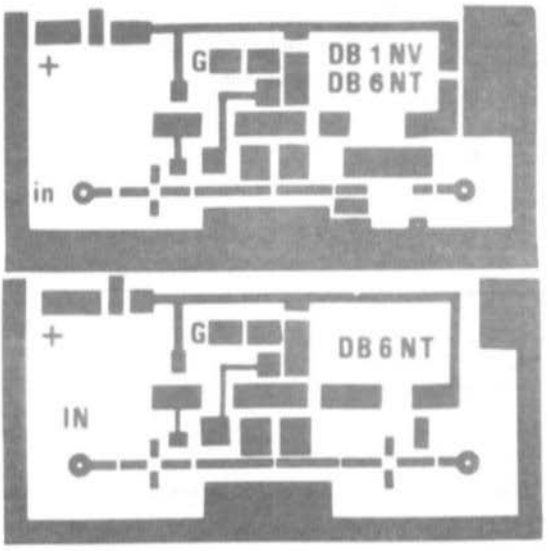


Fig.4:
Printed Circuit Board Layout of the Divider (top) and the Measurement Amplifier (bottom)

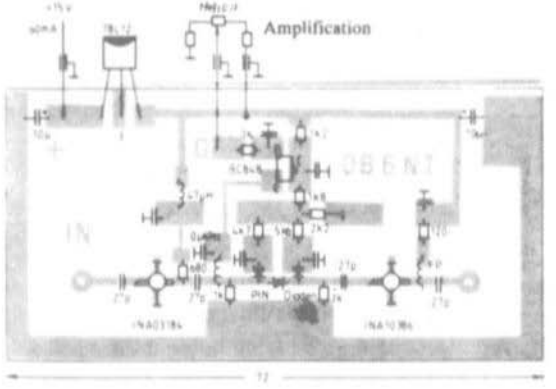
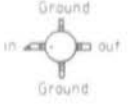


Fig.5:
Component Layout for the Measurement Amplifier



working with components where there is any danger of electrostatic phenomena and keep a steady hand when fitting the SMD components. Make sure you fit the integrated amplifiers I1 and I2 in the correct position - the slanting leg is the input! The blocking capacitors marked with a star on the circuit diagram, which are rated at app. 1nF (the value is not critical) must have the smallest possible format (SMD size 0603) and are soldered "vertically" into appropriate slots between the top and bottom sides of the PCB. This certainly requires precision work, but on the other hand it does provide extremely short earthing paths.

The entire assembly can be built into a suitable sheet metal housing. Feed in the operating voltage and the setting voltage for the PIN diodes through feed-through capacitors. The stop resistors Rx, Ry for the amplifier potentiometer are chosen in such a way that the setting voltage can be varied from about 0.5 V to 3 V.

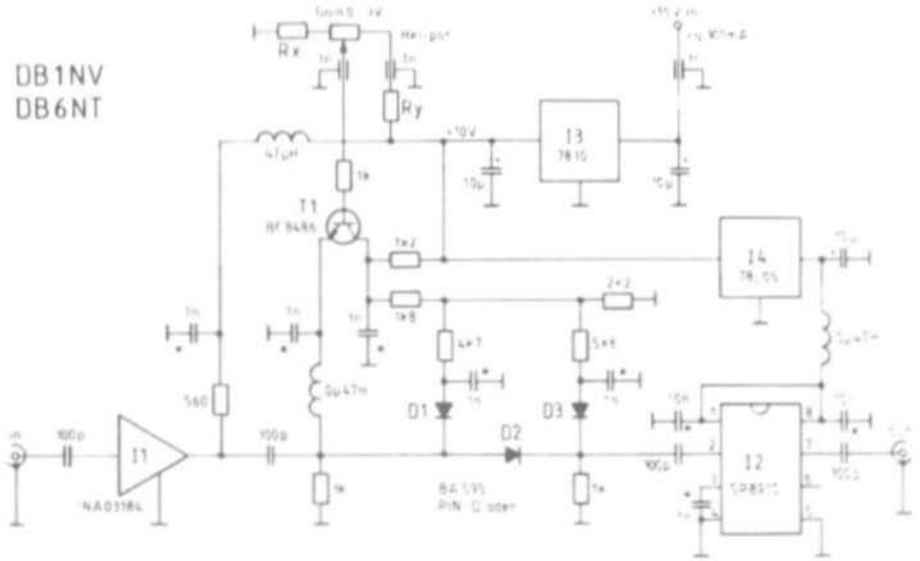


Fig.6: Frequency Divider circuit

The measurement amplifier is balance-free and should operate as soon as the supply voltage is applied if the damping element is set for minimum damping (3 V at adjustment input).

1.5. Parts list

I1:	INA 03184, Avantek/Hewlett-Packard Operates above BFI
I2:	INA 10386, Avantek/Hewlett-Packard Operates above BFI
I3:	78L12, or 78M12 (see text)
T1:	BC848b
D1-D3:	BA595, Siemens
FP:	Ferrite bead

All resistors: SMD, Minimelf or Chip - size 1206
All inductors: SMD
All capacitors: SMD, size not critical, blocking capacitors marked with a star on the circuit: size 0603

2. THE PRE-DIVIDER

2.1. Circuit Description

Until now, direct frequency measurement for the amateur at a reasonable cost has been possible only up to about 3 GHz (the frequency limit of the NEC dividers uPB 581 and uPB 582). Anyone who simply couldn't get hold of a microwave meter had to rely on elaborate transfer oscillator processes with harmonic mixing or expensive GaAs pre-dividers.

Over the last year or so, a family of pre-dividers from Plessey has become familiar which operate at up to 5 GHz for a price of app. DM 120. Types SP8902, SP8904, SP8908, SP8910 and SP8916 are available at present - the last two numbers give the divider factor. Thus any existing 500 MHz meter can be expanded for frequencies of up to 5 GHz.

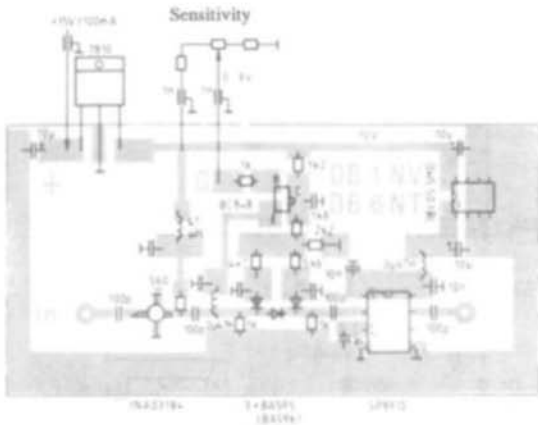
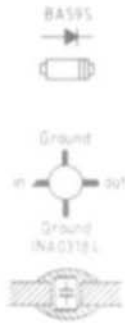


Fig.7:
Component Layout of the Frequency Divider



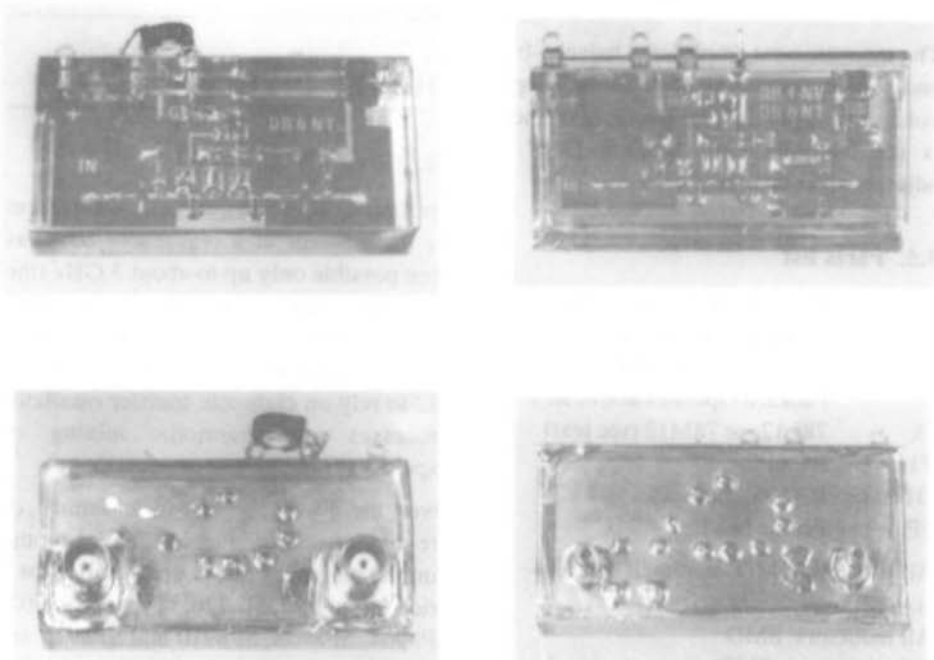


Fig.8: Prototype Measurement Amplifier and Divider units

For the frequency divider, type SP8910 was used, which operates in the normal DIL-8 housing with a scale running from 10 up to 5.5 GHz and needs a supply voltage of only 5 V.

As Fig. 6 shows, only the second amplifier, I1, was replaced by the pre-divider in the measurement amplifier circuit, and a permanent voltage controller was added for the 5 V power supply. The operating voltage of the first amplifier is still only 10 V, so that the entire circuit can be powered at 12 V. The pre-amplifier, I1, not only increases the input sensitivity of the divider, but also protects the divider module, I2, which is ten times more expensive, should the input level be too high. The pre-divider operates in the frequency range from app. 140 MHz to 6 GHz - with careful level app. 100 MHz to 6.5 GHz.

2.2. Assembly

A DB6NT printed circuit board made from RT Duroid 5870 0.5 mm. thick forms the basis for the assembly of the pre-divider. The layout has already been shown in Fig. 4, and the assembly as per the components diagram (Fig. 7) is carried out as for the measurement amplifier.

First make the holes for the connection bushes (SMA or SMC flanged bushes), producing a clearing hole on the earth side of the printed circuit board. The bushes can then be soldered in from the earth side.

Then through-hole plate the earth connections from I1 and shorten all legs on I2 flush with the housing, except pins 4 and 5. Insert pins 4 and 5 through holes in the printed circuit board and solder them to top and bottom sides. All other connections are soldered only to the top side using the strip conductors. When installing the remaining components, once again insert the minimum size units (SMD size 0603) - app. 1nF and app. 10nF blocking capacitors - (values not critical, marked with a star in the wiring diagram) "vertically" into appropriate holes between the top and bottom sides of the printed circuit board. Like the measurement amplifier, the entire assembly can be incorporated into a suitable sheet metal housing. Fig. 8 shows two sample set-ups of the author's.

The pre-divider needs no balancing either. If there is no input signal, the SP8910 oscillates at about 5 GHz, and an unstable signal around 500 MHz can be measured at the output. This phenomenon should be well-known from experience with many other emitter-coupled logic dividers.

2.3. Parts list

I1:	INA 03184, Avantek/H.P.
I2:	SP8910 BDG, Plessey
I3:	7810
I4:	78L05
T1:	BC848b
D1-D3:	BA595, Siemens

All resistors: SMD, Minimelf or Chip, size 1206
All inductors: SMD
All capacitors: SMD, size not critical, blocking capacitors marked with star on circuit: size 0603

Other: 2 SMA or SMC flanged bushes
3 feed-through capacitors, app. 1nF
1 DB6NT 002 PCB
1 tin-plate metal housing 74 x 37 x 30mm