A wideband, low noise, high dynamic range amplifier covering 50MHz to 4GHz

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Introduction

Kent recently produced a series of printed circuit board kits in the USA for use with the RFMD GaAs P-HEMT MMIC type SPF5053Z. The amplifiers cover from 50MHz to over 4.0GHz with a high dynamic range, low noise, excellent input and output return loss (match) together with moderate gain. Power supply can be as low as 3V and up to about 15V, with suitable (external) bias resistors.

The RFMD SPF5043Z has an **inherent** device noise figure below 1dB up to 2.5GHz, with as low as 0.6dB available at 144MHz and 432MHz. At 1296MHz the noise figure is around 0.8dB. Up to 3.8GHz the input return loss is better than 10dB. At 23cm the output P1dB is almost 200mW! The SPF5043Z has usable gain beyond 8GHz, if you really must!

Of course many of these device figures deteriorate when the SPF5043Z is mounted unto a PCB. By using thin (0.79mm) FR4 board the overall performance is kept close to the device performance up to about 2GHz. Careful selection of input and output capacitors together with the value of L1 may also improve the figures at the higher ranges of the amplifier.

Some possible uses for the amplifier are:
Moderately low noise preamplifiers to 13cm
general purpose gain blocks
Transmitter driver stage (ideal for those Mitsubishi PA blocks)
Post mixer amplifiers
Frequency counter input amplifiers
wideband noise generator source amplifiers

I'm sure you can think of many more uses.

There are three types of PC boards available, each with a different type of termination. These are SMA through-board, SMA-edge and cable. Although all three boards are quite small, they are slightly different sizes. The SMA through termination is the largest at 4.1cm x 1.25cm. The SMA edge termination is 3.3cm x 1.0cm and the cable termination board is also 3.3cm x 1.0cm. The SMA edge termination PCB is 0.5mm thick whilst the other two are both 0.8mm thick. In order to avoid fracturing small SMD parts the thinner board should ideally be attached to a stronger back board. **For the moment only the cable termination PCB will be offered with the kit.**

Circuit description

The layout of the amplifier, on a WA5VJB5043Z cable terminated PCB, is shown in figure 1.

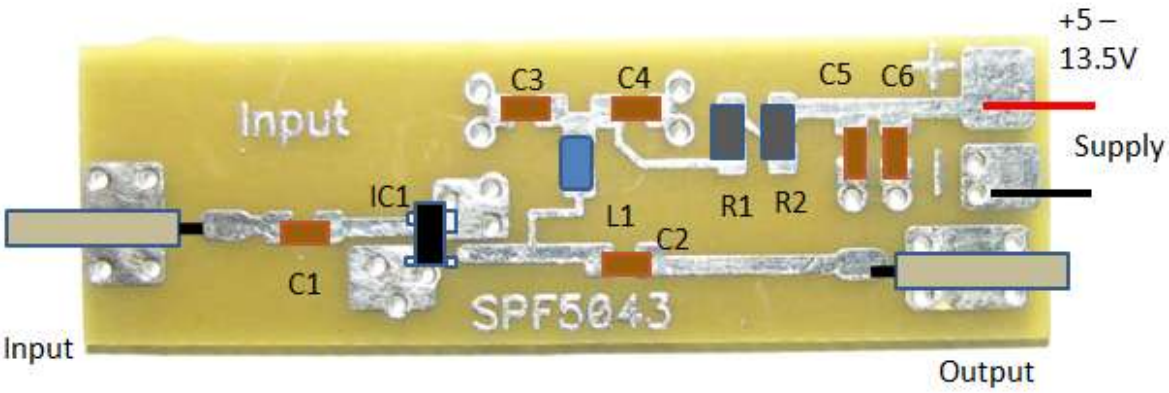

Figure 1 Component layout on the cable termination PCB.

The SPF5043Z is biased from its output (drain lead) via L1 and the resistors R1 and R2. It can be powered from 3V to about 9V using the on-board bias resistors R1 and R2. If you need to use a higher supply voltage then, due to resistor/pad dissipation limits, an off-board 1/4 to 1/2W resistor will be needed. The device is self-biased to the required drain current by setting the drain voltage as appropriate by R1 and R2. For most amateur radio purposes the amplifier will be used with 5V drain voltage. There is a space for two drain dropping resistors, R1 and R2. These are not essential when using 5V, but do help with supply noise decoupling. Use 10Ω for R1 and 0Ω for R2.

The circuit schematic diagram of the amplifier is shown in figure 2.

If the amplifier is to be used with an external 13.5V supply an external 180Ω / 0.5W rated resistor should be inserted in the positive lead to the board. Continue to use R1 and R2. In no circumstances allow the voltage on the drain of IC1 to exceed 5.0V

Note that the DC resistance of L1 is ignored and as long as its current capacity is greater than 46mA, it can safely be forgotten.

The decoupling capacitors C3 to C6 are chosen to give good decoupling across the entire frequency range from 50MHz to 4GHz. C6 actually extends the decoupling to even lower frequencies.

C1 and C2 should be chosen to have self resonant frequencies above the maximum intended frequency of operation. Ideally, for lowest noise figure, these should be low ESR types.

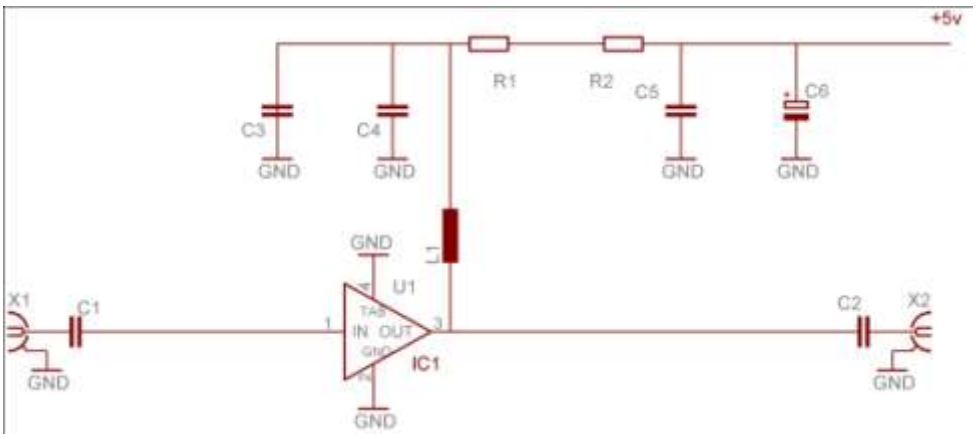

Fig 2 Schematic diagram of the wideband, low noise amplifier.

Component list

R1	**10Ω**	**0603**
R2	0Ω	0603
C1,2,3	100pF	0603
C4	10nF	0805
C5	0.1µF	0805
C6	1µF 16v	A case size
L1	100nH	0603
IC1	SPF5043Z	43
X1, X1	Cable or connectors	SMA or PTFE cable
PCB	WA5VJB5043Z Cable term PCB	

Table 1 Components values for the amplifier (kit version). R1 and R2 value chosen for use with 5V supply.

Construction

Photo 1 shows the SPF5043Z amplifier constructed on the cable termination PCB. Because the parts are well-spaced, construction is easy. You MUST use 0.5mm (28SWG) leaded solder. The boards were produced in the USA and are lead tinned. Larger gauge solder than the recommended size will ensure that you make a mess of the PCB!

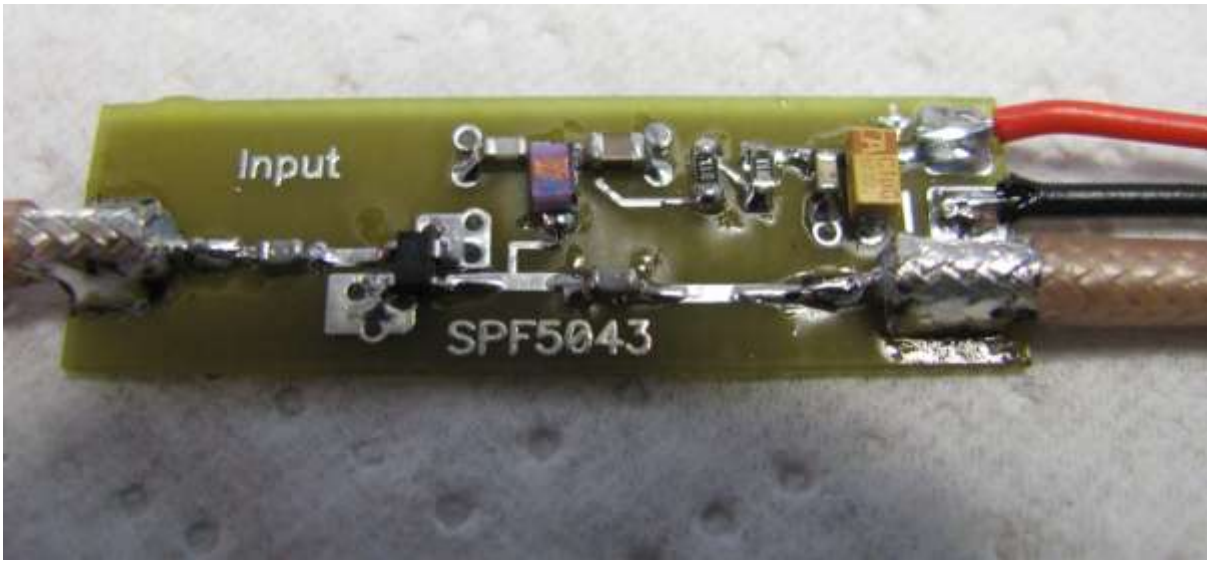

Photo 1 Assembled SPF5043Z amplifier. Note that after kit serial 125 0603 size a 100nH inductor is being supplied for the L1 position

Begin by soldering the bias resistors, R1 and R2, followed by the supply decoupling capacitors C5 and C6. Solder C3 and C4 next, followed by L1.

Solder C1 and C2 in place on the input and output lines.

Carefully solder IC1 into position noting that the biggest (widest) lead is soldered to the GROUND pad nearest to L1. It is advisable to use a grounded soldering iron to prevent static damage to the fragile IC. The SPF5043Z uses the well-known four lead '43' package.

Prepare the ends of some UT085 (or flexible equivalent) and solder the outer to the ground pads and the inner to the pad next to C1 or C2, depending on input or output.

Preparing flexible (PTFE only to be used....) coax should be done in the correct manner as shown in fig 3 and 4. NO PIGTAILS!

Carefully score round the outer jacket 10mm from the end of the cable using a sharp scalpel and slide the jacket off the cable.

Carefully tin the full length of the exposed braiding outer.

Carefully score round the tinned braid 5mm from the end and then carefully 'break' the braid by bending. Slide the braid off the cable to expose the PTFE inner.

Carefully score through the PTFE inner 3MM from the end and slide it off to expose the cable inner.

Carefully tin the inner.

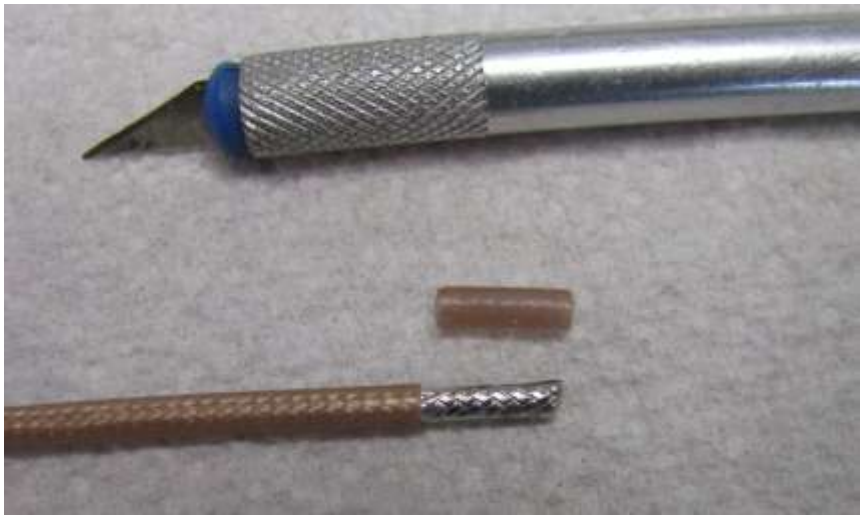

Fig 3 RG316 cable preparation

Fig 4 RG316 Cable preparation, final stage

Solder the tinned outer to the ground pad and the tinned inner to the input or output pad, ensuring that the inner is not shorted to the cable outer.

Solder the two supply leads as shown in figure 1

Results

Photo 2 Insertion gain from 30MHz to 3GHz. Markers at 40, 144, 432 and 1296MHz. The gain is 20dB at 40MHz, 22.7dB at 144MHz, 15dB at 1296MHz and 10.6dB at 2.3GHz. The red line is 0dB gain. The yellow line indicates the gain at 10dB / division. The input power level was set at -20dBm.

Photo 3 Input Return loss (S11) from 30MHz to 3GHz. Input return loss measured 1dB at 40MHz, 8.5dB at 144MHz, 10dB at 1296MHz and 8.2dB at 2.3GHz The red line is 0dB return loss. The yellow line indicates return loss at 10dB / division.

Noise figure and gain measurements at various frequencies. Vdd = 5V and Id = 46mA

Band	*Gain (dB)*	*Noise figure (dB)*
30MHz	20	2.0
50MHz	21.8	1.1
144MHz	22.5	0.68
432MHz	21.1	0.68
1296MHz	15.5	0.86
1420MHz	14.6	0.86
1500MHz	14.0	0.82
1600MHz	13.8	0.88
2320MHz	10.9	1.2
3400MHz	5.2	2.3

Table 2 Gain and noise figure measurements for the kit amplifier. It is possible that these numbers could be improved slightly by adjustment of the bias and also by selection of more optimum component values. The noise figure measurement was made through 4cm of RG316 input cable and an SMA3.5 female to female adapter.

Further information

The SPF5043Z data sheet can be viewed here http://www.rfmd.com/CS/Documents/SPF-5043ZDS.pdf

The SPF5043Z can be used at even lower dissipation by adding a resistor from the input to ground. This is described in http://www.rfmd.com/CS/Documents/SPF-5043Z.pdf

Surprisingly, the P1dB does not degrade as fast as you would expect at these much lower drain currents.

S Parameter etc, for the SPF5043Z can be found here https://estore.rfmd.com/RFMD_Onlinestore/Products/RFMD+Parts/PID-P_SPF-5043Z.aspx

Kits

Kits of components as the component list, Table 1 are available from G4DDK for 10GBP

Postage and packaging is 3GBP in the UK. Please inquire for overseas rates

Paypal payment can be accepted.

See www.g4ddk.com for more details of the amplifier.