G4HUP

DA1-4 General Purpose Distribution Amplifier

Technical Manual

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Contents

Unit Specifications

Model Ref General Purpose Distribution Amplifier

Serial No

Input Frequency[1]	10	MHz
Input Level	+0	dBm (Max i/p +5dBm)
Output Frequency	10	MHz
Output Level[2]	+5	dBm per channel (0dB Atten)
Gain Variation between channels	<4%	At 10MHz
Phase variation between channels	<±3°	At 10MHz
Inter-channel Isolation	>25	dB typ. at 10MHz
Max output	+10	dBm (recommended)
Supply Voltage	12 – 15	V
Supply Current	330	mA @ 13.4vdc

Notes:
1 The GPDA is broadband in nature, but measurements quoted here have been conducted at 10MHz.
2 Output level quoted is without any attenuators in the circuit.
3 Power level measurements quoted here have been taken with HP435 Power Meter.

Scope of Document

This document is intended to provide all necessary information to guide users in the construction and installation of the G4HUP General Purpose Distribution Amplifier Model DA1-4 in normal operation.

Ready built units are supplied complete and tested, and should require no further attention prior to use.

This document is relevant for DA1-4 units constructed on V1_0 PCB's.

Reference data can be found on the DA1-4 pages of the DFS web-site, including any identified issues or problems – http://g4hup.com/DA/DA1-4.html.

DA1-4 Distribution Amplifier Description

Applications

The DA1-4 is designed as a 1 in, 4 out, broadband amplifier. It has approximately 5dB of gain per channel with 0dB of input attenuation implemented at LF. Up to 1.8GHz the overall gain is positive or flat, falling to 0dB nominal at approx 1.8GHz. There are no filtering components provided within the DA1-4. Therefore it is suitable for such applications as:

- 10MHz distribution for GPS reference locking of test equipment and oscillators
- distribution of RF sources to multiple destinations, eg enabling a 144MHz (or 432MHz) microwave IF to be routed to more than one receiver simultaneously, or routing a common LO source to multiple converters.
- distribution of a GPS antenna feed to multiple GPS receivers – optional components allow the DA1-4 to provide the +5v 80mA powerfeed for active GPS antennas

Filtering & Isolation

In some applications RF filtering may be advantageous or even necessary. For instance it is known that some test equipment items do not like sources which have significant levels of harmonics present. In such cases outboard low pass or band pass filters can be provided, or the attenuator positions on the DA1-4 PCB can be used to implement single stage Pi LPF's using 0805 size inductors and capacitors. If the 10MHz source that you are using has a square wave output, then external filtering should be considered an essential addition for this DA.

In addition to the options for on-board LPF Pi filters, a useful source of very good filters and isolation transformers for use at 10MHz is old ISA PC Ethernet cards. These usually contain one package with two filters in it, and another package with up to 3 1:1 transformers – see http://www.uhf-satcom.com/misc/10MHz_dist/ for some good hunting tips! These cards usually also have a DC-DC inverter, which may be useful for

other applications. Note that filtering and isolation using these packages must be implemented outside the DA1-4 box – there is inadequate space inside.

Connectors

No connectors are supplied with the kit – for 10MHz distribution, BNC connectors are both appropriate and convenient, since the equipment being used is usually using these connectors. For higher frequency use, particularly in the GPS antenna distribution case, SMA's are more convenient. Please supply and fit connectors to your preference.

Output Equalisation

Reasonable precautions have been taken in the PCB layout to equalize the path lengths of the four signals, so that the phase variation between the output channels is minimal – measurements made at 10 MHz indicate that this considerably less than ±3°. The variations will be different at other frequencies, and users are recommended to make their own measurements if phase differences are a significant concern.

Physical Description

The DA1-4 is constructed in a tin-plate housing, measuring 111 x 55 x 30 mm (4.375 x 2.2 x 1.2 inches approx)

External connections are provided for:

- Input signal – User provided BNC or SMA
- Output signals – User provided BNC or SMA x 4
- +Vcc power supply
- 0v DC ground

DC connections are by solder terminations to the DC input feedthrough capacitor and the ground tag close by it.

Distribution Amplifier Operation Overview

The DA1-4 is designed to accept a 10MHz GPS locked input signal at a nominal +10dBm level. As an alternative to a GPS locked input signal, the output of a good quality OCXO, amplified to the correct level, can be used, with entirely satisfactory results.

The input signal is resistively split into four, and each path is then amplified using a Siemens BGA616 MMIC amplifier.

There are options provided on the PCB for a Pi attenuator at the input of the DA1-4, and also individually in the outputs of each amplifier path. The attenuator value should be chosen to ensure that the amplifiers are not subjected to overdrive. For a nominal +10dBm input, as is typical from a commercial GPDSO, such as the HP Z3801/3815 or Trimble Thunderbolt, this attenuator should be set for 5dB, which will deliver a nominal +10dBm at each of the four outputs. The 0805 SMD resistors for this input attenuator are supplied with the kit.

Similarly, if the completed DA provides inadequate gain for your application, eg if your source output level is much lower that +10dBm, or you are working at a frequency close to the top end of the units range, then an input amplifier can be grafted in between C1 and R2 – more information later in the manual.

A further option allows the DA1-4 to provide a +5v 80mA supply source at the RF input socket for power feeding of active GPS antennas – this should only be enabled for GPS antenna distribution applications.

Circuit Description

The circuit diagram of the DA1-4 is shown in Fig 1. Components L1 and C23, along with IC6, C22 and C24 form the GPS antenna power feed option.
R1 is not used. R2 should be a short circuit in normal use.

The input attenuator is R3, 4 and 5. For normal usage (L version), R4 should be 33R and R4 and 6 should be 180R (5dB attenuator).

The four way split is in three stages – the input signal is split into two by R6 – 8, and each output is then split again using R9-10 and R11-12. Following each split output is an identical MMIC circuit. Each has an output attenuator available on the PCB, although kit components are not provided for any attenuators.

A 78M08 D-pak style regulator provides the supply for the MMIC's.

Added Input Amplifier

The track between C1 and R2 can be cut and used to insert a MMIC amplifier – MAV-11 is recommended. You will see that vias have been provided between the board layers where the two ground pins of the MMIC will be – it is recommended that you scrape away some of the solder resist around them to improve the contact area if you do need to install this extra stage. C1 will need to provided – typically 10 to 100n, and the R2 pad can be used for the output isolation capacitor of the stage. You will need to build the DC power to the MMIC in 3D, but you should use an identical circuit and values to those used for the BGA-616's – ie a 47R connected directly to the output pin of the MMIC, decoupled at the cold end by a 10n and 100n capacitors in parallel. The stage gain will be approx 12dB over the range up to 1.8GHz.

GPS Power Feed Option

For use as a GPS antenna distribution amplifier, it is recommended to reduce all coupling capacitors to 1nF, and to add the 78L05 5v regulator and its associated components to provide a source of 5v DC, via a choke, at the input socket.

Since the outputs will be connected to GPS receivers, each equipped to provide 5v DC at their respective antenna sockets, it is essential that the output coupling capacitors, C25 – 28 are provided, to avoid DC backfeeding from the GPS receivers into the DA1-4

output attenuator circuits. For other applications of the DA1-4, the use of C25-28 is optional, but recommended.

Errata and Addenda

This section contains information about components that have been changed or added compared with the original PCB design.

See http://g4hup.com/VDA/DAerrata.html for full details, versions impacted and resolution guidance, including pictorial support.

Component Locations

Figs 2 and 3 respectively show the locations of components on the top side and lower side of the PCB

Construction

Mechanical Preparation

BNC connectors will require some preparation work to allow them to sit flat onto the tin-plate housing. If you have access to a lathe, this is easy, but can also be achieved with a hand file. The type of BNC socket you need is the four hole fixing type, not the type that fit through a single large hole.

On the back of the socket, the ridge of metal and the PTFE underneath it must be removed to give a smooth interface onto the centre. I recommend that you use a scalpel to reduce the diameter of the PTFE initially to 5.5mm, the same as the extension that surrounds the centre pin.

Use the PCB to mark the connector locations onto the edges of the tin-plate housing – if you are using BNC connectors, they should be mounted along the centre line of the edge, to ensure that both top and bottom covers will fit. For SMA connectors (2 hole type), the centre lines can be mounted at 10mm above the bottom edge of the box. The following measurement information is given as applied to the individual L shaped box edges, before they are soldered. For the output side spacings, I use 19, 42, 66 and 89mm (internally) from the end of the box. The input connector is 42m from its end of the box – again, this is an internal measurement. For BNC connectors drill these holes out to 5.5mm, and for SMA's drill out to 3.5mm. Also make a hole (3.5mm) for the DC power feedthrough capacitor, so that there is space to install the protection diode between it and TP1- approx 90mm from the box end works well, but it must be above the centre line of the edge. Deburr all holes.

Clean up the soldering faces, and assemble the box with a hot iron. Use a file to trim the PCB to a final fit in the box, and mount the connectors. Push the connectors into place - the PTFE around the centre pin of the connector will now hold it in place while it soldered. Use a scalpel or other sharp blade to remove the excess PTFE insulation, and trim back the centre pins to approx 3mm length.

Do not mount the DC feedthrough at this stage.

Lay the PCB onto the pins of the connectors and solder in place. Now seam solder the edge of the PCB, top and bottom, to the box walls. Finally, the DC power feedthrough ca be installed – place the solder tag beneath it to allow the DC ground connection. Connect D1 between the power feedthrough, Cf, and TP1, with the cathode (band end) to TP1.

Install the components onto the PCB, referring to Fig 2, 3 and the Component List. Note that in normal 10MHz operation, R2, R18, R21, R24 and R27 are replaced by short circuits. The SMD electrolytic capacitors, C20, 21 and 24 (G version only) have the positive end indicated by the band. Make sure that the tab of IC5 is soldered down to the ground land underneath it.

Install the BGA616's last – the pads are quite small, so they will require accurate placement. See the diagram after the Component List for the orientation information.

L version

Use 5dB input attenuator (R3, 4 and 5), C1 use 100nF.

G Version

Use 1n for C1, omit input attenuator (R4 = 0R, R3 and 4 open circuit). Install C22 – 24, IC6 and L1.

Performance

Fig 4 shows the swept frequency response between 10MHz and 1.8GHz. There is some variation at higher frequencies between outputs. Note that all unused outputs should be terminated with a good 50R load.

Through the VHF region there is positive gain, with a dip between approx 500 and 800MHz. Thus the DA1-4 is usable up to the 70cm (430MHz) amateur band, and again through the 33cm (US 902MHz) and 23cm (1296MHz) amateur bands.

When used as a GPS antenna distribution amplifier, the gain is nominally 0dB. This is unlikely to be a significant factor, since antenna gain is not normally an issue with GPS systems. In the rare event that it is a problem, it is recommended that a MMIC, eg MAV-11, is grafted in, before the input resistive splitter.

Fig 5 shows the output signals from all four channels when the DA1-4 is driven at 10MHz. This display is set so that 1 complete cycle covers 10 divisions of the screen – thus 1 division equates to 36° of phase. The crossings of all four channels are very close at the div 10 point, (ie after 1 cycle) indicating that the differential phase error is very small – less than ±3° (ie within 0.2 div).

Maintenance

Construction Practices

Ready built units are assembled using lead bearing solder - any repairs or changes necessary should be made using lead based solder. Use as small a grade of good quality flux based electronic assembly solder as possible.

Kits are not supplied with any solder, but it is recommended that a small diameter, good quality cored flux solder is used, to ensure minimum flux residues on the PCB after assembly. The PCB will accept lead-free solder, and components used are generally ROHS compliant, and should therefore also accept lead-free solder if you prefer.

It is recommended that lead based solder is used for maximum reliability of soldered joints.

Change History

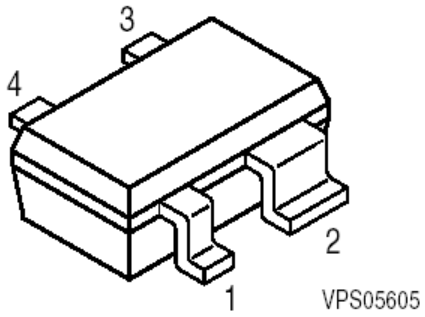
Date	Iss No	Comment	Author
9 Jun 2008	0.A	First Draft version	G4HUP
31 Jul 2008	0.B	Updated, performance measurements included	G4HUP
15 Feb 2009	V1.0	Updated for production PTH PCBs	G4HUP
16 Feb 2009	V1.01	Land G version detail clarified	G4HUP

End of text – Diagrams follow

Component List DA1-4L

ID	Value	Spec	Comment
PCB	GPDA	V1.0	
Box		110x55x30mm	Tin-plate self assembly
Connectors		BNC or SMA	User supplied
solder tag	3mm		Use with Cf for DC in
C1	100n	0805/50v	1n in G version
C2	100n	0805/50v	
C3	100n	0805/50v	
C4	100n	0805/50v	
C5	100n	0805/50v	
C6	100n	0805/50v	
C7	100n	0805/50v	
C8	100n	0805/50v	
C9	100n	0805/50v	
C10	10n	0805/50v	
C11	100n	0805/50v	
C12	10n	0805/50v	
C13	100n	0805/50v	
C14	10n	0805/50v	
C15	100n	0805/50v	
C16	10n	0805/50v	
C17	100n	0805/50v	
C18	100n	0805/50v	
C19	100n	0805/50v	
C20	6u8	16v 1210	
C21	6u8	16v 1210	
C22	100n	0805/50v	G version only
C23	1n	0805/50v	G version only
C24	6u8	16v 1210	G version only
C25	100n	0805/50v	
C26	100n	0805/50v	
C27	100n	0805/50v	
C28	100n	0805/50v	
Cf	1n	feedthrough	
R1	Not used		
R2	0R	0805/ 0.125W	
R3	180R	0805/ 0.125W	L version only
R4	33R	0805/ 0.125W	0R in G version
R5	180R	0805/ 0.125W	L version only
R6	16R	0805/ 0.125W	
R7	33R	0805/ 0.125W	
R8	33R	0805/ 0.125W	
R9	16R	0805/ 0.125W	
R10	16R	0805/ 0.125W	
R11	16R	0805/ 0.125W	
R12	16R	0805/ 0.125W	
R13	47R	0805/ 0.125W	
R14	47R	0805/ 0.125W	
R15	47R	0805/ 0.125W	

R16	47R	0805/ 0.125W	
R17	Not used	0805/ 0.125W	
R18	0R	0805/ 0.125W	
R19	Not used	0805/ 0.125W	
R20	Not used	0805/ 0.125W	
R21	0R	0805/ 0.125W	
R22	Not used	0805/ 0.125W	
R23	Not used	0805/ 0.125W	
R24	0R	0805/ 0.125W	
R25	Not used	0805/ 0.125W	
R26	Not used	0805/ 0.125W	
R27	0R	0805/ 0.125W	
R28	Not used	0805/ 0.125W	
L1	1uH	1210	G version only
D1	1N4001		DC Protection
IC1	BGA616		
IC2	BGA616		
IC3	BGA616		
IC4	BGA616		
IC5	78M08Q	D Pak	
IC6	78L05	TO92	G version only



BGA 616 connections

Input – pin 1
Output pin 3
Ground pins 2,4

Pinout data courtesy of Infineon BGA616 data sheet.

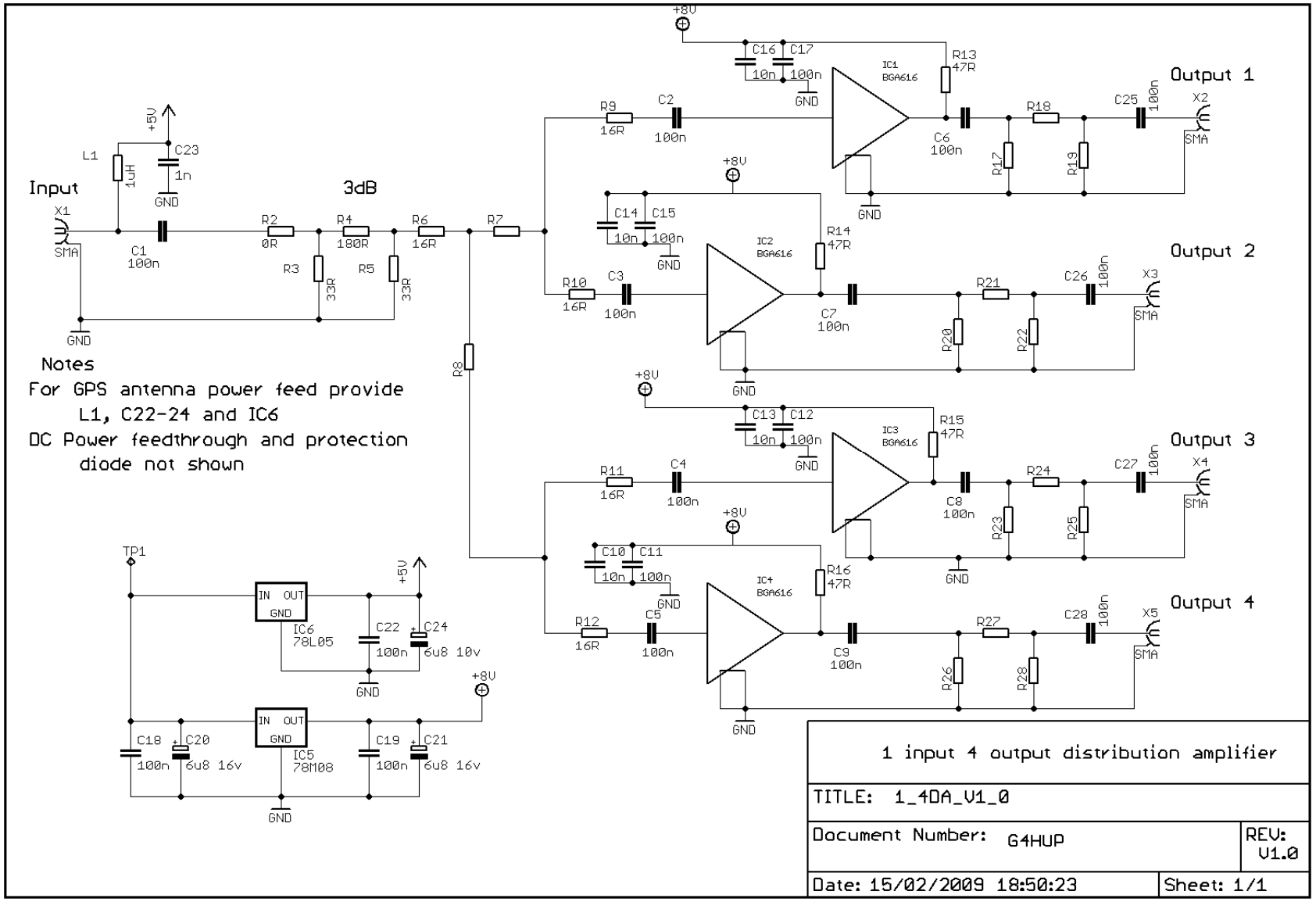


Fig 1 – General Purpose Distribution Amplifier circuit

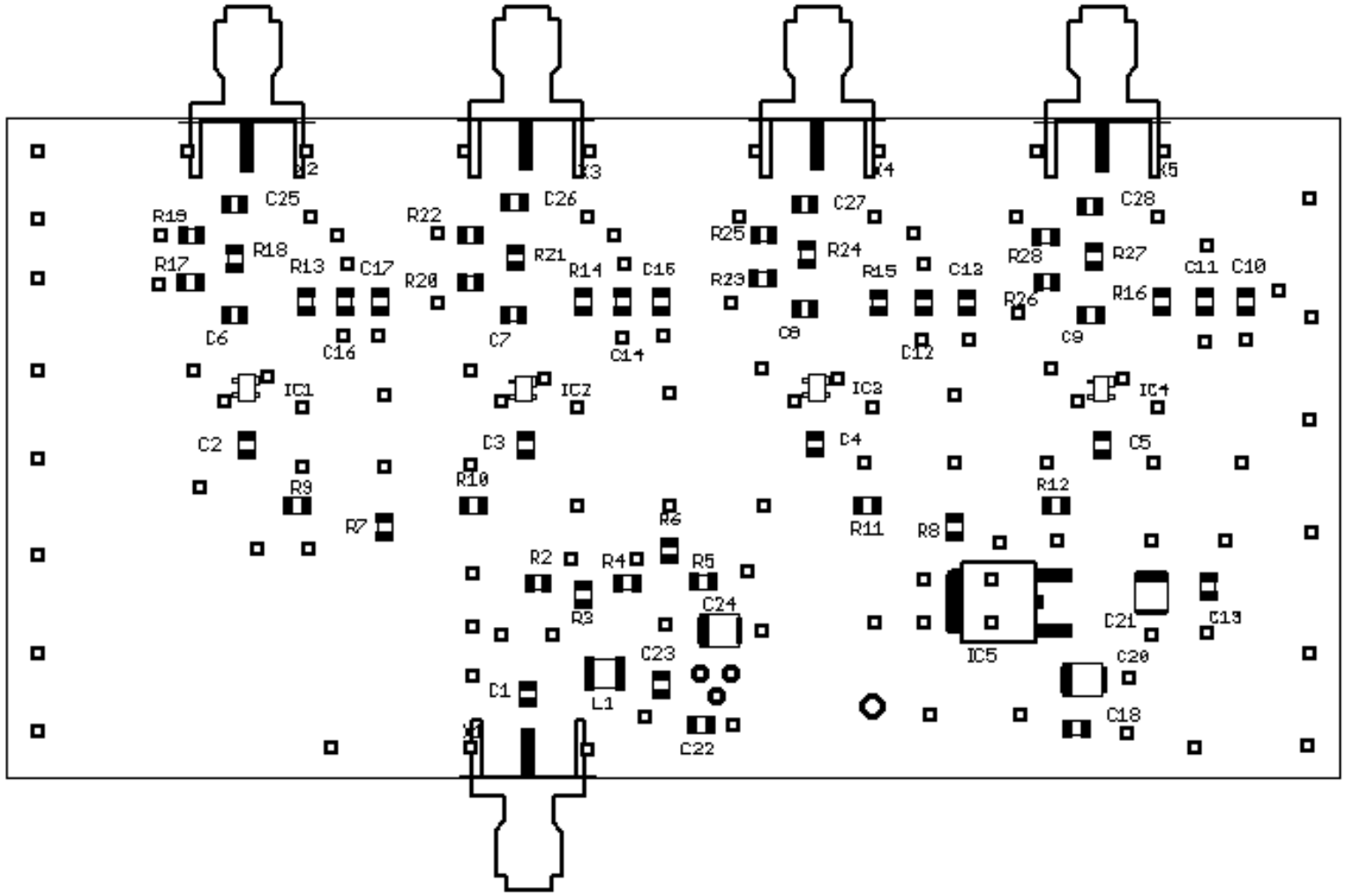


Fig 2 – PCB Component side Locations
- note – SMA sockets shown

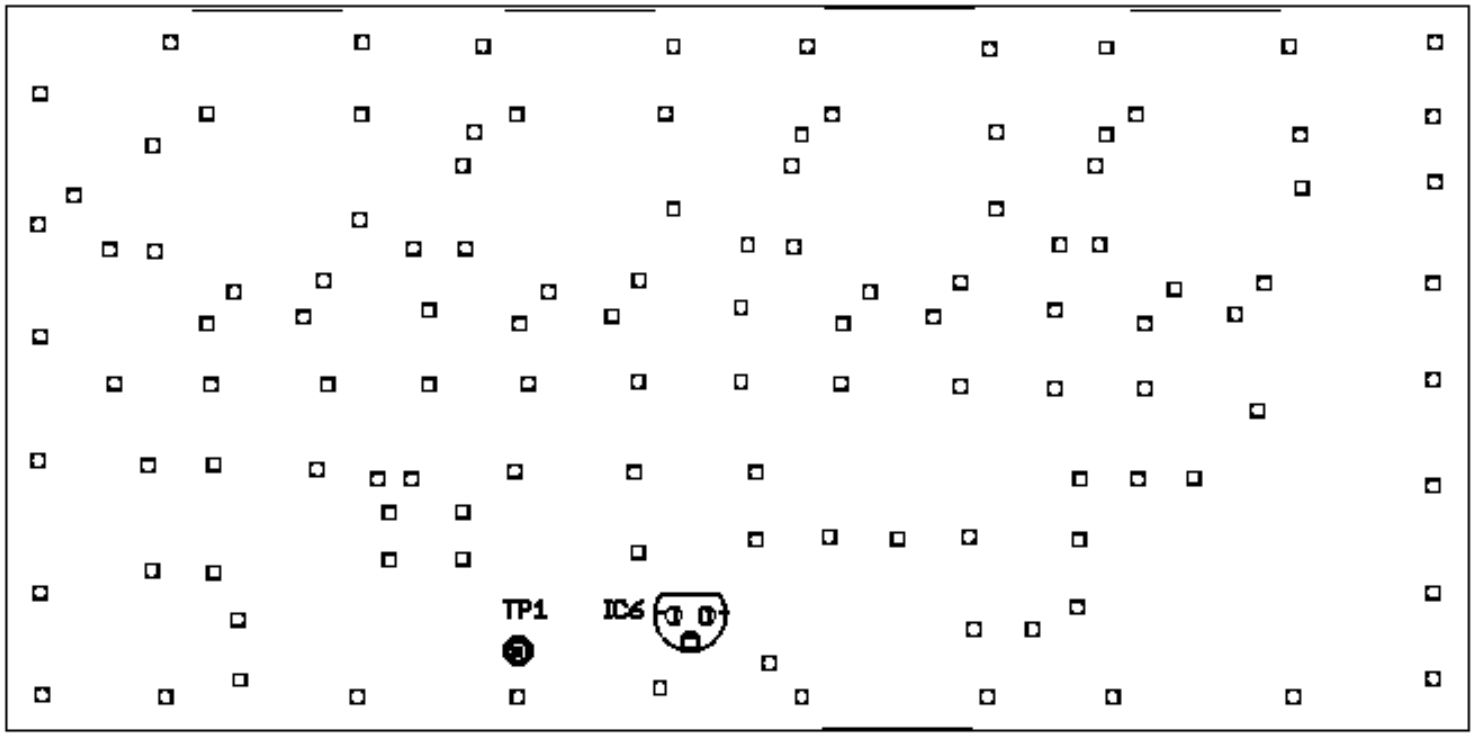


Fig 3 – Top side PCB overlay

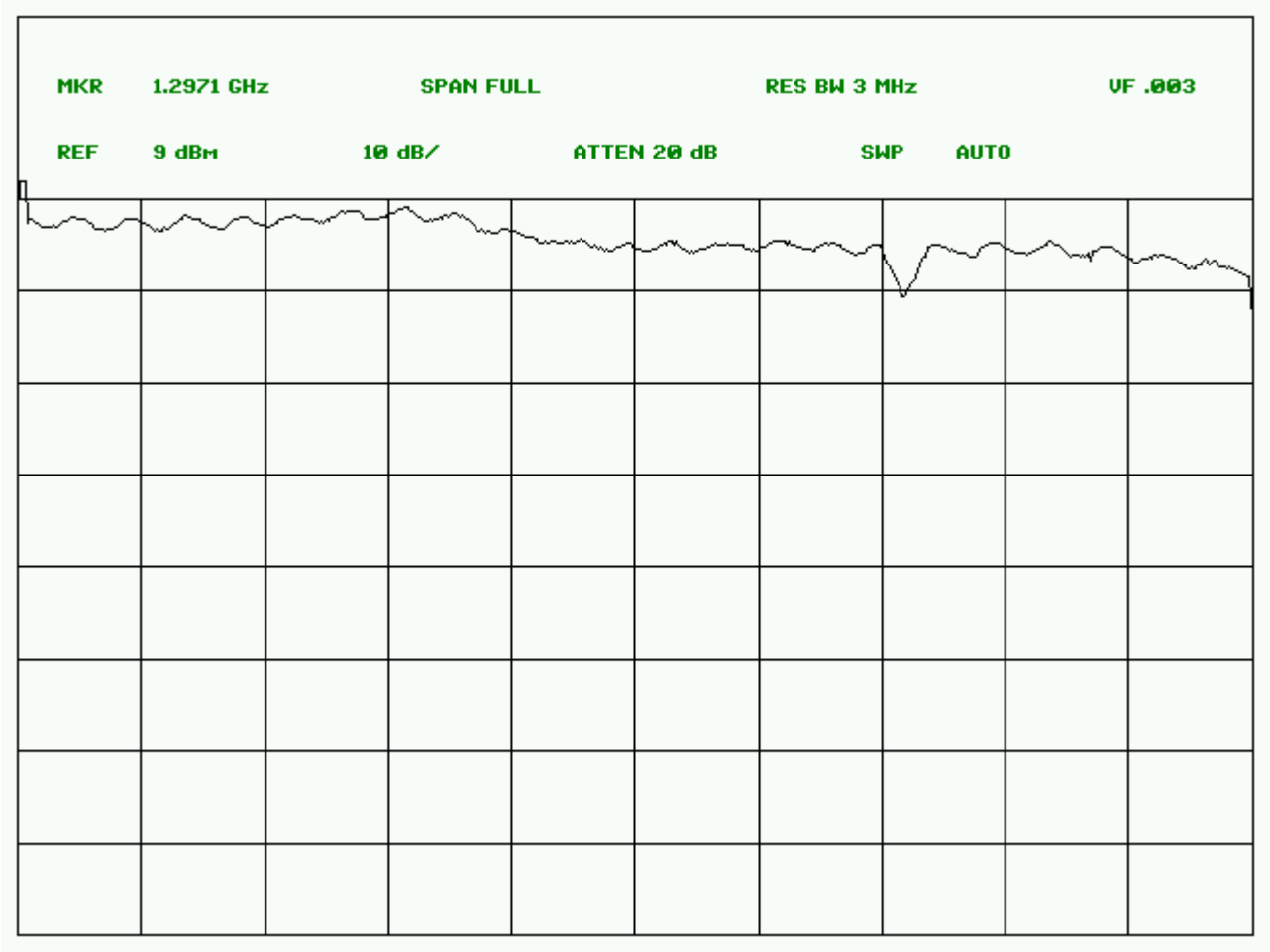


Fig 4 – DA1-4 swept frequency response from 10MHz to 1800MHz, with 5dB input attenuator.
Input level +10dBm, 0dbm output ref is top of grid. Marker is at approx 1297MHz
Measurement levels here are nominal

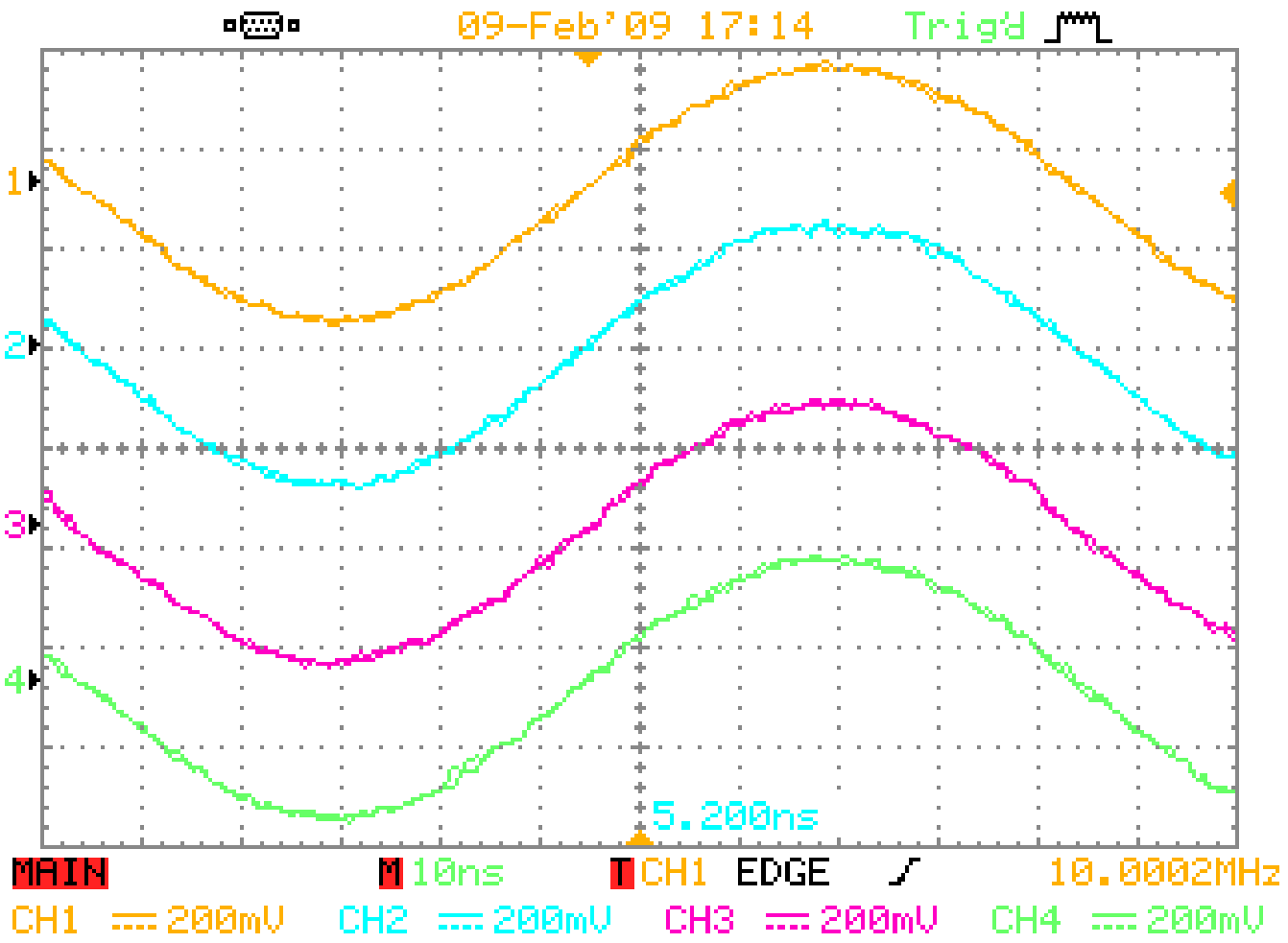


Fig 5 – Phase variation between output channels at 10MHz
– 1 cycle =10 div, 1div = 36°