PIP2 IT Beam Pattern Generator Drive Amplifier

Design Changes

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Introduction:

This document capture all of the changes to the original BPG drive amplifier design that were required to be made following bring-up and test of the first article. Though the board design was simulated in LTSPICE, circuit parasitics present in a real-world PCB were not included in the simulation since it is not possible to estimate and model said parasitics (which include the PCB, discrete components as well the IC packaging) without considerable effort.

Input Signal Requirements:

The AWG signal was originally assumed to be required to swing between 400mVp-p, for higher dynamic range. The output signal requirements was for signal swing 0… > Vthresh, where Vthresh = 0.612V. The output was swing was chosen to be 0…+1.5V into 50 ohms. This required handling of the negative input swing signal required additional circuity to provide a DC offset in order to produce a linear output signal. Additional work revealed that operating the AWG in single-ended output mode (0V….+400mV maximum swing) simplifies the design and offers increased slew rate. Additionally, the LabView AWG control software offers adjustable output amplitude (the screen control is variable between 0V…550V – these units are not applicable to the application, but 550V is full-scale output and the control varies linearly), which allows the drive signal amplitude to be adjusted to accommodate for increased risetimes (by reducing the amplitude) as needed.

U1, U4 device change:

When the board was first powered up, it was discovered that the preamp (U1 self-oscillated at approximately 350MHz). U1 (and U4) were current-feedback amplifiers (TI LMH6703). In their non-inverting configuration with Av = 2, the non-inverting input is particularly sensitive to parasitic capacitance. The PCB layout should have voided out the copper ground plane from around the opamp's input pins, which was not done. A different amplifier was identified for the preamp (TI THS4271 wideband, high slew rate voltage feedback amplifier). Being voltage feedback, it allowed different feedback resistor values to be used as well as the addition of a parallel feedback frequency compensation capacitor if needed. In using the THS4271, it was discovered that the amplifier tended towards instability with Av = +2. The datasheet states that the frequency response peaks at Av=+2, which led to the ringing at the pulse edges. The gain was changed to Av=+3, which altered the frequency response and led to a more well-behaved pulse response. For the single-ended output drive amplifier, the THS4271 was tried and then changed to the EL5166, which gave better pulse response performance. Note that the R12 (EL5166 feedback resistor) is 750 ohms, which is larger than the recommended optimal value (392 ohms is suggested). This was done to roll off the devices frequency response somewhat and it may be possible to change the R12/R10 combo (while maintaining the Av=+3 gain) to increase the slew rate and sharpen the pulse edges further at the expense of possible ringing response at the pulse edges.

System Signal Levels / Gains:

The input signal is expected to swing between 0….+400mV (maximum). The preamp gain = +3, the single-ended amplifier gain is +3, but with the series termination and voltage divider effect, the output signal is expected to swing 0…+1.69V at the load. The differential amplifier's gain is changed from 1.8 to 4, which gives a ~0.800Vp-p signal swing at the 100 ohm load for the maximum input signal.

Change List:

All changes to the design are listed in the following tables. There is one change that requires the cutting of a trace and addition of a component (a resistor) not present in the original design. This is described following the changes list.

Component Changes:

Reference Designator	Original Value	New Value	Comment
U1	LMH6703	THS4271	THS4271DGK, lift pin 8 when installing
U4	LMH6703	EL5166	EL5166ISZ, lift pin 8 when installing
R2	392 ohms	124 ohms	CRCW0805124RFKEA
R10	392 ohms	374 ohms	CRCW0805374RFKEA
R3	392 ohms	249 ohms	CRCW0805249RFKEA
R12	392 ohms	750 ohms	CRCW0805750RFKEA
R11	2.49 ohms	10 ohms	CRCW080510R0FKEA
R20, R27	0 ohms	DNI	Remove/do not install
R17, R24	169 ohms	62 ohms	CRCW080562R0FKEA

Removed Components:

Reference Designator	Value	Comment
C3	0.01uF	bypass cap, not needed
C16	0.01uF	bypass cap, not needed
U2	ADR3412	design change
U3	OPA191	design change
FB3, FB4, FB5	Ferrite bead	design change
C7, C10, C13	6.8uF	design change
C8, C9, C11, C12	6.8uF	design change
R4, R7	0 ohms	design change
R6	3.92K	Design Change
R8	4.99K	Design Change

Added Components:

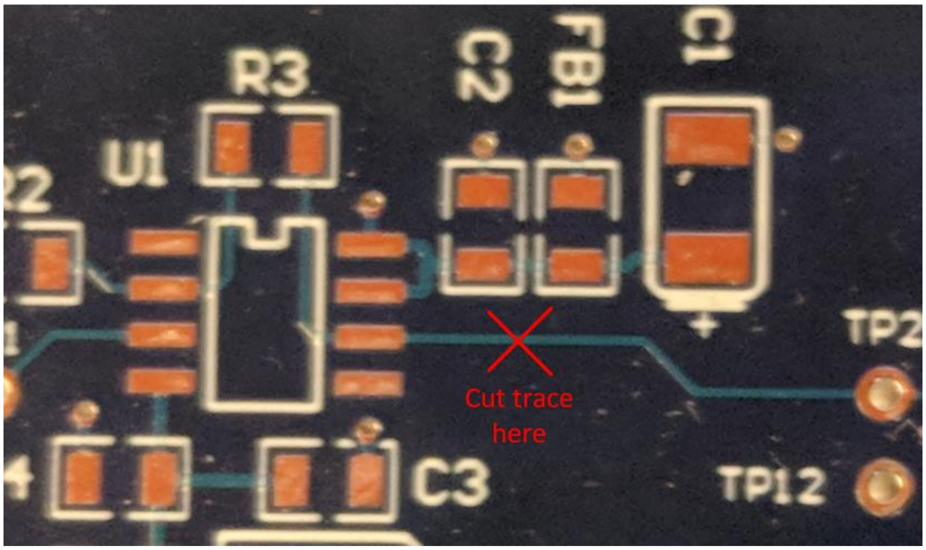
Reference Designator	**Value**	**Comment**
R9	0 ohms	Was originally Do Not Install
R1000	30 ohms	Rework: add 0805, 30 ohm resistor to U1-6: place close to U1-6, cut trace & remove solder mask. Solder resistor onto exposed trace copper across the cut section of trace

<u>PCB Rework</u>:
This rework can be applied to either an assembled or un-assembled board.

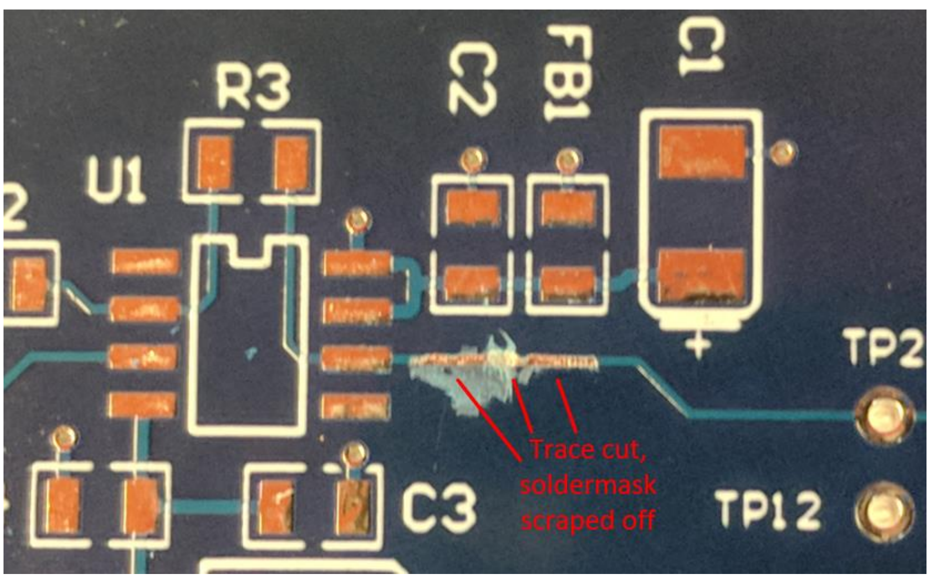
<u>Preamp series output resistor addition</u>:

1) Locate U1-6

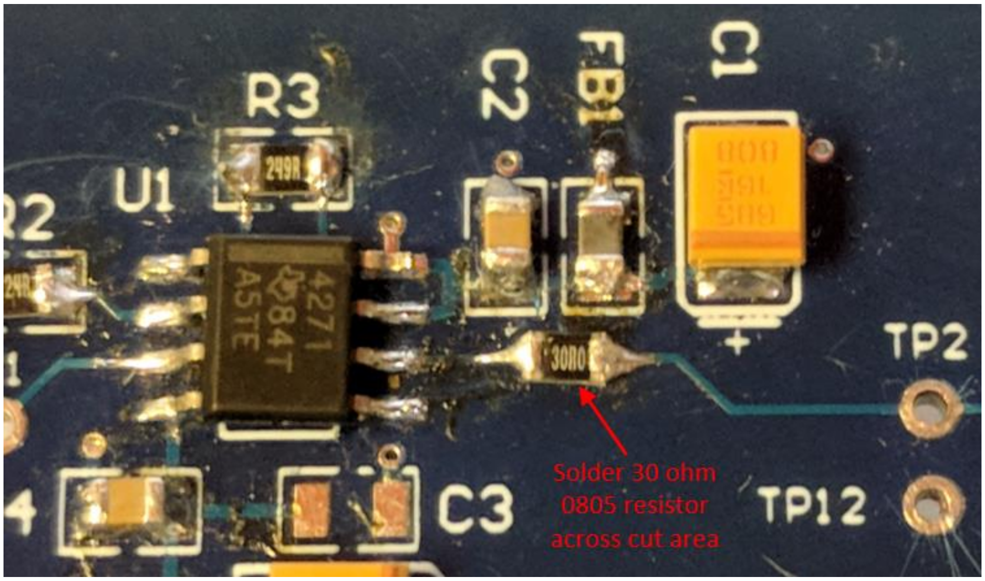
2) Using and xacto-knife, make a small cut in the trace in two places and remove the copper between the cuts (the amount removed should be less than the with of the 0805 resistor). Do not too deeply (don’t want to short the power plane).



3) Scrape off the solder mask on the PCB trace before and after the cut.



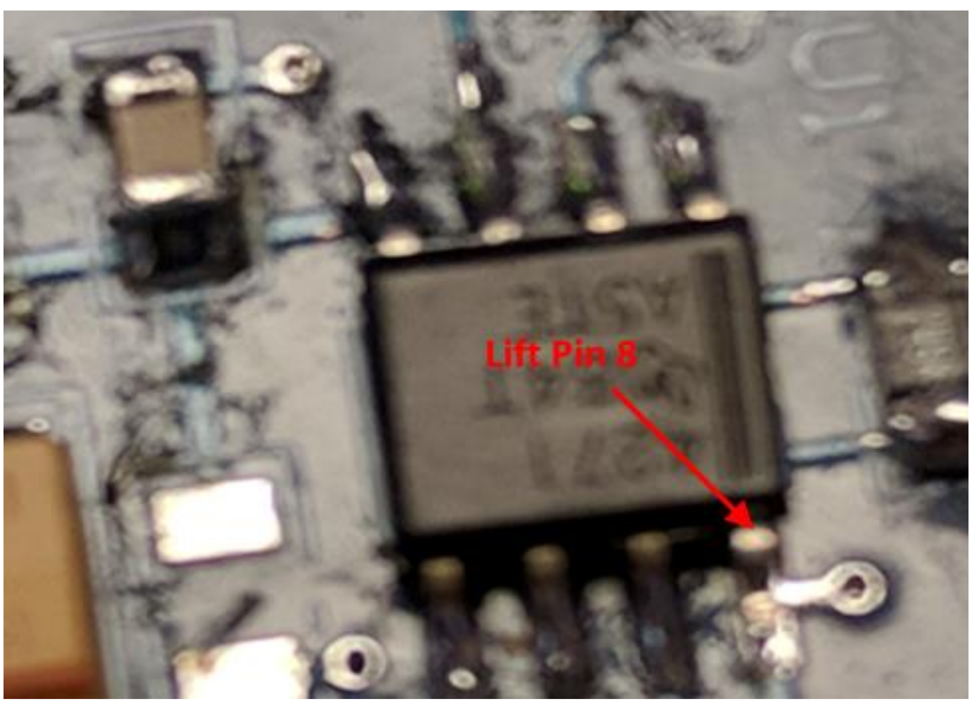
4) Place a 30 ohm, 0805 resistor (R1000) onto the exposed copper on the traces (it should sit over the cut) and solder in.



<u>THS4171 & EL5166 OPAMP Rework</u>:

1) When installing U1 (THS4271), lift pin 8 (should NOT be soldered downto pin 8 pad)

2) When installing U4 (EL5166), lift pin 8 (should NOT be soldered downto pin 8 pad)



(Example on U1)

Note on Board Performance:

With the current opamp device choice for U4 (EL5166) , the single pulse width performance (measured at the receiver threshold level of 600mV) is approximately 6.35ns (min pulse width for 162.5MHz pattern is 6.1538ns). Note that this is measured directly into the oscilloscope using a 5ns RG-58 cable. The actual system cable plant will most likely cause dispersion in the patter signal, leading to pulse widening.

The differential output performance is determined by the LMH6552 device. The rise/fall times are approximately 2ns, it may be possible to increase the slew rate by adjusting the amplifier's gain (at the cost of reduced output signal amplitude. The differential amplifier's response does have a small amount of ringing at the pulse edges.