To: Whom it may concern.

Subject: AD604 – Group Delay Measurements.

Date: June 5th, 2007.

From: James Staley

Rev. B - July 06, 2007, Supplemental measurements - Expanded frequency range and Vgain resolution of delay measurements. (Pg 2)

Rev. A - June 11,2007. Supplemental measurements - Added various values of V_{GN}. (Pg. 2)

INTRODUCTION

In response to a customer request a set of measurements was made on 5 AD604ARZ dual channel VGAs. The purpose of the measurements was determine the matching of delay between devices and channels. The application requires no more than 1 ns mismatch between channels or devices from lot to lot. Although a statistically significant number of devices would need to be evaluated (perhaps several thousand) in order to determine the likelihood of large quantities, it was felt that a few devices would constitute a 'good start' and at least determine what sort of consistency could be expected. Presently, there is no data that might serve to characterize delay.

EXPERIMENTAL SETUP

As it happens a fab-lot of a newly designed socketed eval board for the AD604ARZ wide-body device was just received. The schematic is similar to the AD604 eval board, with resistor values changed in the input and output signal paths to facilitate calibration, output matching of the amplifier. The schematic is shown in Figure 1 and the bench setup in Figure 2

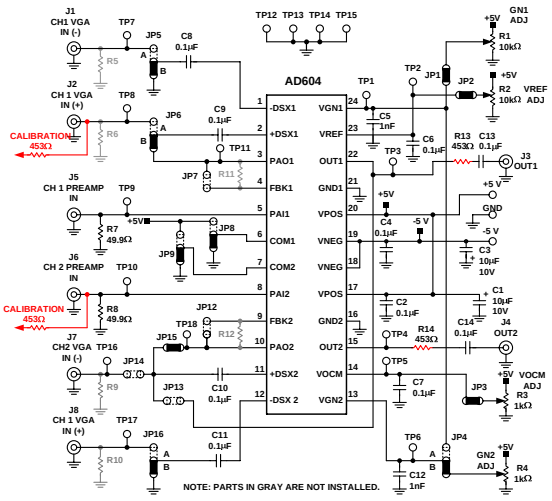

Figure 1. AD604 Delay Test Schematic

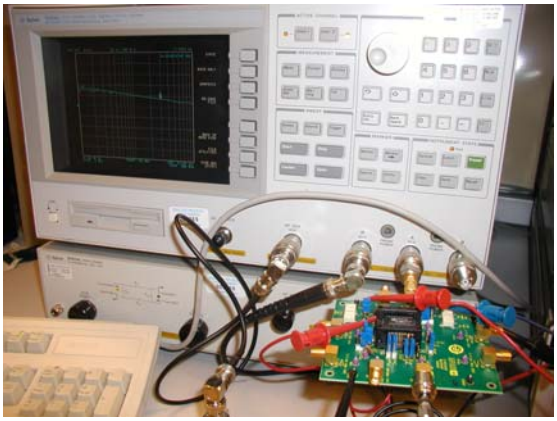

Figure 2. Bench Test setup

DESCRIPTION OF TEST

The AD604 is made on the 'Flash' process and was developed on the mid-nineties primarily for medical ultrasound markets. The amplifier chain includes a flexible gain preamp and a single-supply differential VGA. The gain of the preamp can be adjusted from 14 dB to 20 dB by means of pins connected to a simple resistor array. For the purposes of this test, the delay was checked at the minimum preamp gain.

The delay of 10 channels in 5 devices was measured on an Agilent 4395A network analyzer. In order to operate the device within it's rated limits, a 453Ω resistor was connected in series with the AD604 output. A splitter was used at the input and the A/R ratio method selected to display data. The board was initially calibrated using another 453Ω external resistor at the input to account for

the 20dB attenuation at the output of the AD604. The delay is noted in text in the upper right hand corner of each graph and is summarized in Table 1. Measurements were taken at V_{GN} = 1.2Vdc

Table 1. Group Delay of Five Samples

Sample/Channel	Delay (ns)
U1CH1	8.7787
U1CH2	7.6353
U2CH1	8.7815
U2CH2	7.8299
U3CH1	8.8488
U3CH2	7.7778
U4CH1	8.8162
U4CH2	7.8643
U5CH1	8.8553
U5CH2	7.7206

Table 2. (Rev. A) Group delay vs V_{GN} at 30 MHz

Sample/Channel	Delay (ns) at 30 MHz			
	V_{GN} = 0.75V	V_{GN} = 1.5V	V_{GN} = 2.25V	V_{GN} = 2.9V
U1CH1	8.956	8.7849	8.6395	9.752
U1CH2	8.8065	8.7726	8.6329	8.9449
U2CH1	8.7929	8.7703	8.6469	9.6163
U2CH2	8.6626	8.7658	8.7793	8.5652
U3CH1	8.7069	8.7676	8.7726	9.5628
U3CH2	8.7144	8.801	8.8044	8.6797
U4CH1	8.7117	8.7265	8.5593	9.697
U4CH2	8.7174	8.732	8.6362	8.6113
U5CH1	8.9352	8.7644	8.6804	9.6417
U5CH2	8.8698	8.7396	8.6005	8.6005

Delay vs frequency and V_{GN}

A single measurement was taken of delay vs VGN at 5 MHz., and at V_{GN}s of 0.75 V and 2.9 V. The delays were 11.486 ns and 15.589 ns respectively.

Rev. B Supplemental measurements.

Additional measurements at 1 MHz, 15 MHz and 30 MHz, and Vgain values of 0.4V, 0.5V, 0.75V, 1.5V, 2.25V, 2.5V, 2.7V, and 2.9V were requested. These appear in the table below. Because the VGA of the AD604 is a single supply device, the input and output coupling capacitor were increased from 0.1µF to 1µF to mitigate delay effects caused by capacitive coupling at the lower frequency. As can be seen in the data, the delay spread across the specified gain and frequency ranges increase considerably to approximately 11 ns. The impact on potential communications applications requiring precise delay over widely ranging gain and frequency should be carefully weighed.

Sample/Channel	Delay (ns)							
	V_{GN} = 0.4V	V_{GN} = 0.5V	V_{GN} = 0.75V	V_{GN} = 1.5V	V_{GN} = 2.25V	V_{GN} = 2.5V	V_{GN} = 2.7V	V_{GN} = 2.9V
F = 1 MHz								
U1CH1	10.41	11.39	11.06	11.28	11.46	14.71	16.88	18.23
U1CH2	12.78	12.79	12.58	12.21	12.41	14.10	16.66	17.78
U2CH1	11.17	11.55	11.86	11.40	11.47	13.51	15.12	16.10
U2CH2	12.02	12.12	12.02	11.59	11.42	13.41	16.98	19.13
U3CH1	11.05	11.45	11.87	11.09	11.31	14.41	17.12	18.62
U3CH2	11.3	11.52	11.78	11.26	11.04	12.98	16.28	17.37
U4CH1	10.82	10.07	10.72	11.12	11.33	14.67	17.52	19.39
U4CH2	12.43	12.53	12.56	12.50	12.66	14.66	17.15	12.14
U5CH1	11.36	11.28	11.19	11.29	11.19	14.66	17.34	18.6
U5CH2	12.72	13.02	12.73	12.27	12.68	14.52	16.38	16.28

F = 15 MHz								
U1CH1	9.87	9.9	9.96	10.02	10.36	11.58	12.40	12.42
U1CH2	10.87	10.9	10.87	10.84	11.06	11.72	11.85	11.67
U2CH1	9.98	10.03	10.06	10.12	10.55	11.62	12.35	12.50
U2CH2	10.15	10.16	10.13	10.10	10.13	10.6	10.74	10.71
U3CH1	9.77	9.82	9.86	9.90	10.58	11.93	12.33	12.10
U3CH2	9.77	9.84	9.86	9.90	10.07	10.64	10.78	10.49
U4CH1	9.79	9.87	9.89	9.93	10.34	11.65	12.36	12.35
U4CH2	11.07	11.01	11.14	11.08	11.36	12.09	11.76	10.43
U5CH1	9.72	9.81	9.85	9.92	10.54	11.93	12.44	12.10
U5CH2	11.2	11.18	11.15	11.08	11.46	12.31	12.38	12.37
F = 15 MHz								
U1CH1	8.93	8.87	8.84	8.66	8.81	9.53	9.64	9.61
U1CH2	9.11	9.14	9.05	8.97	9.16	8.99	8.60	8.73
U2CH1	8.84	8.80	8.80	8.68	8.98	9.54	9.58	9.58
U2CH2	8.70	8.71	8.71	8.58	8.56	8.61	8.49	8.57
U3CH1	8.75	8.68	8.73	8.62	9.07	9.55	9.41	9.41
U3CH2	8.38	8.43	8.47	8.56	8.66	8.66	8.47	8.61
U4CH1	8.85	8.81	8.74	8.59	8.84	9.38	9.25	9.24
U4CH2	9.10	9.09	9.11	9.11	9.32	9.07	8.70	8.51
U5CH1	8.90	8.87	8.82	8.69	9.01	9.59	9.49	9.51
U5CH2	9.06	9.07	9.10	9.10	9.37	9.21	8.94	9.09

Conclusion:

The maximum delay between channel 1 of each of the five samples is 76 ps, and 229 ps for channel 2. The maximum delay between channel 1 and channel 2 for any single device was in sample #5, 1.134 ps. This would be the most critical delay specification if the device were used in an application where channel-to-channel matching is critical. The experiment sheds some light on delay matching of the AD604. For a more reliable estimate, a statistically significant sample of devices is required..

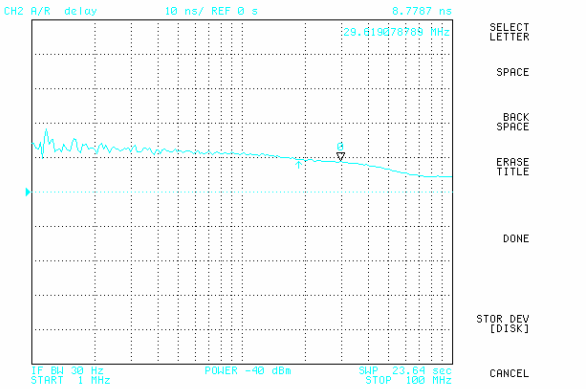

Figure 3. U2 Channel 1

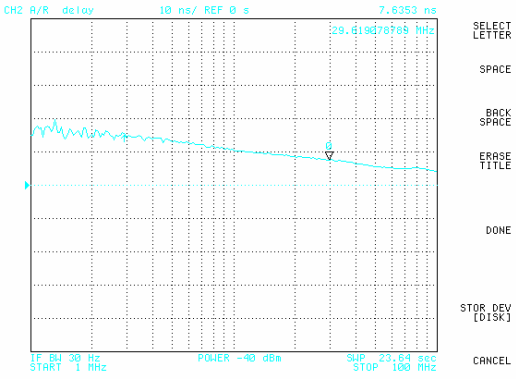

Figure 4. U1 Channel 2

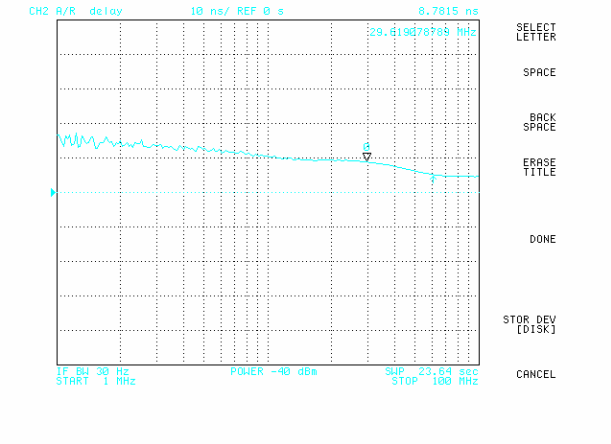

Figure 5. U2 Channel 1

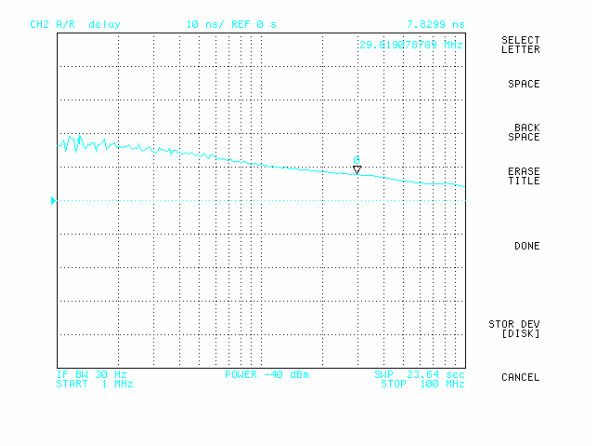

Figure 6. U2 Channel 2

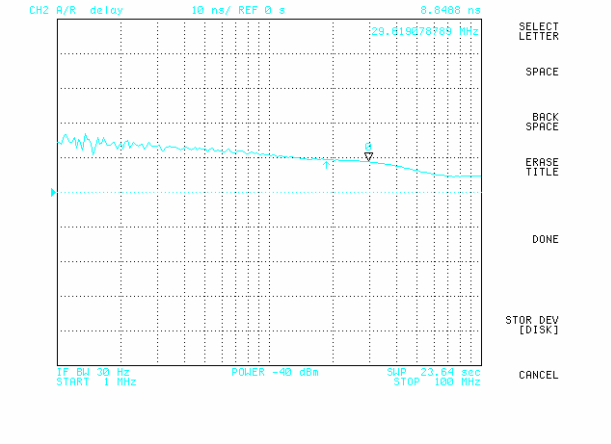

Figure 7. U3 Channel 1

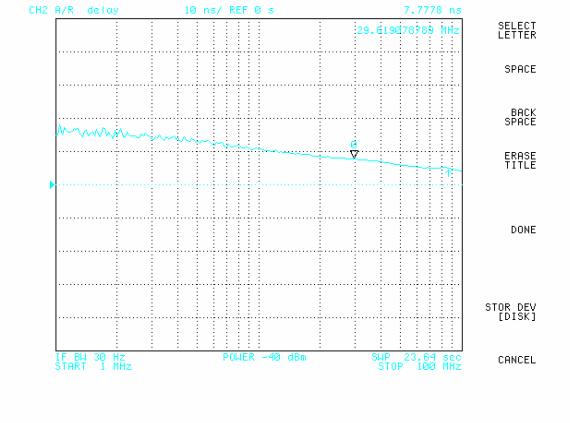

Figure 8. U3 Channel 2

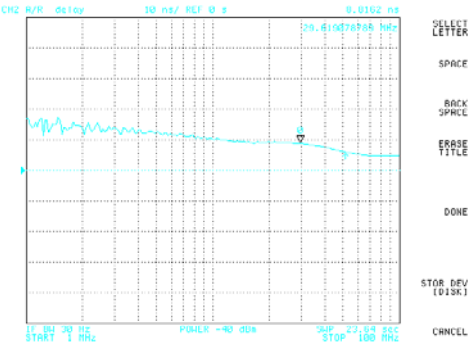

Figure 9. U4 Channel 1

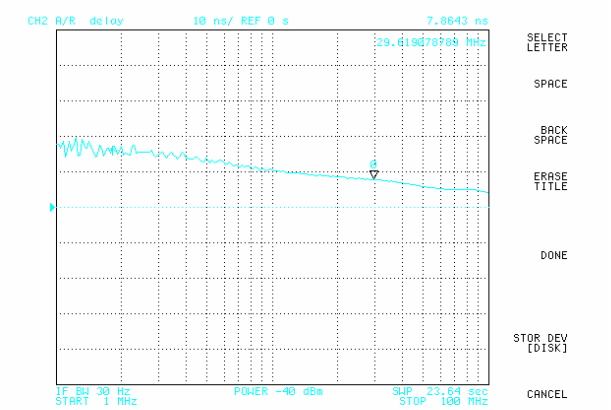

Figure 10. U4 Channel 2.

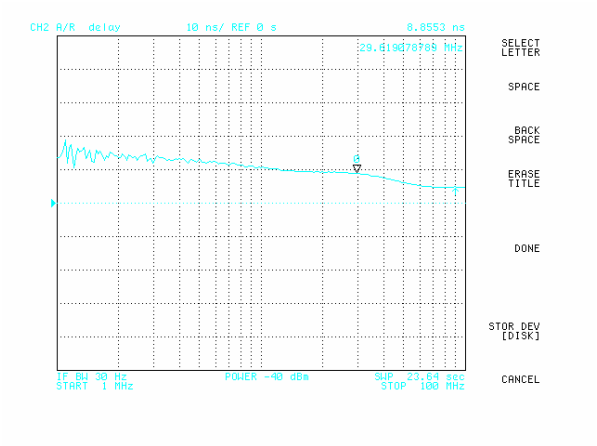

Figure 11. U5 Channel 1

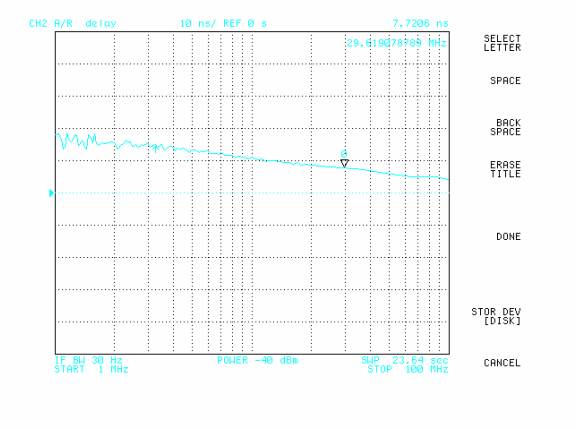

Figure 12. .U5 Channel 2