TAS5066-5112F6EVM Application Report

Jonas Svendsen *Digital Audio & Video Products*

The TAS5066-5112F6EVM PurePath Digital™ customer evaluation module demonstrates two integrated circuits TAS5066 and TAS5112ADFD from Texas Instruments (TI).

TAS5066 is a high-performance 24-bit six-channel digital pulse width modulator (PWM) based Equibit™ technology. The TAS5066 has a wide variety of serial input (I²S) options including right justified, left justified and DSP data formats. It accepts I²S data with sample rates up to 192kHz.

TAS5112ADFD is a compact, high-power, stereo digital amplifier power stage designed to drive a 6-Ohm loudspeaker up to 50 W. It contains integrated gate-drivers, eight matched and electrically isolated enhancement-mode N-channel power DMOS transistors, and protection / fault-reporting circuitry.

The TAS5066-5112F6EVM, together with a TI input board, is a complete digital audio amplifier system that includes digital input (S/PDIF), analog inputs, interface to PC, digital volume control, and failure protection. The system was design for home theater applications such as DVD minicomponent systems, home theater in a box (HTIB), DVD receivers, A/V receivers, or plasma display panels (PDP).

This document covers:

- EVM Specifications
- Audio performance and power efficiency graphs:
  - THD+N vs Power
  - THD+N vs Frequency
  - FFT Spectra with dithered -60dB Fs tone
  - Idle Channel Noise FFT Spectra
  - Channel Separation
  - Gain-Frequency Response
  - High Current Protection
  - Output Stage Efficiency
  - Subwoofer Line Out
- Design documentation of the EVM:
  - Schematics
  - Parts list
  - PCB specification & layout
  - Mechanical design

For EVM setup and use, please see “TAS5066-5112F6EVM User’s Guide”.

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1 TAS5066-5112F6EVM Specification

Table 1. General Test Conditions

General Test Conditions		Notes
Output Stage Supply Voltage:	29.5 V	Laboratory Power Supply (EA-PS 7065-10A)
System Supply Voltage:	15 V	
Load Impedance:	6 ohm	
Sampling Frequency	48 kHz	
PWM Processor	TAS5066	
Output stage	TAS5112ADFD	
TI Input Board	Input-PC	Rev 3

Table 2. Electrical Data

Electrical Data		Notes/Conditions
Output Power 6 Ohm:	50 W/Channel	<0.2% THD+N, 1 kHz, T_A = 25°C
Output Power 6 Ohm, 10% THD:	>65 W/Channel	10% THD+N, 1 kHz, T_A = 25°C
Output Power 8 Ohm:	40 W/Channel	<0.15% THD+N, 1 kHz, T_A = 25°C
Maximum Output Power pr Channel	50 W/Channel	2 ch at max power for 5 min, 1 kHz, preheated 1 hour at 1/3 max power. T_A = 25°C <0.2% THD+N.
Output Stage Efficiency:	87 %	P_{OUT} = 2 x 50W, 6 ohm, 1 kHz
Total Board Idle Power Consumption:	9 W	Output stage power supply 29.5V + system power supply 15V, -60dBFS signal
Rated Load Impedance:	6-8 Ohm	
Damping factor:	16	1 kHz, relative to 8 ohm load
Maximum Peak Current:	>8 A	1 kHz burst, 1 ohm
H-Bridge Supply Current	220 mA	1 kHz, -60dBFS signal
System Supply Current:	170 mA	1 kHz, -60dBFS signal

Table 3. Audio Performance

Audio Performance		Notes/Conditions
THD+N, 1 watt, 6 ohm:	<0.05 %	1 kHz
THD+N, 10 watt, 6 ohm:	<0.09 %	1 kHz
THD+N, 50 watt, 6 ohm:	<0.2 %	1 kHz
Dynamic Range:	>97 dB	Ref: rated power, A-weighted, AES17 filter
Noise Voltage	<250 μV_{RMS}	A-weighted, AES17 filter
Channel separation:	61 dB	1 kHz, P_{OUT} = 50W
Amplitude Response DC – 20kHz, 6 ohm	+0.75dB	50 Watts unclipped

Table 4. Thermal specification

Thermal specification	$T_{HEATSINK}$	Notes/Conditions
Idle, all channels switching	37 °C	1 kHz, 15min, -60dBFS signal, T_A = 25°C
2 x 17 Watts, 6 ohm (1/3 power)	44 °C	1 kHz, 1 hour, T_A = 25°C
2 x 50 Watts, 6 ohm	65 °C	1 kHz, 5min, T_A = 25°C

Note: Amplifier mounted with a prototype heat sink, free air.

Table 5. Subwoofer Output (Line-level)

Subwoofer Output (Line-level)		Notes/Conditions
THD+N	0.05 %	100 Hz, 10k load, AES17 filter
Maximum Output Voltage	1,0 $V_{PEAK-PEAK}$	
Frequency Response	10 Hz – 200 Hz	-3 dB
Noise Voltage	40 uV	A-weighted, AES17 filter

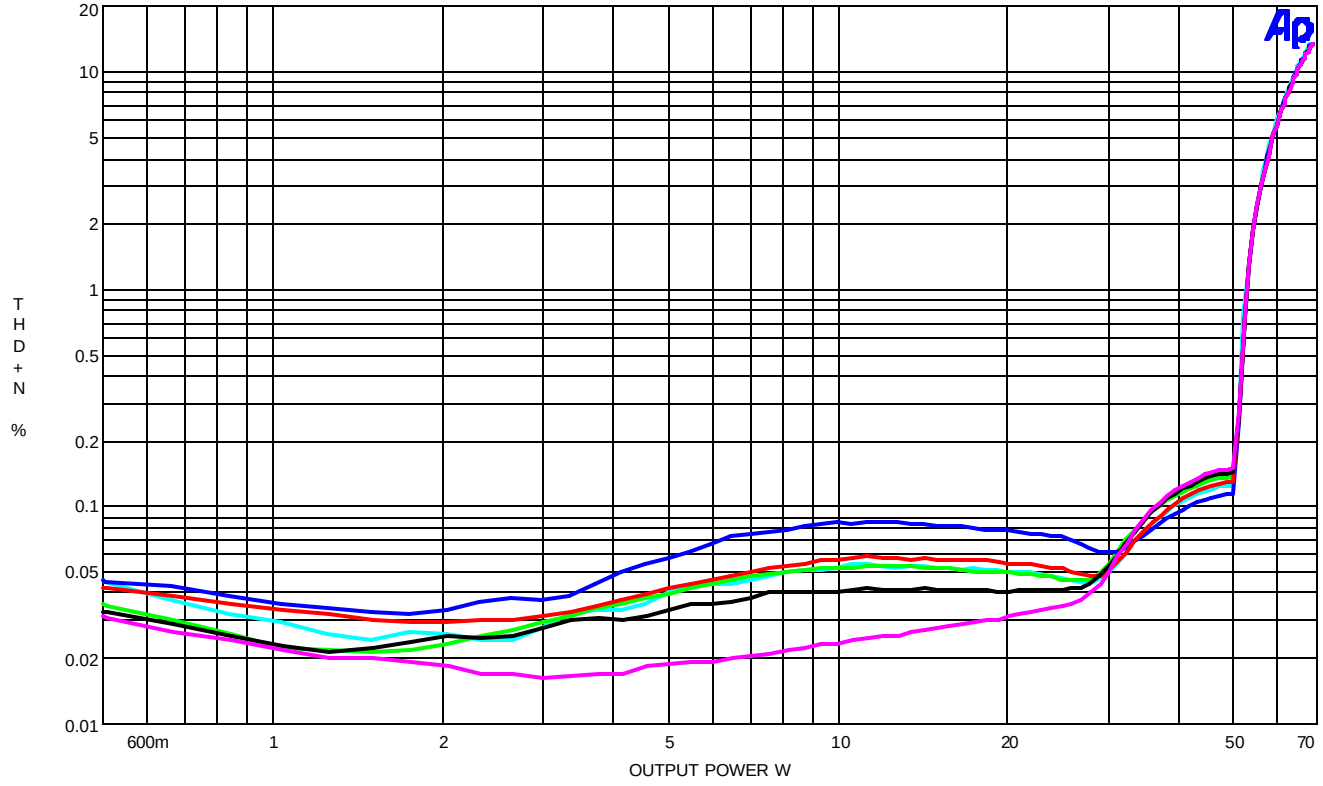
Table 6. Physical Specifications

Physical Specifications		Notes/Conditions
PCB Dimensions:	126mm x 125mm	Width x Length
Heat sink:	32mm x 126mm x 35mm	Width x Length x Height
Total weight:	360 g	Components + PCB + Mechanics

Note: All electrical and audio specifications are typical values.

1.1 THD+N vs Power

All Channels



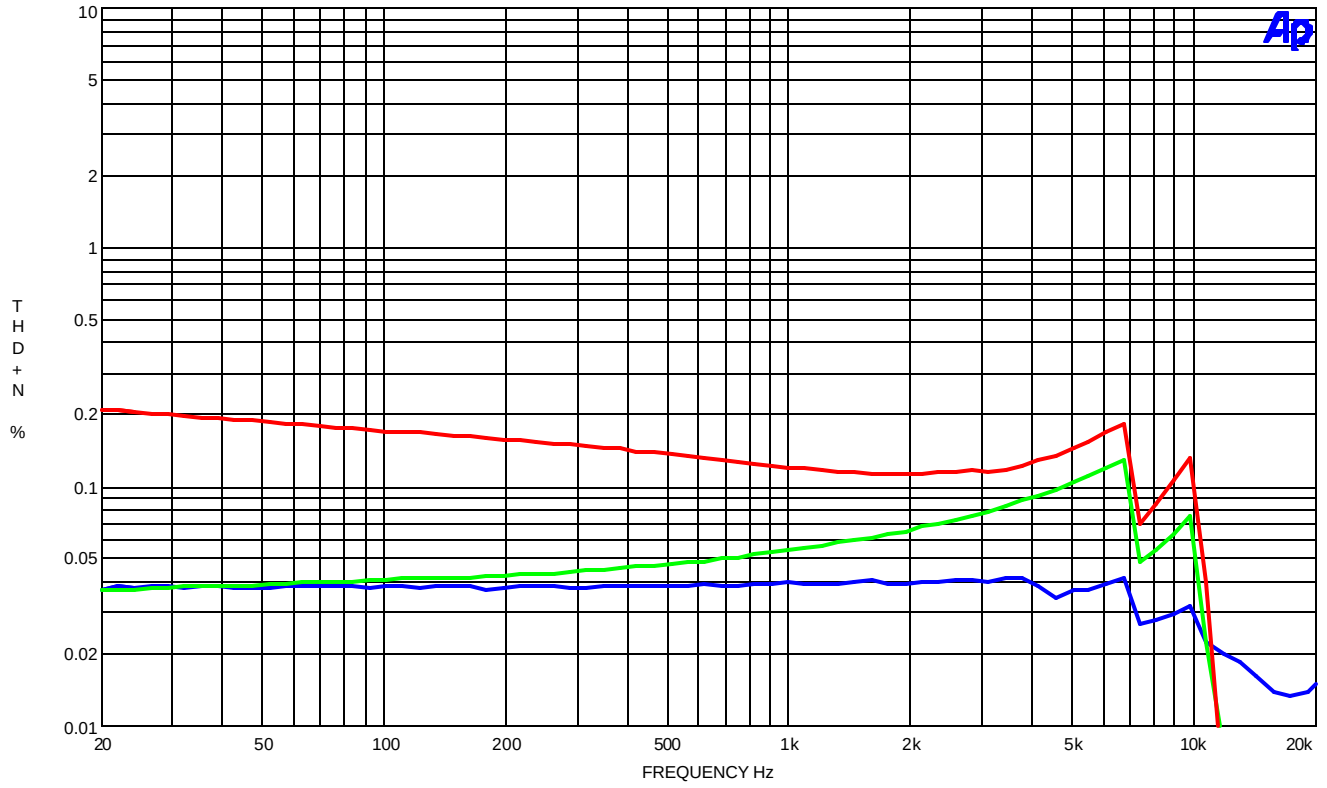
Comments:	Power supply: 29.5 V DC	Load: 6 ohm	Filter: AES17
	Input signal: 1kHz	+3 dB gain in TAS5066	Sample frequency: 48kHz
	6 channels, one trace for each channel, one channel running, rest muted		With extra H-Bridge PSU cable*

* See TAS5066-5112F6EVM User's Guide for details.

Figure 1. THD+N vs Power

1.2 THD+N vs Frequency

Channel 1



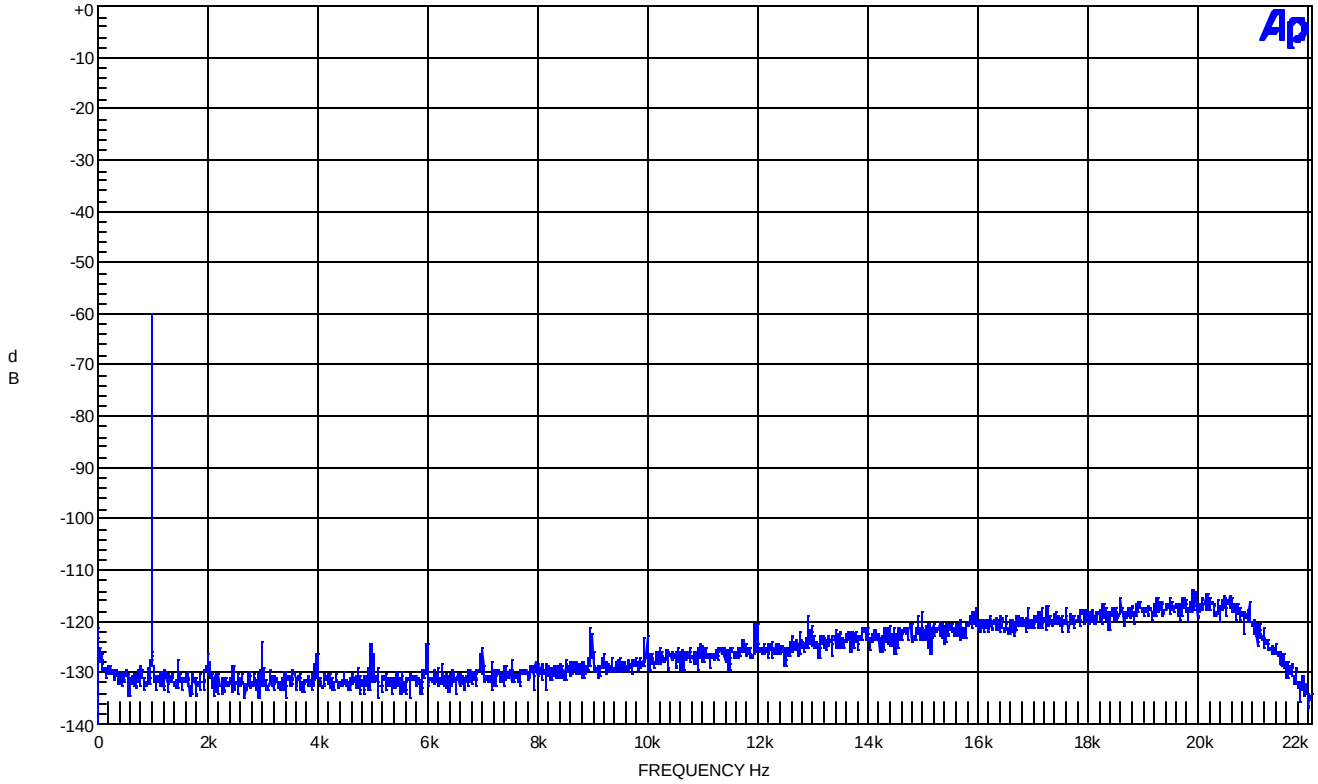
Comments:	Blue: 1 watt	Green: 10 watts	Red: 50 watts	Sample frequency: 48kHz
	Power supply: 29.5V DC	Load: 6 ohm	Filter: AES17	

Note: THD+N at high frequencies depend on the output-filter coil material.

Figure 2. THD+N vs Frequency

1.3 FFT Spectra with Dithered -60dB Fs Tone

Channel 1

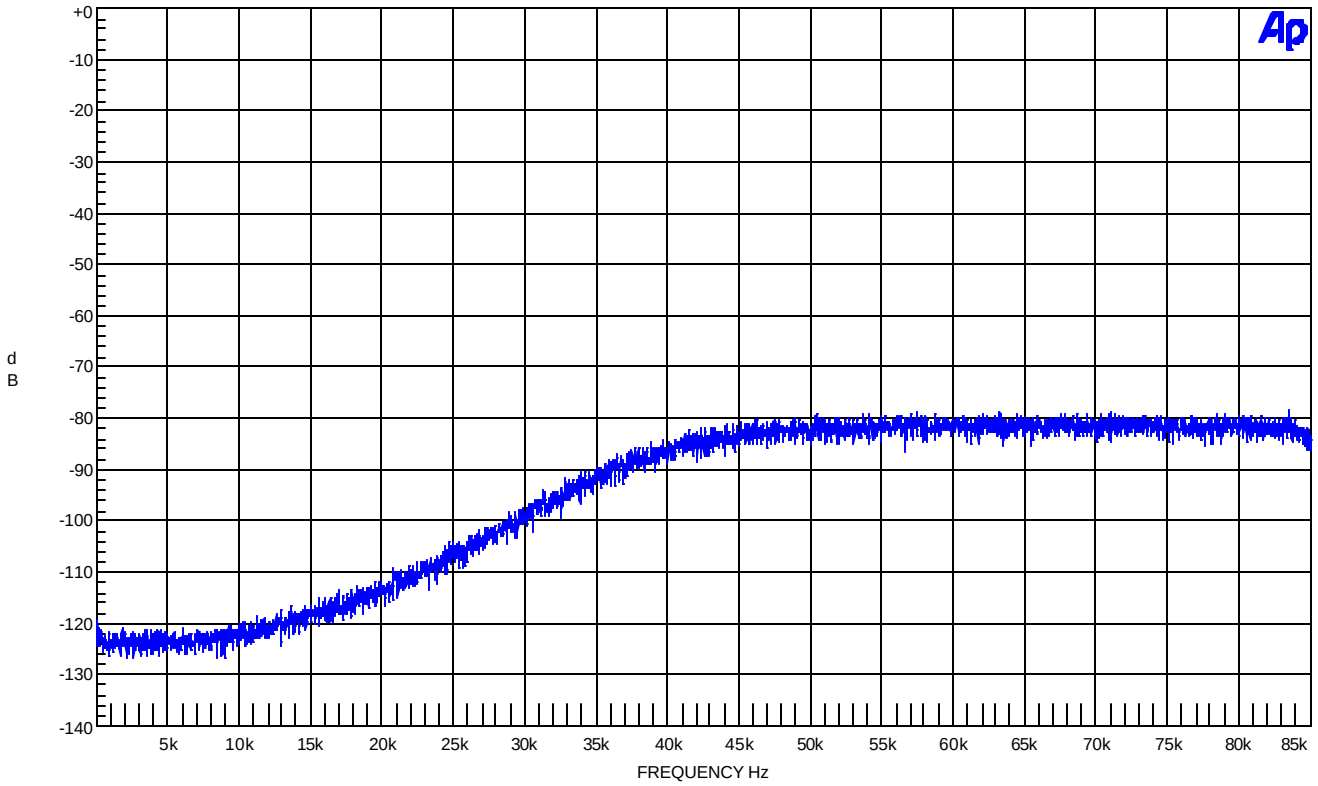


Comments:	Power supply: 29.5V DC	Load: 6 ohm	Filter: AES17	
	Input signal: 1kHz	Sample frequency: 48kHz	FFT size: 16k	Reference: 17.4 volt = full scale

Figure 3. FFT Spectra with Dithered -60dB Fs Tone

1.4 Idle Channel Noise FFT Spectra

Channel 1

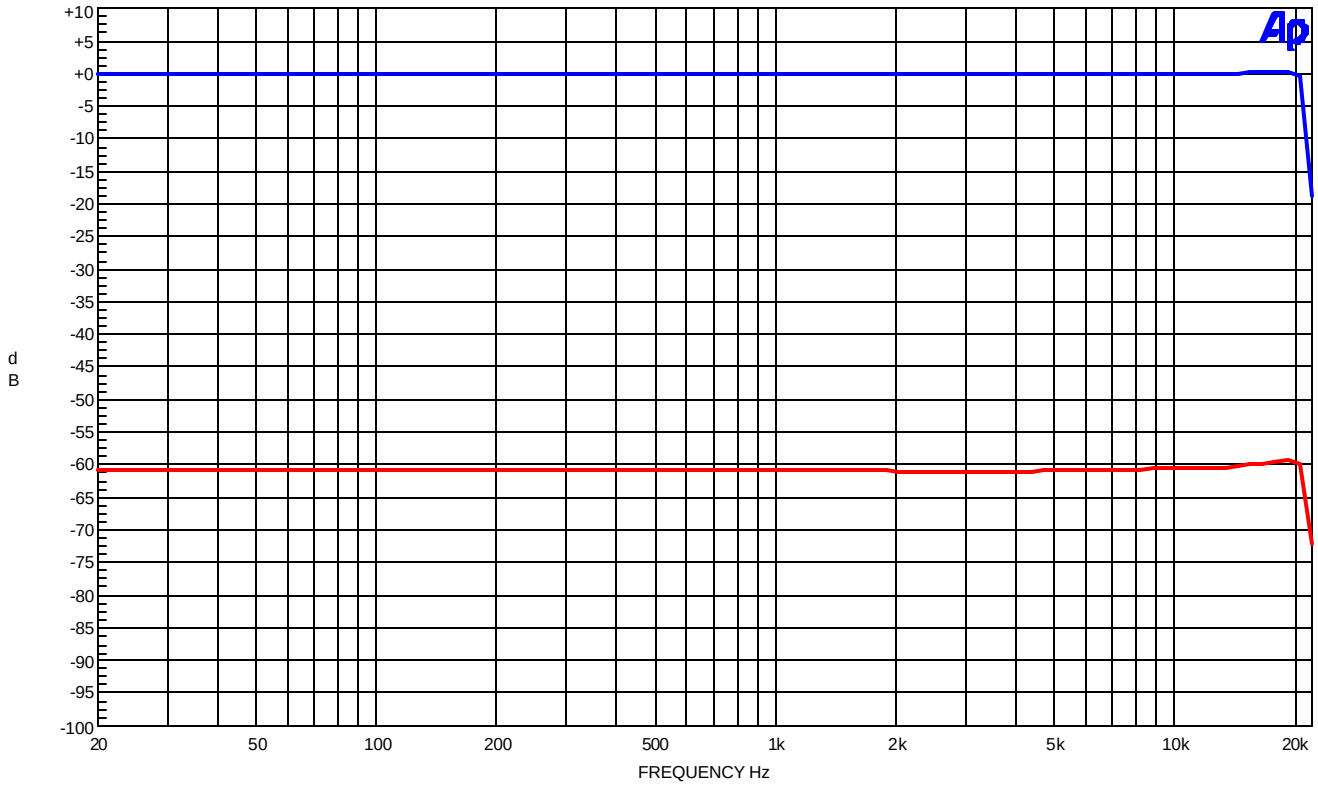


Comments:	Power supply: 29.5 V DC	Load: 6 ohm	FFT size: 16k	Reference: 17.4 volt = full scale
	Input signal: 0Fs	Sample frequency: 48kHz		

Figure 4. Idle Channel Noise FFT Spectra

1.5 Channel Separation

Channel 5 and 6

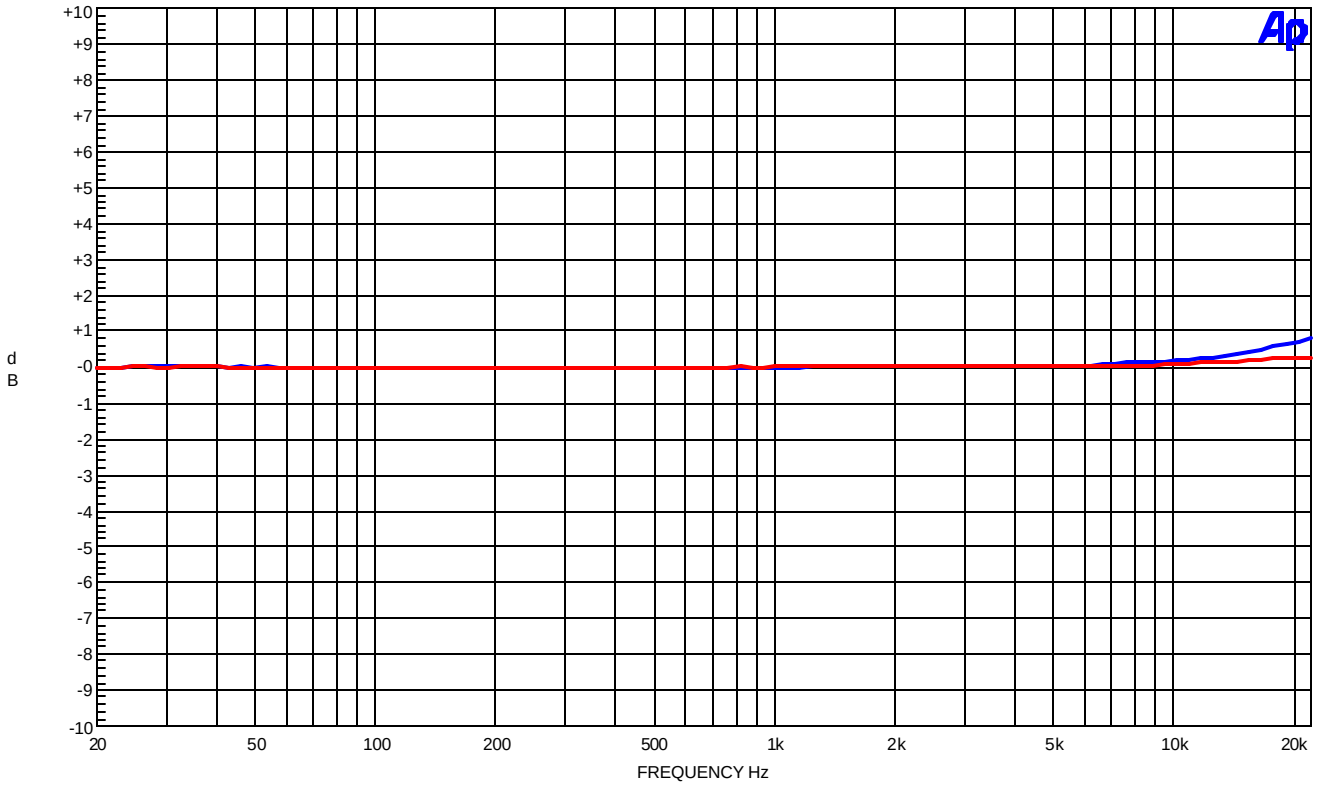


Comments:	Blue: Channel 5	Red: Channel 6		
	Input subwoofer: 1Fs	Load: 6 ohm	Sample frequency: 48kHz	Reference: 17.4 volt
	Input center: 0Fs	Filter: AES17	Power supply: 29.5 V DC	

Figure 5. Channel Separation

1.6 Gain-Frequency Response

Channel 1

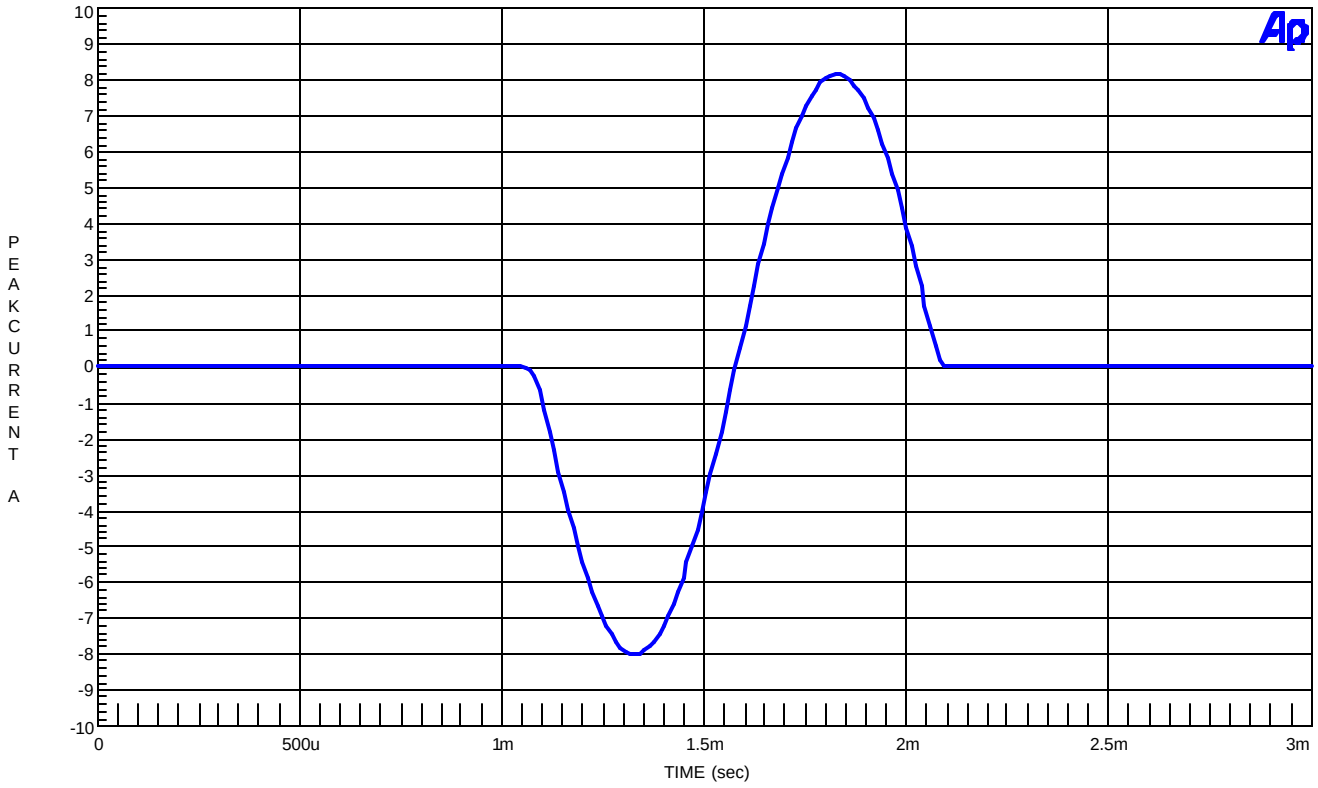


Comments:	Blue: 8 ohm	Red: 6 ohm		Power supply: 29.5 V DC
	Input signal: 1kHz	Sample frequency: 48kHz	Filter: AES17	

Figure 6. Gain-Frequency Response

1.7 High Current Protection

Channel 1

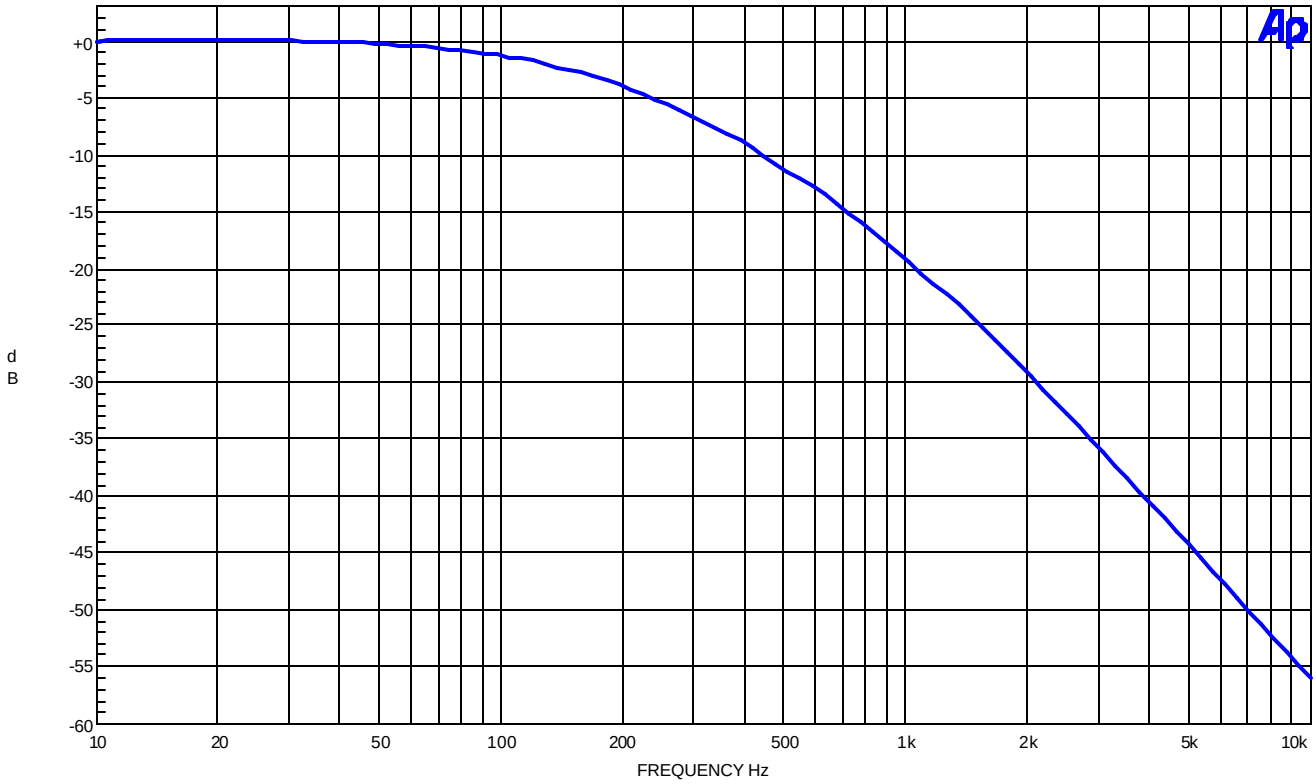


Comments:	**Blue: 1 ohm**		
	Input signal: 1kHz	Sample frequency: 48kHz	Power supply: 29.5 V DC

Figure 7. High Current Protection

1.8 Subwoofer Line Out

Subwoofer Line Out

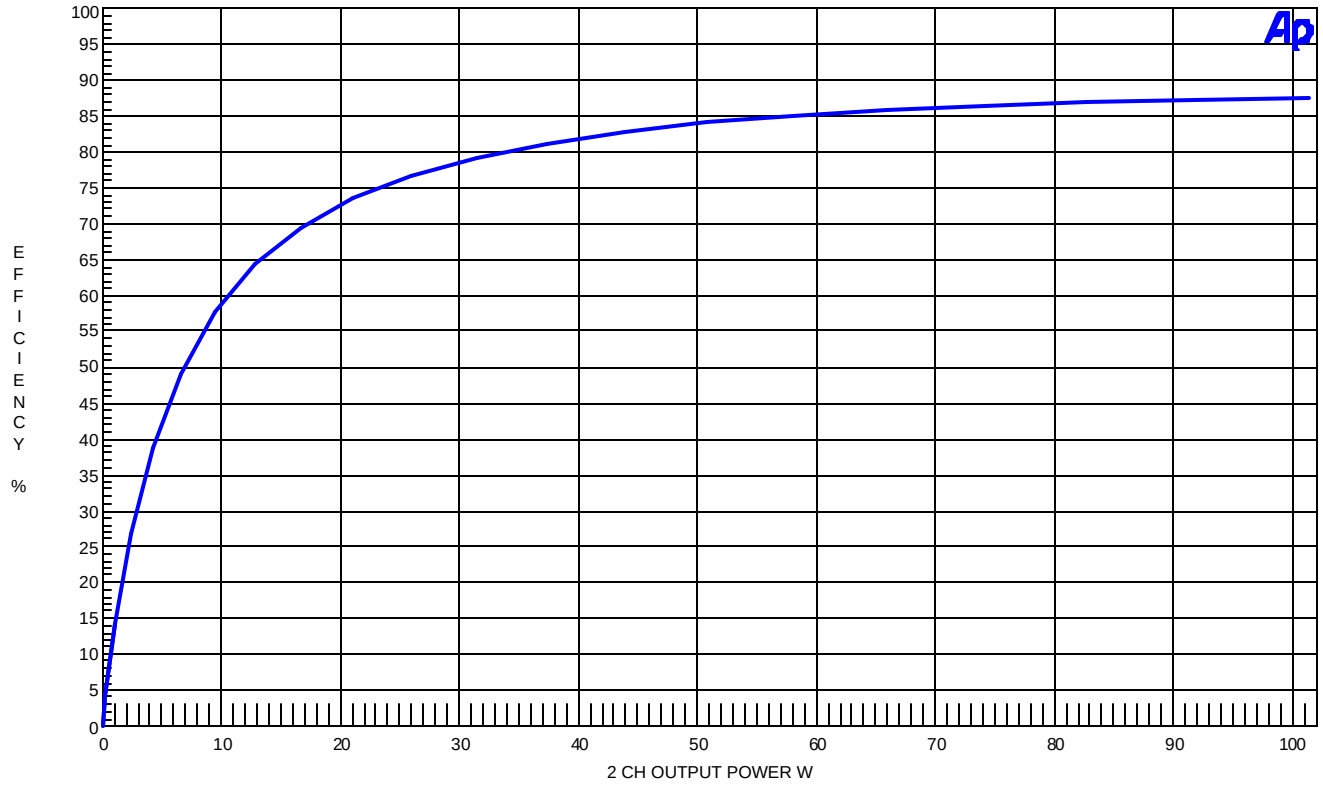


Comments:	Power supply: 29.5 V DC	Sample frequency: 48kHz	Input signal: 1kHz

Figure 8. Subwoofer Line Out

1.9 Output Stage Efficiency

Amplifier Efficiency versus Total Delivered Power



Comments:	Power supply: 29.5 V DC Input signal: 1kHz	Loads: 6 ohm	Sample frequency: 48kHz

Figure 9. Output Stage Efficiency

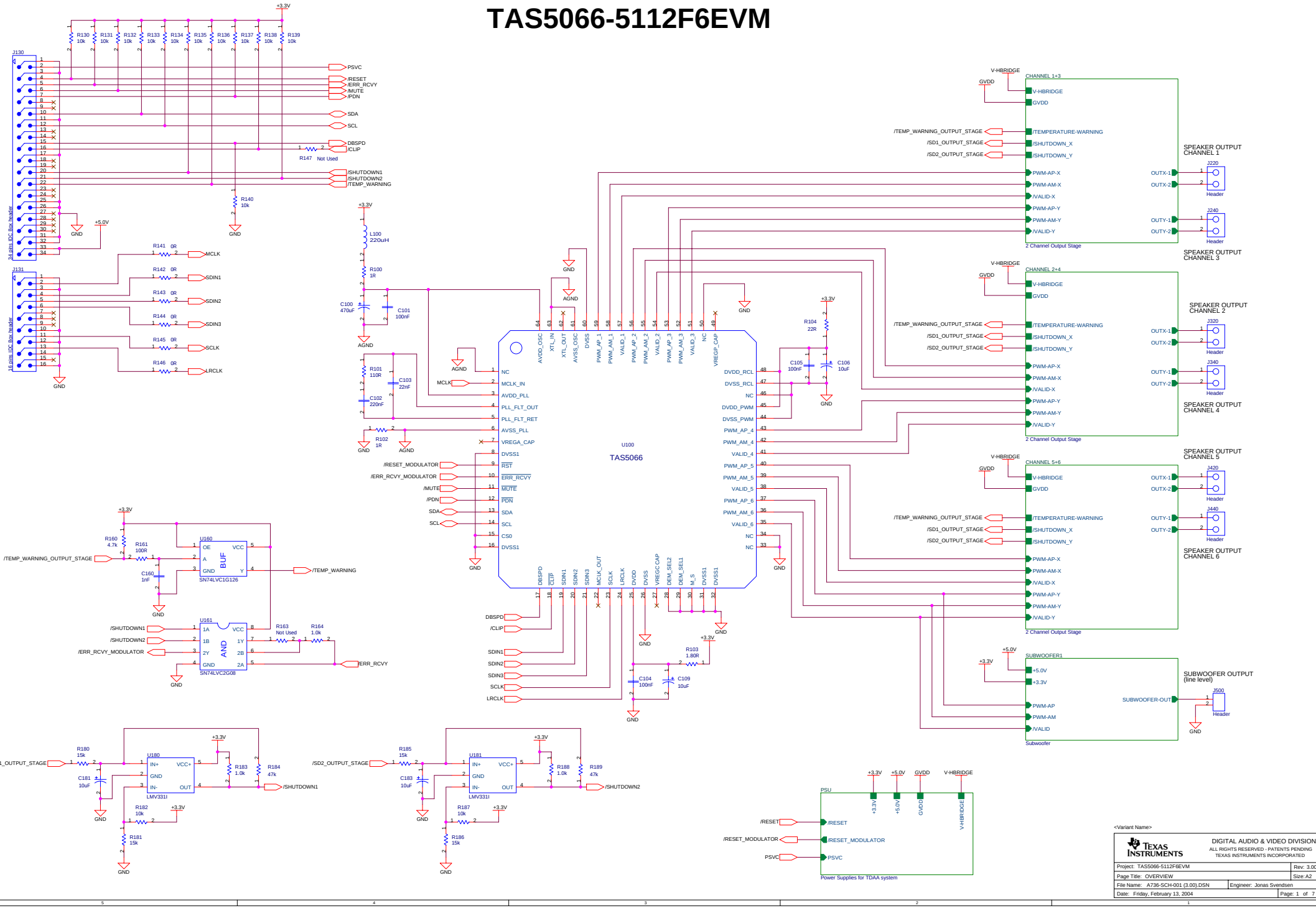
2 References

1. *System Design Considerations for True Digital Audio Power Amplifiers* (SLAA117)
2. *Digital Audio Measurements* (SLAA114)

Appendix A. Design documents

TAS5066-5112F6EVM Schematic	Version 3.00	7 pages
TAS5066-5112F6EVM Partslist	Version 3.00	2 pages
TAS5066-5112F6EVM PCB specification	Version 3.00	1 page
TAS5066-5112F6EVM PCB layers	Version 3.00	4 pages
TAS5066-5112F6EVM Mechanical design	Version 1.00	3 pages

TAS5066-5112F6EVM



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DIGITAL AUDIO & VIDEO DIVISION

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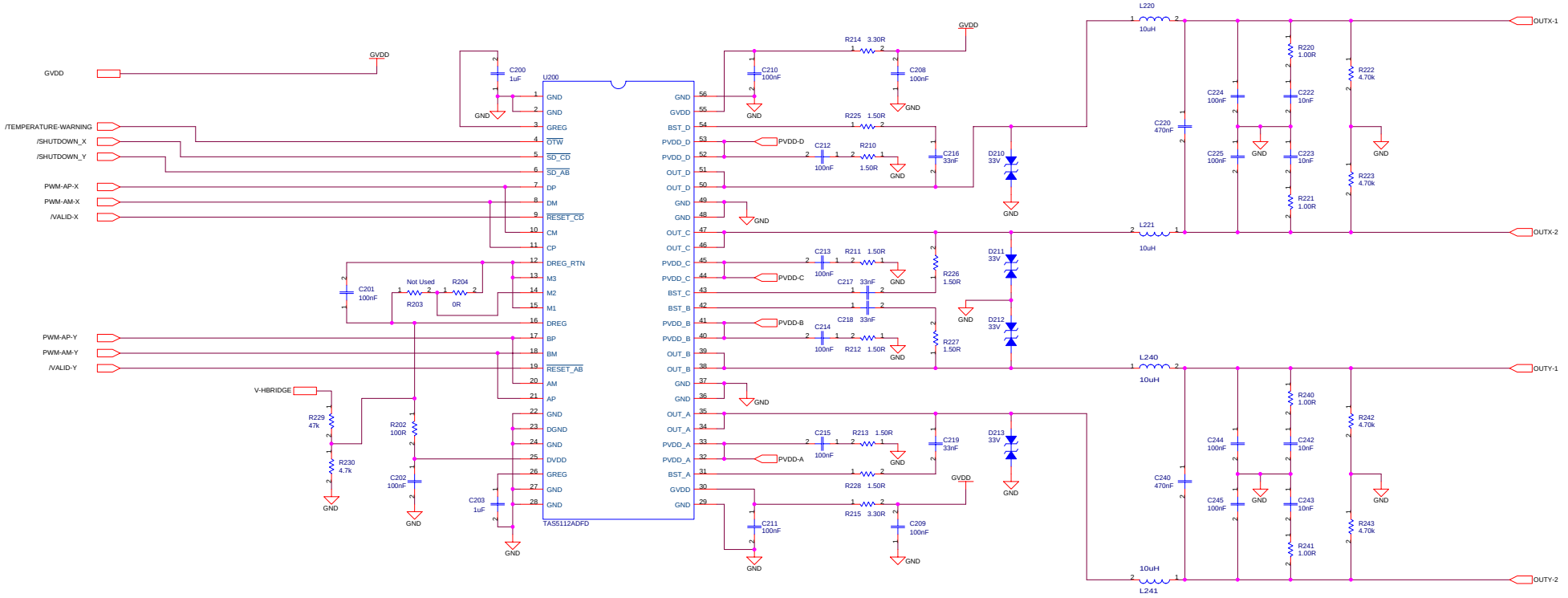
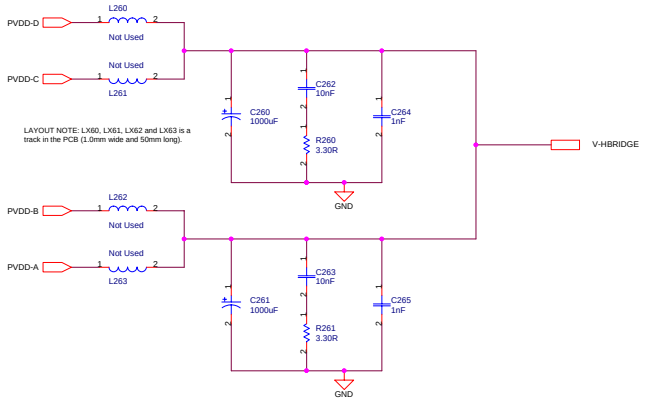
File Name: A736-SCH-001 (3.00).DSN	Engineer: Jonas Svendsen
Date: Friday, February 13, 2004	Page: 1 of 7

2 CHANNEL OUTPUT STAGE





Patents pending in circuitry design and layout (WO99/59241 & WO99/59242).

This circuitry may only be used together with the integrated circuit TAS5100/TAS5110/TAS5111/TAS5112/TAS5122 from Texas Instruments Incorporated.

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Page Title: CHANNEL 1 + 3	Size: A2
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Date: Friday, February 13, 2004	Page: 2 of 7

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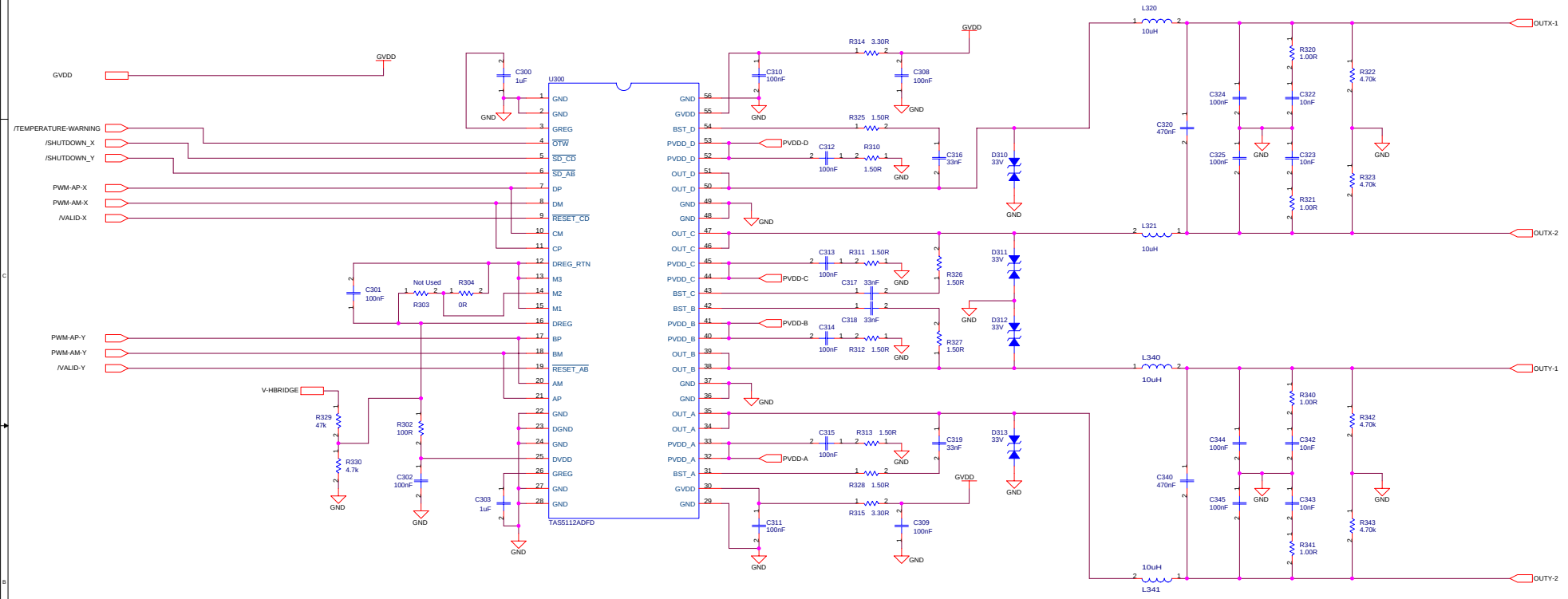

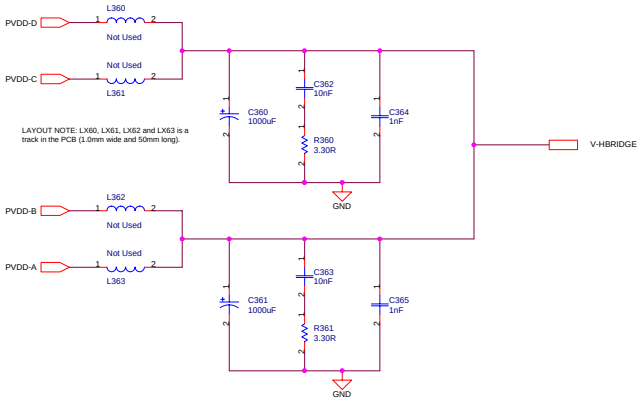

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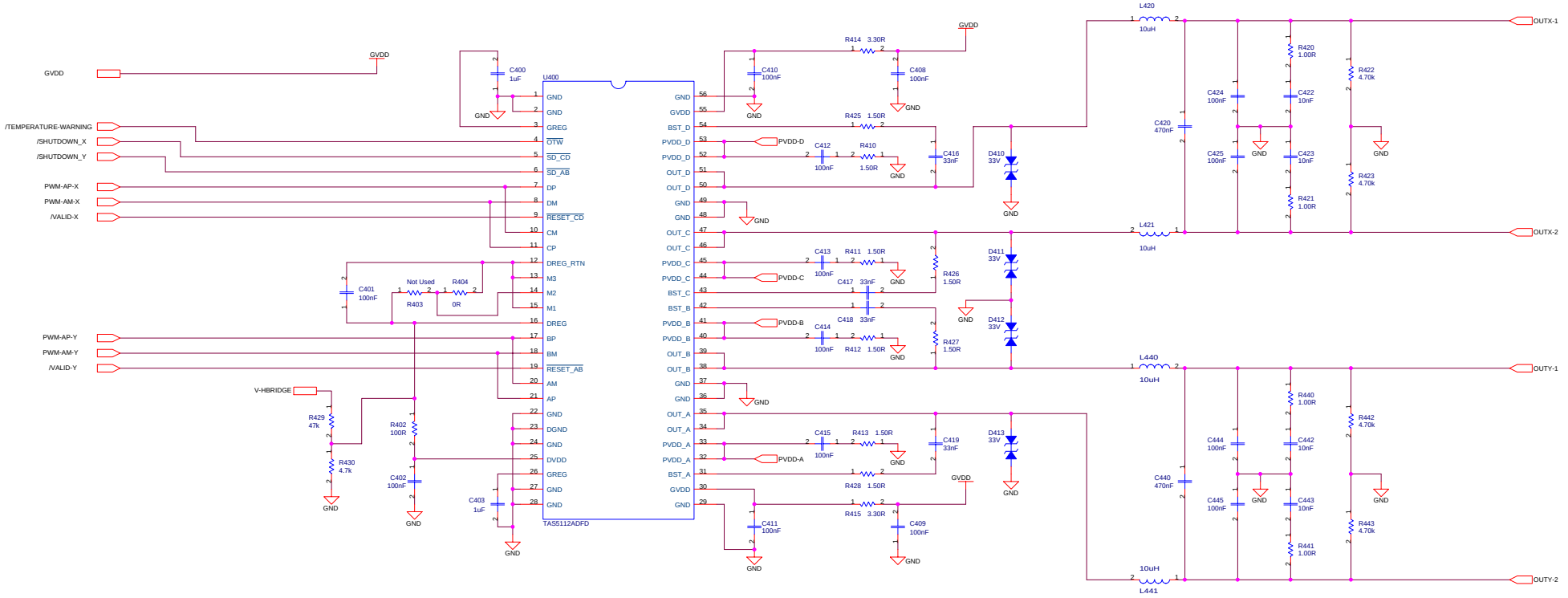
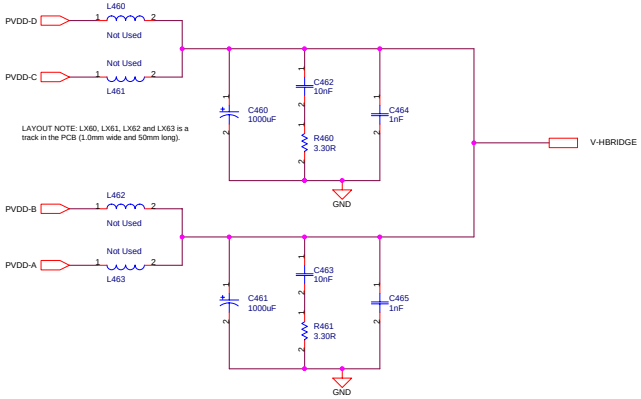
Date: Friday, February 13, 2004	Page: 3 of 7

2 CHANNEL OUTPUT STAGE





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Page Title: CHANNEL 4 + 6	Size: A2
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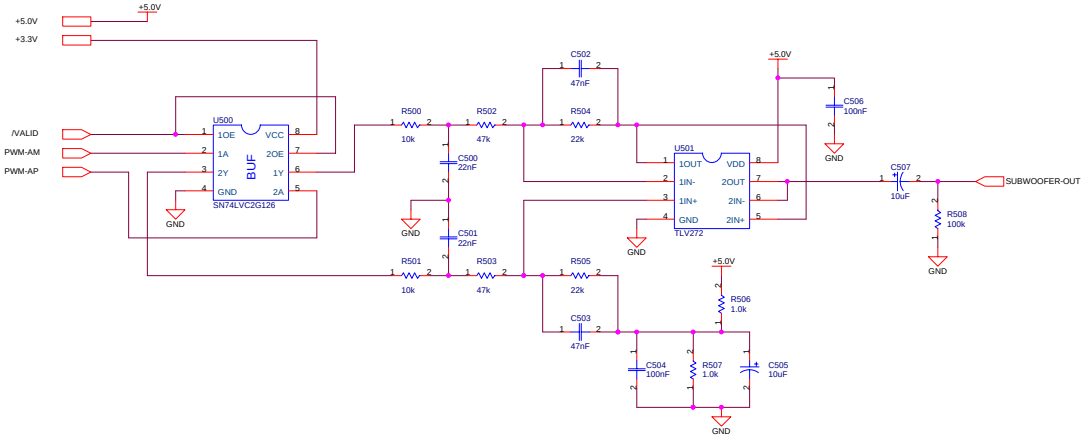
Date: Friday, February 13, 2004	Page: 4 of 7

SUBWOOFER OUTPUT



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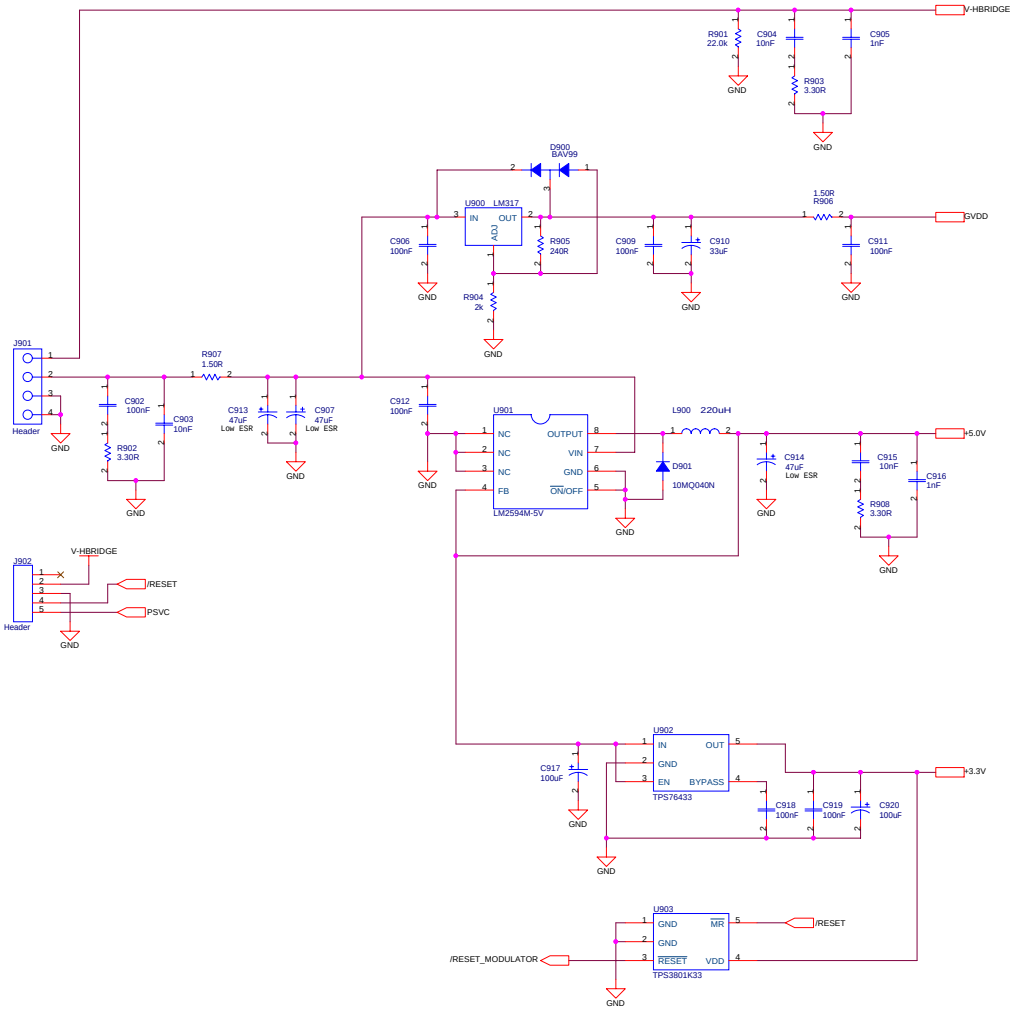

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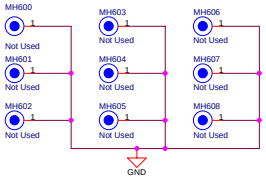
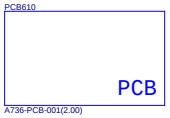
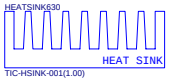
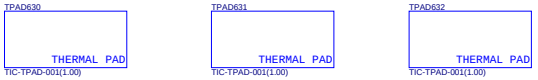
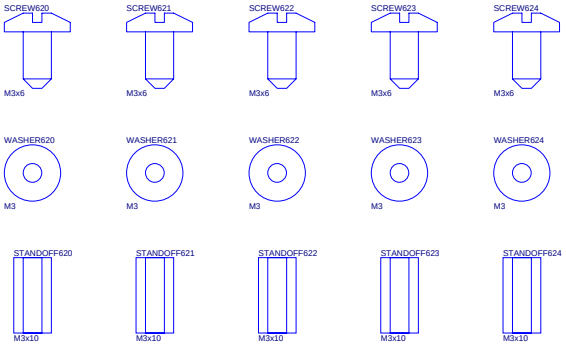
MECHANICS

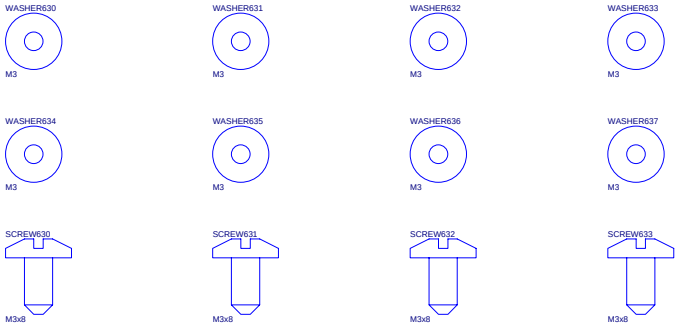












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Date: Friday, February 13, 2004	Page: 7 of 7

TAS5066-5112F6EVM Parts List (3.00).xls

Qty	Part Reference	Description	Manufacture	First Mfr P/N
12	R220 R320 R420 R221 R321 R421 R240 R340 R440 R241 R341 R441	1.00R/125mW 1% 0805 Metal Film Resistor	BC Components	DCU 0805 1% 1R00
12	R225 R325 R425 R226 R326 R426 R227 R327 R427 R228 R328 R428	1.50R/125mW 1% 0805 Metal Film Resistor	BC Components	DCU 0805 1% 1R50
1	R901	22.0k/125mW 1% 0805 Metal Film Resistor	BC Components	DCU 0805 1% 22k0
15	R902 R903 R908 R214 R314 R414 R215 R315 R415 R260 R360 R460 R261 R361 R461	3.30R/125mW 1% 0805 Metal Film Resistor	BC Components	DCU 0805 1% 3R30
12	R222 R322 R422 R223 R323 R423 R242 R342 R442 R243 R343 R443	4.70k/125mW 1% 0805 Metal Film Resistor	BC Components	DCU 0805 1% 4k70
9	R204 R304 R404 R141 R142 R143 R144 R145 R146	0R 0603 Metal Film Resistor	BC Components	DCT 0603 JUMPER
4	R202 R302 R402 R161	100R/100mW 5% 0603 Metal Film Resistor	BC Components	DCT 0603 5% 100R
5	R506 R507 R164 R183 R188	1.0k/100mW 5% 0603 Metal Film Resistor	BC Components	DCT 0603 5% 1k00
15	R500 R501 R130 R131 R132 R133 R134 R135 R136 R137 R138 R139 R140 R182 R187	10k/100mW 5% 0603 Metal Film Resistor	BC Components	DCT 0603 5% 10k0
1	R508	100k/100mW 5% 0603 Metal Film Resistor	BC Components	DCT 0603 5% 100k
2	R100 R102	1R/100mW 5% 0603 Metal Film Resistor	BC Components	DCT 0603 5% 1R00
1	R101	110R/100mW 1% 0603 Metal Film Resistor	BC Components	DCT 0603 1% 110R
4	R180 R185 R181 R186	15k/100mW 5% 0603 Metal Film Resistor	BC Components	DCT 0603 5% 15k0
1	R103	1.80R/100mW 1% 0603 Metal Film Resistor	BC Components	DCT 0603 1% 1R80
1	R904	2k/100mW 5% 0603 Metal Film Resistor	BC Components	DCT 0603 5% 2k00
2	R504 R505	22k/100mW 5% 0603 Metal Film Resistor	BC Components	DCT 0603 5% 22k0
1	R104	22R/100mW 5% 0603 Metal Film Resistor	BC Components	DCT 0603 5% 22R
1	R905	240R/100mW 5% 0603 Metal Film Resistor	BC Components	DCT 0603 5% 240R
4	R230 R330 R430 R160	4.7k/100mW 5% 0603 Metal Film Resistor	BC Components	DCT 0603 5% 4k70
7	R502 R503 R229 R329 R429 R184 R189	47k/100mW 5% 0603 Metal Film Resistor	BC Components	DCT 0603 5% 47k0
14	R906 R907 R210 R310 R410 R211 R311 R411 R212 R312 R412 R213 R313 R413	1.50R/250mW 5% RC3715 Mini-Melf Resistor	BC Components	MMA0204-50 5% BL 1R50
21	C903 C904 C915 C222 C322 C422 C223 C323 C423 C242 C342 C442 C243 C343 C443 C262 C362 C462 C263 C363 C463	Ceramic 10nF/100V 20% X7R 0805 Capacitor	BC Components	0805B103M101NT
37	C902 C208 C308 C408 C209 C309 C409 C210 C310 C410 C211 C311 C411 C212 C312 C412 C213 C313 C413 C214 C314 C414 C215 C315 C415 C224 C324 C424 C225 C325 C425 C244 C344 C444 C245 C345 C445	Ceramic 100nF/50V 20% X7R 0805 Capacitor	BC Components	0805B104M500NT
6	C200 C300 C400 C203 C303 C403	Ceramic 1uF/16V 20% X7R 0805 Capacitor	BC Components	0805B105M160NT
1	C103	Ceramic 22nF/100V 20% X7R 0805 Capacitor	BC Components	0805B223M101NT
1	C102	Ceramic 220nF/16V 20% X7R 0805 Capacitor	BC Components	0805B224M160NT
12	C216 C316 C416 C217 C317 C417 C218 C318 C418 C219 C319 C419	Ceramic 33nF/100V 20% X7R 1206 Capacitor	BC Components	1206B333M101NT
8	C905 C916 C264 C364 C464 C265 C365 C465	Ceramic 1nF/50V 2% NP0 0805 Capacitor	BC Components	0805N102G500NT
2	C505 C507	Electrolytic 10uF/16V 20% Aluminium 4x5mm SMD Capacitor	Panasonic	ECEV1CA100SR
4	C106 C109 C181 C183	Electrolytic 10uF/16V 20% Aluminium 4x5mm SMD Ultra Low ESR Capacitor	Panasonic	EEVFK1C100R
2	C917 C920	Electrolytic 100uF/6.3V 20% Aluminium 6x7mm SMD Ultra Low ESR Capacitor	Panasonic	EEVFK0J101P
1	C910	Electrolytic 33uF/25V 20% Aluminium 6x7mm SMD Capacitor	Panasonic	ECEV1EA330SP
1	C100	Electrolytic 470uF/16V 20% Aluminium 8x10mm SMD Low ESR Capacitor	Panasonic	EEVFK1C471P
17	C101 C201 C301 C401 C202 C302 C402 C104 C504 C105 C506 C906 C909 C911 C912 C918 C919	Ceramic 100nF/16V 20% X7R 0603 Capacitor	BC Components	0603B104M160NT
2	C500 C501	Ceramic 22nF/50V 20% X7R 0603 Capacitor	BC Components	0603B223M500NT
2	C502 C503	Ceramic 47nF/16V 20% X7R 0603 Capacitor	BC Components	0603B473M160NT
1	C160	Ceramic 1nF/50V 10% NP0 0603 Capacitor	BC Components	0603N102K500NT
6	C260 C360 C460 C261 C361 C461	Electrolytic 1000uF/35V 20% Aluminium 5mm ø12.5mm Low ESR Capacitor	Panasonic	EEUFC1V102
3	C907 C913 C914	Electrolytic 47uF/35V 20% Aluminium 2.5mm ø6.3mm Low ESR Capacitor	RUBYCON	35YXF47MY0611
6	C220 C320 C420 C240 C340 C440	Metal Film 470nF/100V 10% Polyester 7.5mm (W:5mm L:10.3mm) Capacitor	Wima	MKS 4 0.47uF/10%/100Vdc PCM7.5
1	L900	220uH/0.5A 20% (390mR) Magnetically shielded Ferrite Inductor	CoilCraft	DT3316P-224
1	L100	220uH/45mA 10% Ferrite Inductor (1210)	Panasonic	ELJFA221KJF
12	L220 L320 L420 L221 L321 L421 L240 L340 L440 L241 L341 L441	10uH/4.4A 20% (24mR) Ferrite Inductor (see note 1)	Taiyo Yuden	LHFP13BB100M
1	D900	250mA/70V 350mW Small Signal Dual (A-C-CA) Diode (SOT-23)	General Semi.	BAV99
1	D901	1A/40V Schottky Diode (SMA)	Int. Rectifier	10MQ040N
12	D210 D310 D410 D211 D311 D411 D212 D312 D412 D213 D313 D413	33V 400W (1ms) Zener Bidictional Transient Voltage Suppressor Diode (SMA)	ON/Motorola	1SMA33CAT3
3	U200 U300 U400	Stereo Digital Audio PWM Power Output Stage (HTSSOP56)	Texas Instruments	TAS5112ADFD
1	U100	6 ch PWM processor (AD, VOL, 192kHz, High BW) (TQFP64)	Texas Instruments	TAS5066PFB
1	U501	Dual RtR Output Opamp (VSSOP8)	Texas Instruments	TLV272CDGK
2	U180 U181	Differential Comparator (SOT23-5)	Texas Instruments	LMV331IDBVR
1	U161	Dual AND gate, LVC (SSOP8)	Texas Instruments	SN74LVC2G08DCTR
1	U160	Single Bus Buffer, LVC (SOT23-5)	Texas Instruments	SN74LVC1G126DBVR
1	U500	Dual Buffer, LVC (SSOP8)	Texas Instruments	SN74LVC2G126DCT
1	U903	3.3V Supply Voltage Supervisor (SOT323-5)	Texas Instruments	TPS3801K33DCK
1	U900	0.5A Positive Adjustable Regulator (KTP)	Texas Instruments	LM317MKTP
1	U901	5V/0.5A Buck Converter (SO8)	National Semi.	LM2594M-5.0V
1	U902	3.3V/150mA Low Drop Linear Regulator (SOT23-5)	Texas Instruments	TPS76433DBVR
5	SCREW620 SCREW621 SCREW622 SCREW623 SCREW624	M3x6, Pan Head, Pozidriv, A2 Screw	Bossard	BN 31108 M3x6
4	SCREW630 SCREW631 SCREW632 SCREW633	M3x8, Pan Head, Pozidriv, A2 Screw	Bossard	BN 31108 M3x8
5	WASHER620 WASHER621 WASHER622 WASHER623 WASHER624	M3 Stainless Steel Washer	Bossard	BN 670 M3
8	WASHER630 WASHER631 WASHER632 WASHER633 WASHER634 WASHER635 WASHER636 WASHER637	M3 White Nylon (o/d:9.0 i/d:3.2 t:0.8) Washer	Bossard	BN1075 M3

5	STANDOFF620 STANDOFF621 STANDOFF622 STANDOFF623 STANDOFF624	M3x10 Aluminum Stand-off	Ettinger	05.03.108
1	J500	2 pins/1 row/2.54mm Pitch Vertical Male Friction lock Pin header	Molex	22-27-2021
1	J902	5 pins/1 row/2.54mm Pitch Vertical Male Friction lock Pin header	Molex	22-27-2051
6	J220 J320 J420 J240 J340 J440	2 pins/1 row/3.96mm Pitch Vertical Male Pin header	JST	B2P-VH
1	J901	4 pins/1 row/3.96mm Pitch Vertical Male Pin header	JST	B4P-VH
1	J131	16 pins/2 rows/2.54mm Pitch Vertical Male IDC	Molex	87256-1611
1	J130	34 pins/2 rows/2.54mm Pitch Vertical Male IDC	Molex	87256-3411
1	PCB610	TAS5066-5112F6EVM Printed Circuit Board (ver. 2.00)	Printline	A736-PCB-001(2.00)
1	HEATSINK630	3.6K/W @ 12W (125x35x32mm)	A.K.S.	TIC-HSINK-001(1.00)
3	TPAD630 TPAD631 TPAD632	Self-adhesive thermal pad, DFD package, 15 mill SILPAD2000 (6x14mm)	Valentin	TIC-TPAD-001(1.00)
	Note 1			
	L220 L320 L420 L221 L321 L421 L240 L340 L440 L241 L341 L441	can be replaced by:	DB Tech	DBF-1310A

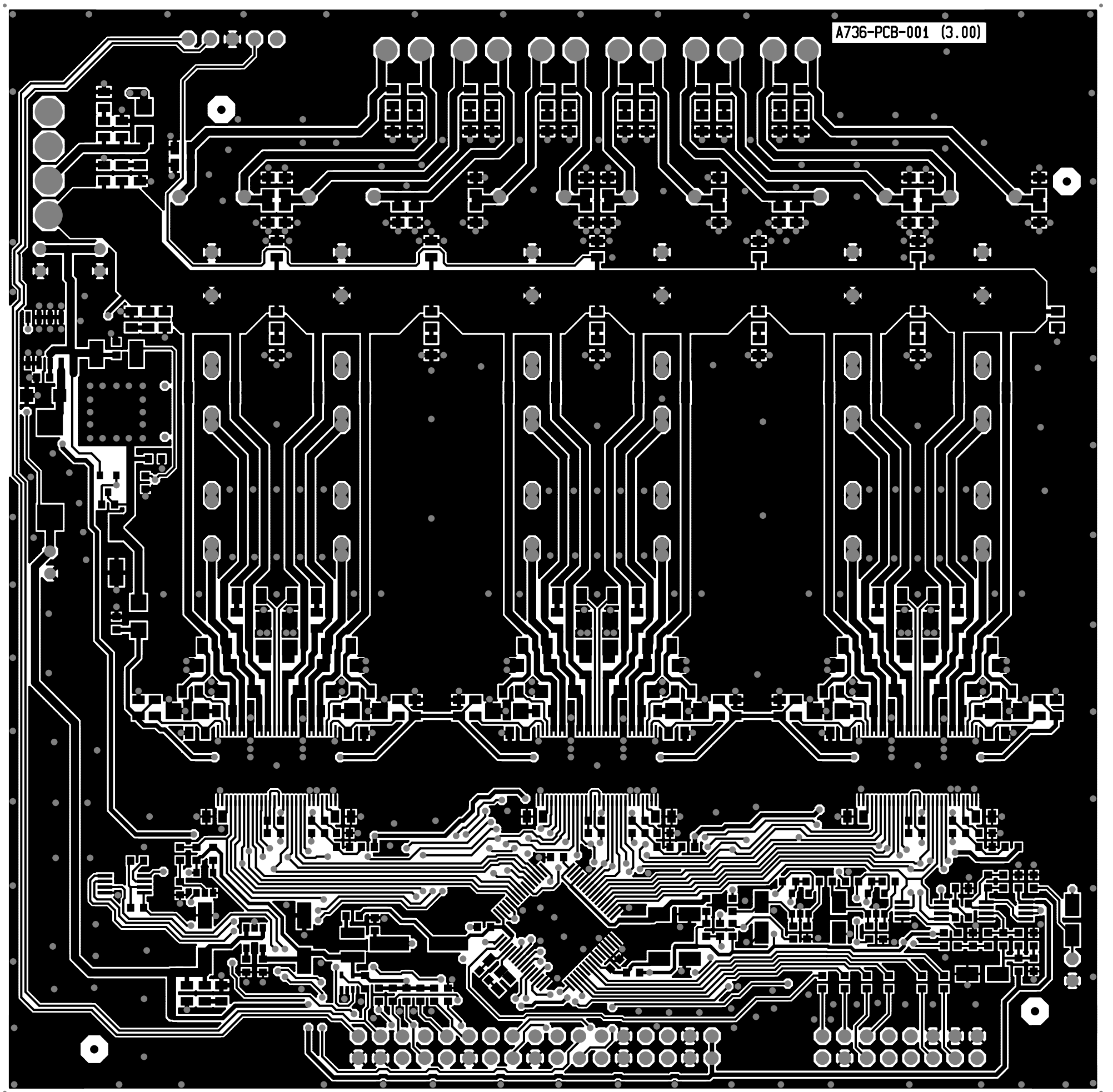
Jonas Svendsen

TAS5066-5112F6EVM PCB SPECIFICATION

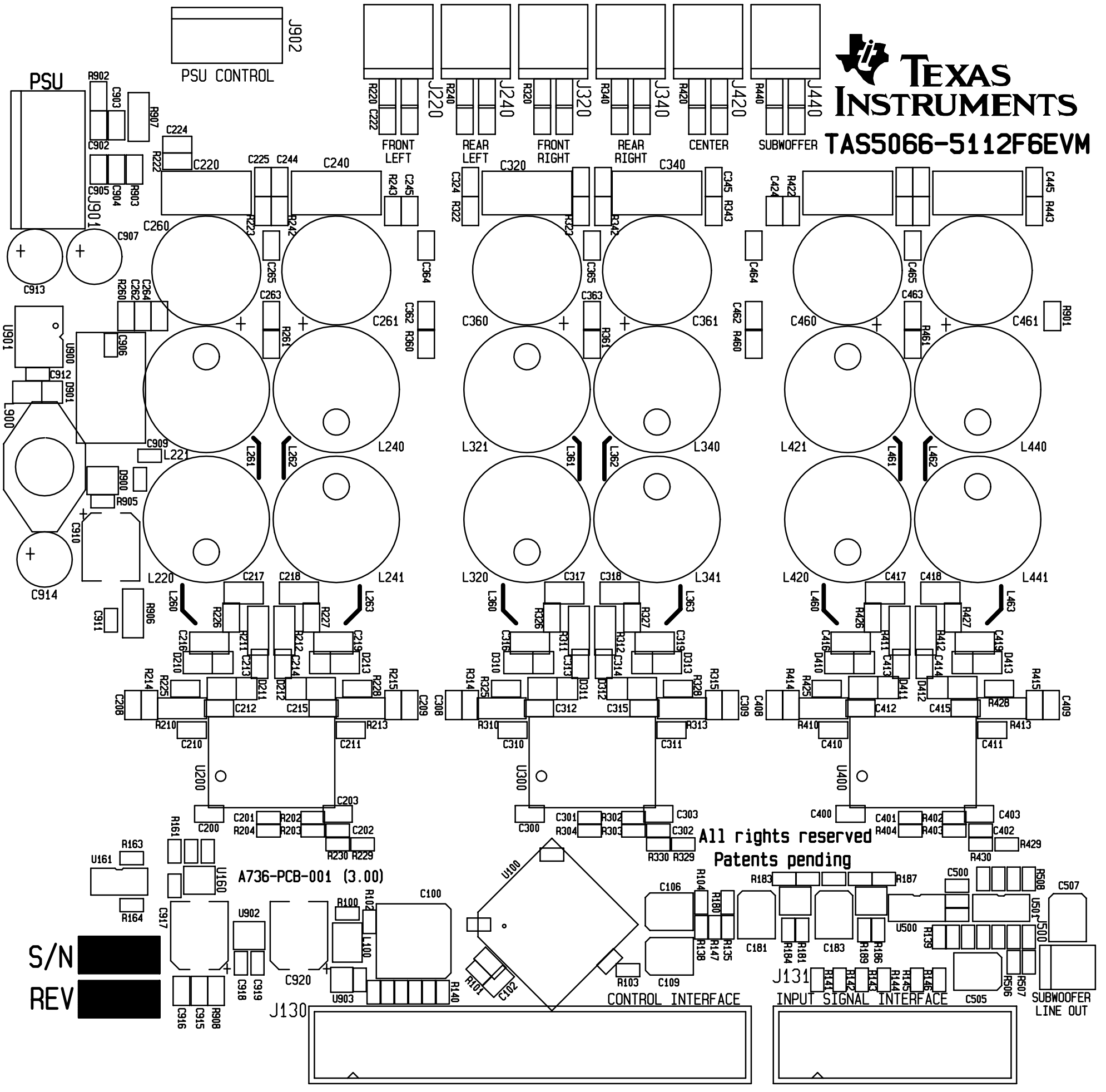
Version 3.00

BOARD IDENTIFICATION:	A736-PCB-001(3.00)
BOARD TYPE:	DOUBLE-SIDED PLATED-THROUGH BOARD
LAMINATE TYPE:	FR4
LAMINATE THICKNESS:	1.6mm
COPPER THICKNESS:	70µm (INCL. PLATING EXTERIOR LAYER)
COPPER PLATING OF HOLES:	>25µm
MINIMUM HOLE DIAMETER	0.3 mm
SILKSCREEN COMPONENT SIDE:	WHITE - REMOVE SILKSCREEN FROM SOLDER AREA & PRE-TINNED AREAS
SILKSCREEN SOLDER SIDE:	None
SOLDER MASK COMPONENT SIDE:	GREEN
SOLDER MASK SOLDER SIDE:	GREEN
PROTECTIVE COATING:	SOLDER COATING AND CHEMICAL SILVER ON FREE COPPER
ELECTRICAL TEST:	PCB MUST BE ELECTRICAL TESTED
MANUFACTURED TO:	PERFAG 2E (www.perfag.dk)
APERTURE TABLE:	PERFAG 10A (www.perfag.dk)
BOARD SIZE:	126 x 125 mm

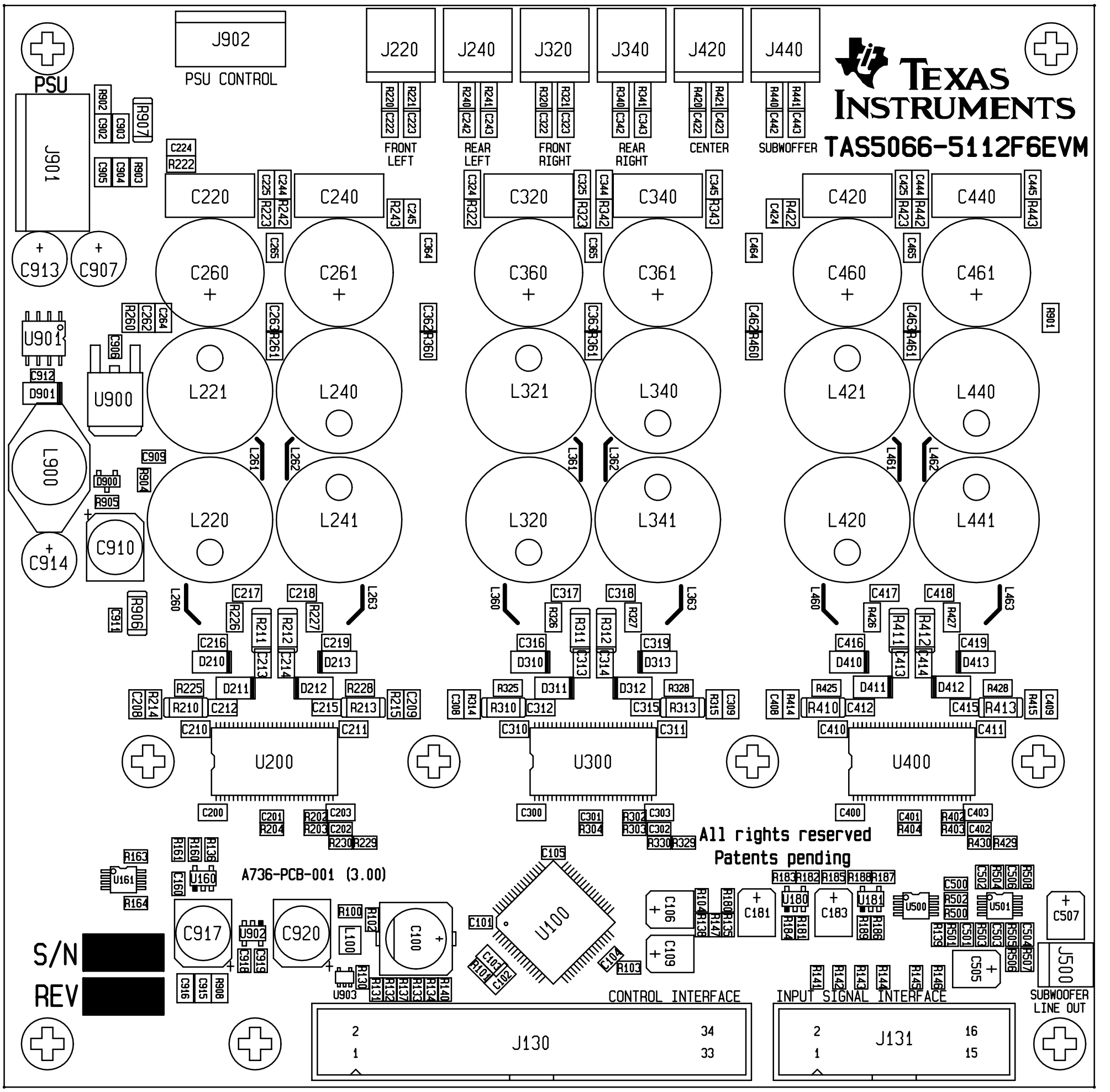
COMPONENT SIDE	DpS 4943 040128
TI Denmark A736-PCB-001 (3.00)	

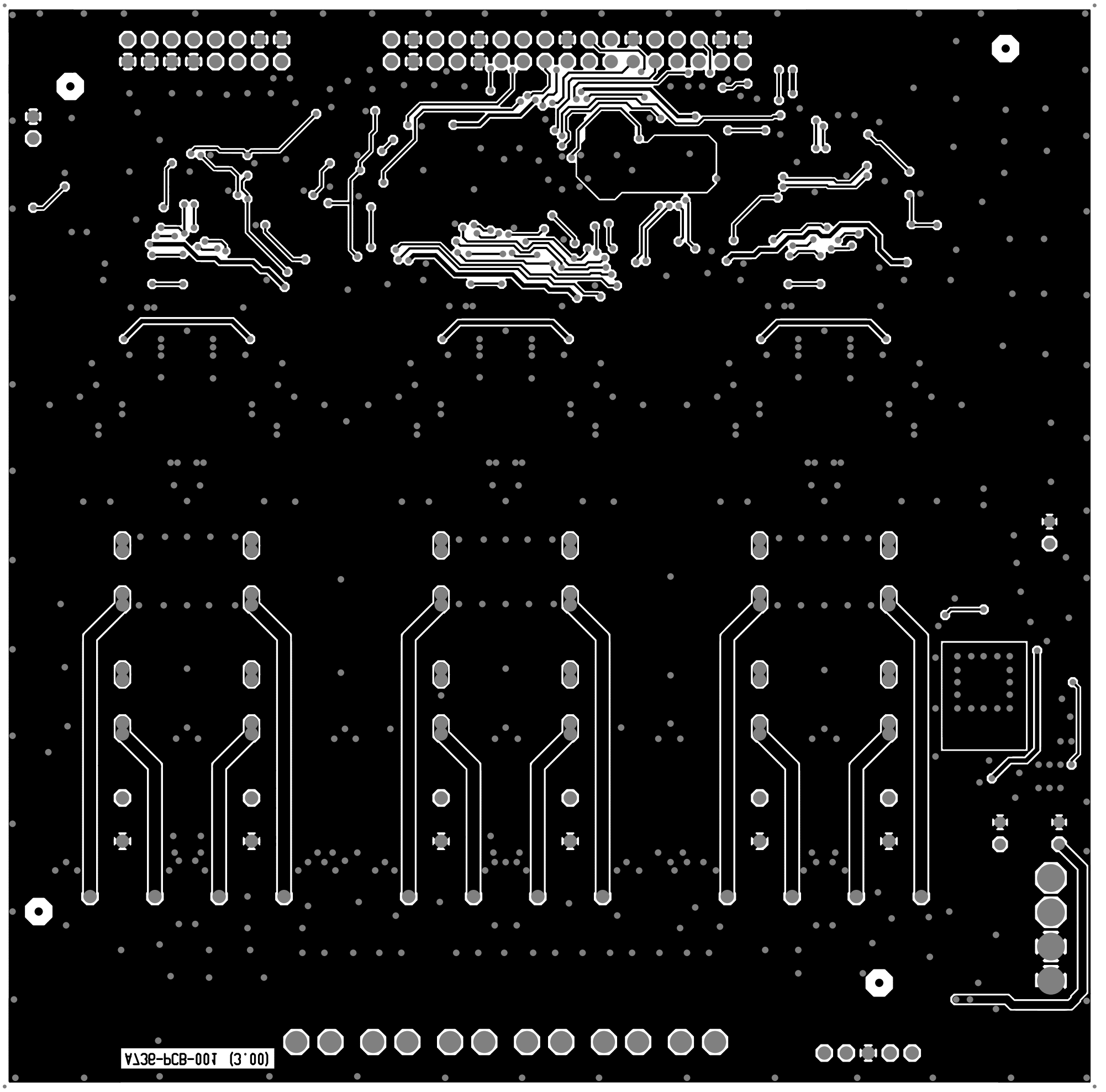


SILKSCREEN COMP	DpS 4943 040128
TI Denmark A736-PCB-001 (3.00)	



COMP. LAYOUT COMP	DpS 4943 040128
TI Denmark A736-PCB-001 (3.00)	



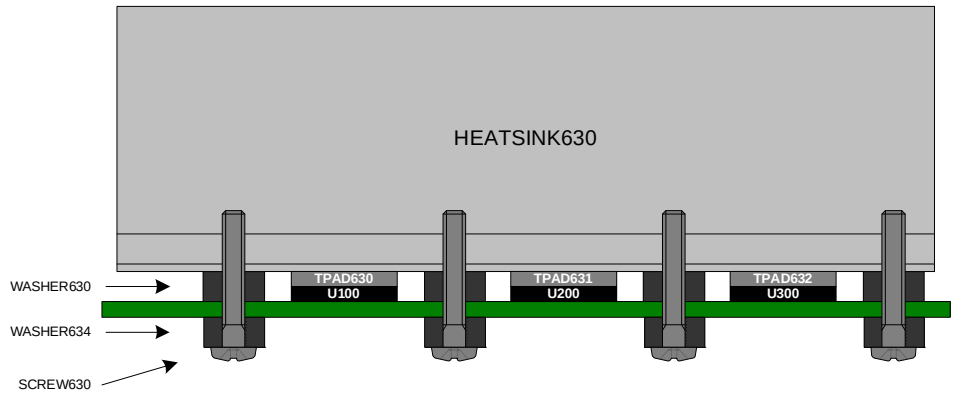


TI Program AM3E-PCB-001 (3.00)		
SOLDER SIDE		Dps 4943 0401258

TAS5066-5111D6EVM
Mechanical Design

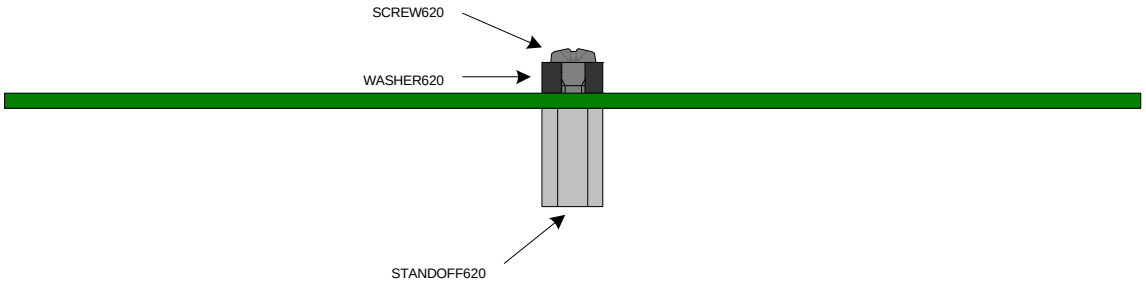
16. February 2004
A736-MECH-001 (1.00).vsd

Jonas Svendsen



TORQUE-LIMITING SCREWDRIVER HAVE TO BE USED DURING ASSEMBLY OF HEAT SINK (TORQUE LIMITED TO 0.3 N*m).

MOUNT STAND OFF'S IN ALL POSSIBLE HOLES OF THE PCB



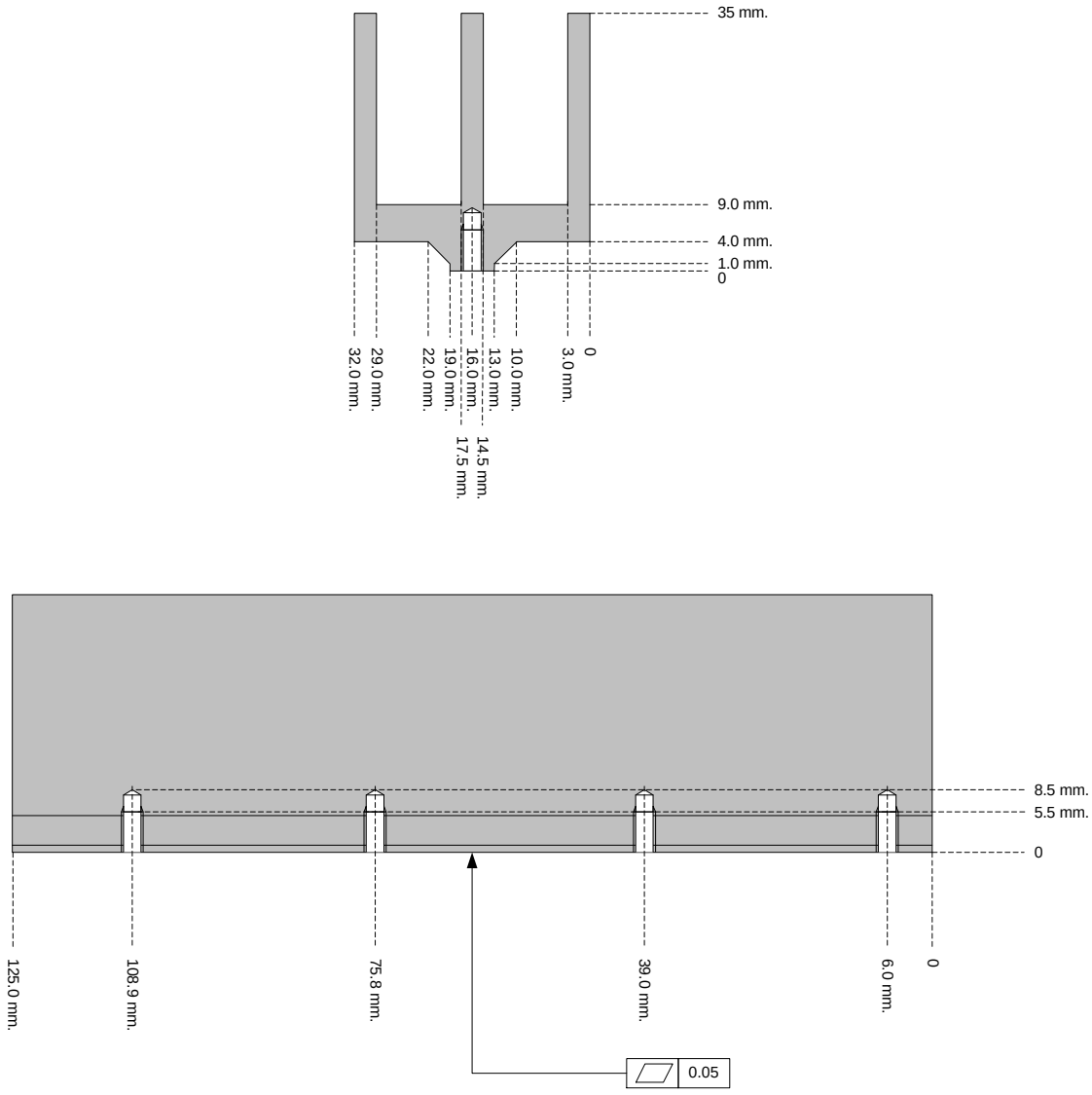
TIC-HSINK-001
Heat Sink with 3 Fins (35 mm.)

Friday, January 03, 2003
TIC-HSINK-001 (1.00).vsd

Claus Reckweg

$R_{HEAT\ SINK\ -\ AMBIENT}$: 3.6 K/W @ P = 12W (measured)

$m_{HEAT\ SINK}$: 0.144 kg (calculated)



MATERIAL: ALUMINIUM

INTERNAL SCREW THREADS: M3

SURFACE: GLASS BLOWED, FREE OF SHARP EDGES

SURFACE TREATMENT: BLACK ANODIZED

TOLERANCES: +/- 0.1mm.

TIC-TPAD-001
Thermal Pad for the DFD Package

Wednesday, November 20, 2002
TIC-TPAD-001 (1.00).vsd

Claus Reckweg

MATERIAL MANUFACTURER: THE BERGQUIST COMPANY (www.bergquistcompany.com)

MATERIAL: SIL-PAD 2000

SELF-ADHESIVE: YES

THICKNESS OF MATERIAL: 15 MILL

THERMAL CONDUCTIVITY: 3.5 W/m-K

PAD SIZE: 6.0 x 14.0 mm.