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# LV5696P

Bi-CMOS IC

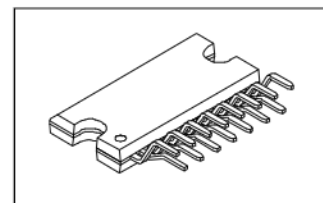
## System Power Supply IC for Automotive Infotainment Multiple Output Linear Voltage Regulator

### Overview

The LV5696P is a multiple output linear regulator IC, which allows reduction of quiescent current. The LV5696P is specifically designed to address automotive infotainment systems power supply requirements. The LV5696P integrates 6 linear regulator outputs, a high side power switch, over current protection, overvoltage protection and thermal shutdown circuitry.

### Function

- Low current consumption : typ 50 $\mu$ A
- 6 system of regulators
  - V<sub>DD</sub> (Micon) : V<sub>OUT</sub> 3.3/5.0V, I<sub>OUT</sub> MAX 200mA
  - CD : V<sub>OUT</sub> 8.0V, I<sub>OUT</sub> MAX 1000mA
  - Illumination : V<sub>OUT</sub> 3.0V to 8.0V (Adjustable external resistors),  
I<sub>OUT</sub> MAX 200mA
  - Audio : V<sub>OUT</sub> 8.5V, I<sub>OUT</sub> MAX 300mA
  - SYS : V<sub>OUT</sub> 5.0V, I<sub>OUT</sub> MAX 500mA
  - DSP : V<sub>OUT</sub> 3.3V, I<sub>OUT</sub> MAX 800mA
- 1 high-side switch coupled V<sub>CC</sub>
  - ANT : I<sub>OUT</sub> MAX 200mA, V<sub>CC</sub>-V<sub>OUT</sub> = 0.5V
- Over current protection
- Over voltage protection typ 21V (All outputs except for V<sub>DD</sub> are turned off)
- Thermal shut down circuit typ 175°C
- Applied P-LDMOS to output stage



HZIP15J

(Warning) The protector functions only improve the IC's tolerance and they do not guarantee the safety of the IC if used under the conditions out of safety range or ratings. Use of the IC such as use under overcurrent protection range, thermal shutdown state may degrade the IC's reliability and eventually damage the IC.

### ORDERING INFORMATION

See detailed ordering and shipping information on page 15 of this data sheet.

# LV5696P

## Specifications

### Absolute Maximum Ratings at $T_a = 25^\circ\text{C}$

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	$V_{CC}$ max		36	V
Power dissipation	$P_d$ max	IC Unit	1.5	W
		At using Al heat sink of (50×50×1.5mm <sup>3</sup> )	5.6	W
		Infinite large heat sink	32.5	W
Peak voltage	$V_{CC}$ peak	See below about Pulse wave	50	V
Operating temperature	$T_{opr}$		-40 to +85	°C
Storage temperature	$T_{stg}$		-55 to +150	°C
Junction maximum temperature	$T_j$ max		150	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

### Recommended Operating Conditions at $T_a = 25^\circ\text{C}$

Parameter	Conditions	Ratings	Unit
Power supply voltage rating 1	$V_{DD}$ output, ANT output	7.5 to 16	V
Power supply voltage rating 2	AUDIO output	10.5 to 16	V
Power supply voltage rating 3	CD output, ILM output, SYS output, DSP output	10 to 16	V

\*Make sure that  $V_{CC1}$  is as follows:  $V_{CC1} > V_{CC} - 0.7V$

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

### Electrical Characteristics at $T_a = 25^\circ\text{C}$ , $V_{CC} = V_{CC1} = 14.4V$

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Quiescent current	$I_{CC}$	$V_{DD}$ No Load, CTRL1/2/3 = [L/L/L]		50	100	μA
<b>CTRL1 (ANT)</b>						
Low input voltage	$V_{IL1}$	ANT: OFF	0		0.3	V
High input voltage	$V_{IH1}$	ANT: ON	2.7	3.3	5.5	V
Input impedance	$R_{IN1}$	input voltage $\leq 3.3V$	280	400	520	kΩ
<b>CTRL2 (ILM)</b>						
Low input voltage	$V_{IL2}$	ILM: OFF	0		0.3	V
High input voltage	$V_{IH2}$	ILM: ON	2.7	3.3	5.5	V
Input impedance	$R_{IN2}$	input voltage $\leq 3.3V$	280	400	520	kΩ
<b>CTRL3</b>						
Low input voltage	$V_{IL3}$	CD, AUDIO, SYS5V, DSP: OFF	0		0.3	V
Middle input voltage	$V_{IM3}$	CD, DSP:OFF SYS5V, AUDIO: ON	1.3	1.65	2.0	V
High input voltage	$V_{IH3}$	CD, AUDIO, SYS5V, DSP: ON	2.7	3.3	5.5	V
Input impedance	$R_{IN3}$	input voltage $\leq 3.3V$	280	400	520	kΩ
<b><math>V_{DD}</math> output 5.0V/3.3V -ON ; <math>IKV_{DD} = V_{CC1} : V_{DD} = 5V/IKV_{DD} = GND : V_{DD} = 3.3V</math></b>						
$V_{DD}$ output voltage 1	$V_{O1}$	$I_{O1} = 200mA$ , $IKV_{DD} = V_{CC1}$	4.75	5.0	5.25	V
$V_{DD}$ output voltage 2	$V_{O1}'$	$I_{O1} = 200mA$ , $IKV_{DD} = GND$	3.13	3.3	3.47	V
$V_{DD}$ output current	$I_{O1}$		200			mA
Line regulation	$\Delta V_{OLN1}$	$7.5V < V_{CC} < 16V$ , $I_{O1} = 200mA$		30	100	mV
Load regulation	$\Delta V_{OLD1}$	$1mA < I_{O1} < 200mA$		70	150	mV
Dropout voltage 1	$V_{DROP1}$	$I_{O1} = 200mA$		1.0	1.5	V
Dropout voltage 2	$V_{DROP1}'$	$I_{O1} = 100mA$		0.5	0.75	V
Ripple rejection	$R_{REJ1}$	$f = 120Hz$ , $I_{O1} = 200mA$	40	50		dB

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Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
<b>CD output 8.0V-ON ; CTRL3 = [H]</b>						
CD output voltage	V <sub>O2</sub>	I <sub>O2</sub> = 1000mA	7.6	8.0	8.4	V
CD output current	I <sub>O2</sub>		1000			mA
Line regulation	ΔV <sub>OLN2</sub>	10.5V < V <sub>CC</sub> < 16V, I <sub>O3</sub> = 1000mA		50	100	mV
Load regulation	ΔV <sub>OLD2</sub>	10mA < I <sub>O2</sub> < 1000mA		100	200	mV
Dropout voltage 1	V <sub>DROP2</sub>	I <sub>O2</sub> = 1000mA		1.0	1.5	V
Dropout voltage 2	V <sub>DROP2'</sub>	I <sub>O2</sub> = 500mA		0.5	0.75	V
Ripple rejection	R <sub>REJ2</sub>	f = 120Hz, I <sub>O2</sub> = 1000mA	40	50		dB
<b>ILM output 3.0 to 8.0V-ON ; CTRL2 = [H]</b>						
ILM_ADJ voltage	V <sub>I3</sub>		1.222	1.260	1.298	V
ILM_ADJ current	I <sub>I3</sub>		-1		1	μA
ILM output voltage1	V <sub>O3</sub>	I <sub>O3</sub> = 200mA, R1 = 300kΩ, R2 = 56kΩ	7.65	8.0	8.35	V
ILM output voltage2	V <sub>O3'</sub>	I <sub>O3</sub> = 200mA, R1 = 51kΩ, R2 = 36kΩ	2.86	3.0	3.14	V
ILM output current	I <sub>O3</sub>	R1 = 300kΩ, R2 = 56kΩ	200			mA
Line regulation	ΔV <sub>OLN3</sub>	10.5V < V <sub>CC</sub> < 16V, I <sub>O4</sub> = 200mA		30	90	mV
Load regulation	ΔV <sub>OLD3</sub>	1mA < I <sub>O3</sub> < 200mA		70	150	mV
Dropout voltage 1	V <sub>DROP3</sub>	I <sub>O3</sub> = 200mA		0.7	1.05	V
Dropout voltage 2	V <sub>DROP3'</sub>	I <sub>O3</sub> = 100mA		0.35	0.53	V
Ripple rejection	R <sub>REJ3</sub>	f = 120Hz, I <sub>O4</sub> = 200mA	40	50		dB
<b>AUDIO output 8.5V-ON ; CTRL3 = [M or H]</b>						
AUDIO output voltage	V <sub>O4</sub>	I <sub>O4</sub> = 300mA	8.07	8.5	8.93	V
AUDIO output current	I <sub>O4</sub>		300			mA
Line regulation	ΔV <sub>OLN4</sub>	10.5V < V <sub>CC</sub> < 16V, I <sub>O4</sub> = 300mA		30	90	mV
Load regulation	ΔV <sub>OLD4</sub>	1mA < I <sub>O4</sub> < 300mA		70	150	mV
Dropout voltage 1	V <sub>DROP4</sub>	I <sub>O4</sub> = 200mA		0.7	1.05	V
Dropout voltage 2	V <sub>DROP4'</sub>	I <sub>O4</sub> = 100mA		0.35	0.53	V
Ripple rejection	R <sub>REJ4</sub>	f = 120Hz, I <sub>O4</sub> = 300mA	40	50		dB
<b>SYS output 5.0V-ON ; CTRL3 = [M or H]</b>						
SYS output voltage	V <sub>O5</sub>	I <sub>O5</sub> = 500mA	4.75	5.0	5.25	V
SYS output current	I <sub>O5</sub>		500			mA
Line regulation	ΔV <sub>OLN5</sub>	10.5V < V <sub>CC</sub> < 16V, I <sub>O5</sub> = 500mA		30	90	mV
Load regulation	ΔV <sub>OLD5</sub>	1mA < I <sub>O5</sub> < 500mA		70	150	mV
Dropout voltage	V <sub>DROP5</sub>	I <sub>O5</sub> = 500mA		1.3	2.5	V
Ripple rejection	R <sub>REJ5</sub>	f = 120Hz, I <sub>O5</sub> = 500mA	40	50		dB
<b>DSP output 3.3V-ON ; CTRL3 = [H]</b>						
DSP output voltage	V <sub>O6</sub>	I <sub>O6</sub> = 800mA	3.13	3.3	3.47	V
DSP output current	I <sub>O6</sub>		800			mA
Line regulation	ΔV <sub>OLN6</sub>	10.5V < V <sub>CC</sub> < 16V, I <sub>O6</sub> = 800mA		30	90	mV
Load regulation	ΔV <sub>OLD6</sub>	1mA < I <sub>O6</sub> < 800mA		70	150	mV
Dropout voltage	V <sub>DROP6</sub>	I <sub>O6</sub> = 800mA		1.5	3.0	V
Ripple rejection	R <sub>REJ6</sub>	f = 120Hz, I <sub>O6</sub> = 800mA	40	50		dB
<b>ANT Remote-ON ; CTRL1 = [H]</b>						
Output voltage	V <sub>O7</sub>	I <sub>O7</sub> = 200mA	V <sub>CC</sub> -1.0	V <sub>CC</sub> -0.5		V
Output current	I <sub>O7</sub>	V <sub>O7</sub> ≥ V <sub>CC</sub> -1.0	200			mA

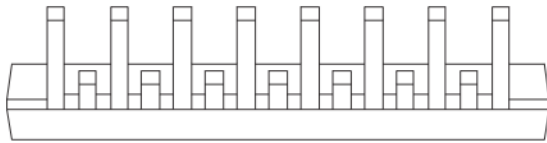
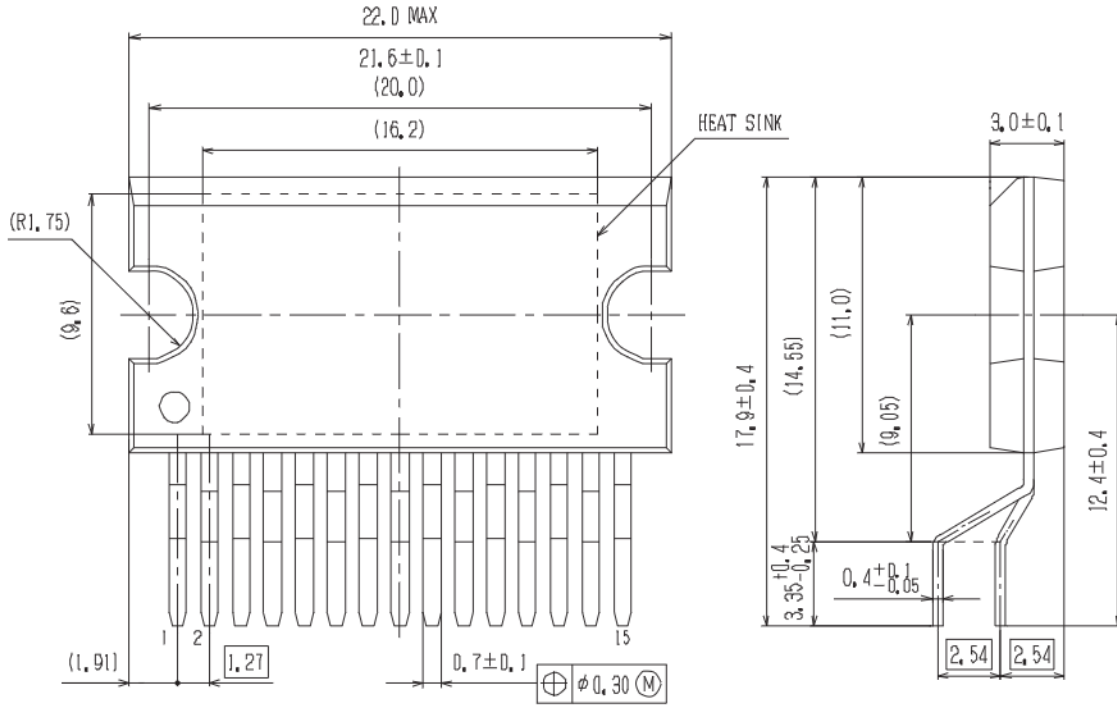
Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

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## Package Dimensions

unit : mm

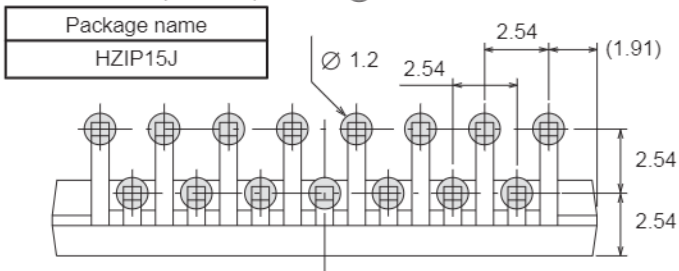
**HZIP15J**  
CASE 945AC  
ISSUE A



### SOLDERING FOOTPRINT\*

(Unit: mm)

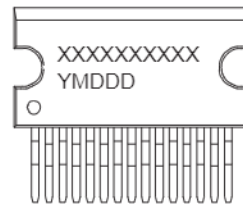
○ Through Hole Area



NOTE: The measurements are not to guarantee but for reference only.

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

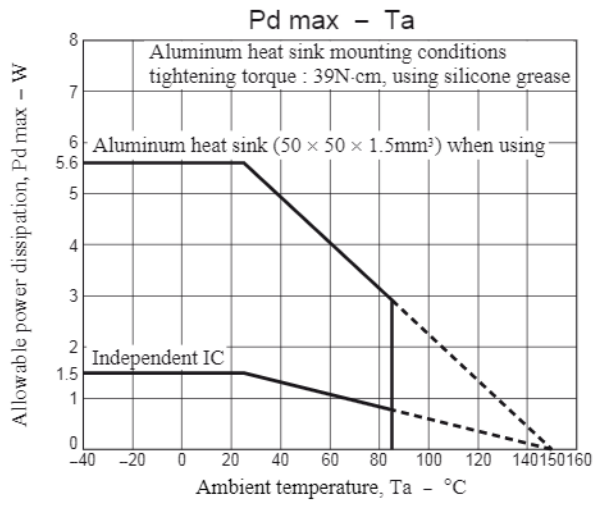
### GENERIC MARKING DIAGRAM\*



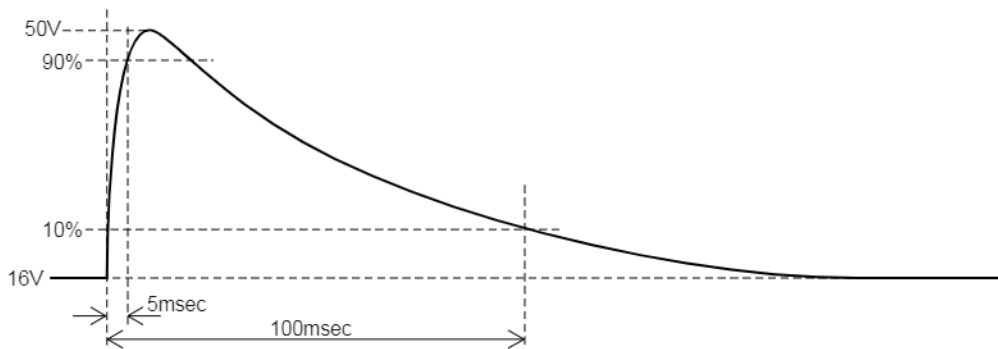
XXXXX = Specific Device Code  
Y = Year  
M = Month  
DDD = Additional Traceability Data

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "•", may or may not be present.

• Allowable power dissipation derating curve



• Peak Voltage testing pulse wave



**CTRL logic truth table**

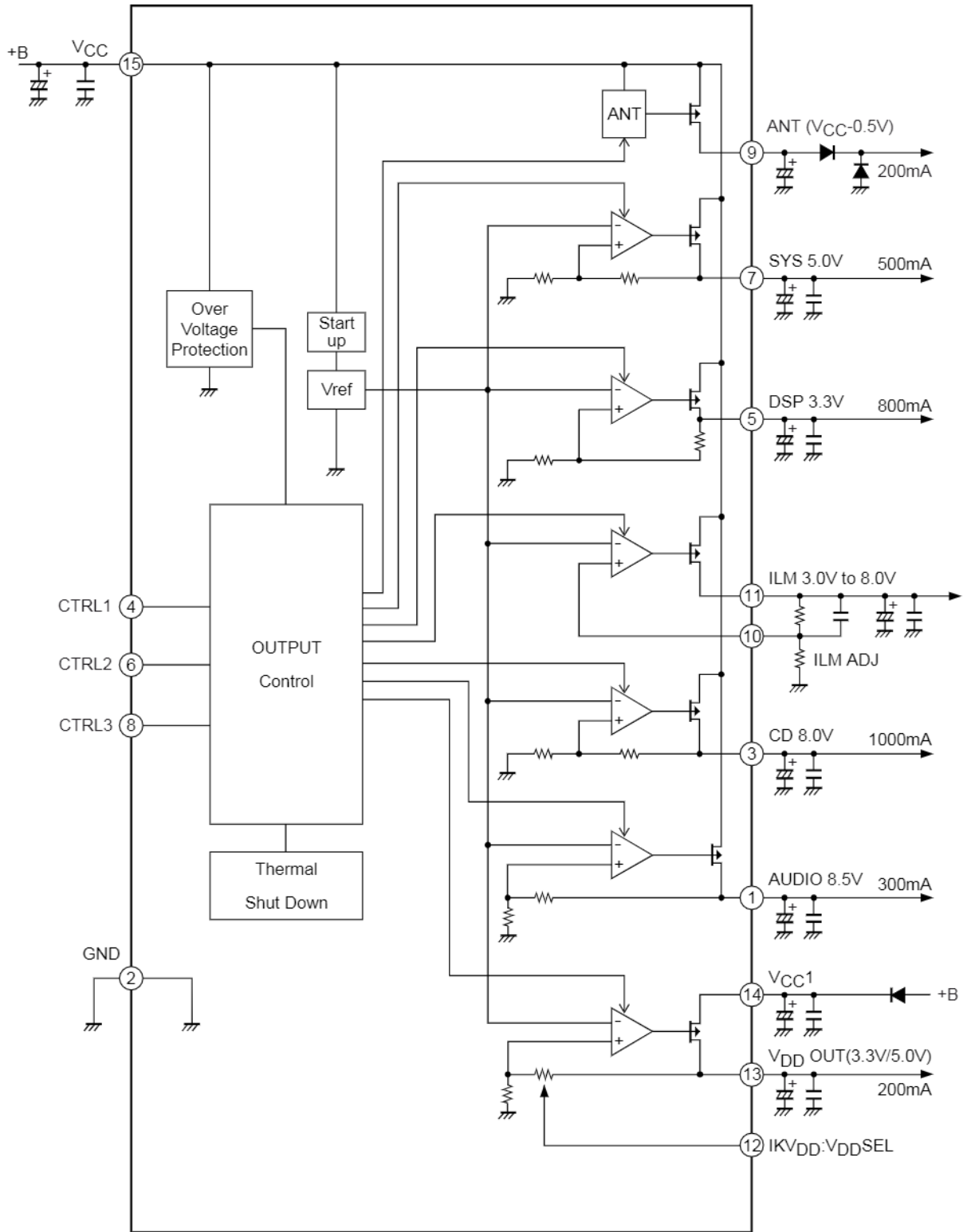
CTRL1	ANT
L	OFF
H	ON

CTRL2	ILM
L	OFF
H	ON

CTRL3	AUDIO	SYS	CD	DSP
L	OFF	OFF	OFF	OFF
M	ON	ON	OFF	OFF
H	ON	ON	ON	ON

# LV5696P

## Block Diagram



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## Pin Function

Pin No.	Pin name	Description	Equivalent Circuit
1	AUDIO	AUDIO output pin CTRL3 = M, H-ON 8.5V/0.3A	
2	GND	GND pin	
3	CD	CD output pin CTRL3 = H-ON 8.0V/1.0A	
4	CTRL1	CTRL1 input pin Input of two values	
5	DSP	DSP output pin CTRL3 = H-ON 3.3V/0.8A	

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Pin No.	Pin name	Description	Equivalent Circuit
6	CTRL2	CTRL2 input pin Input of two values	
7	SYS	SYS output pin CTRL3 = M, H-ON 5.0V/0.5A	
8	CTRL3	CTRL3 input pin Input of three values	
9	ANT	ANT output pin CTRL1 = H-ON VCC-0.5V/0.2A	

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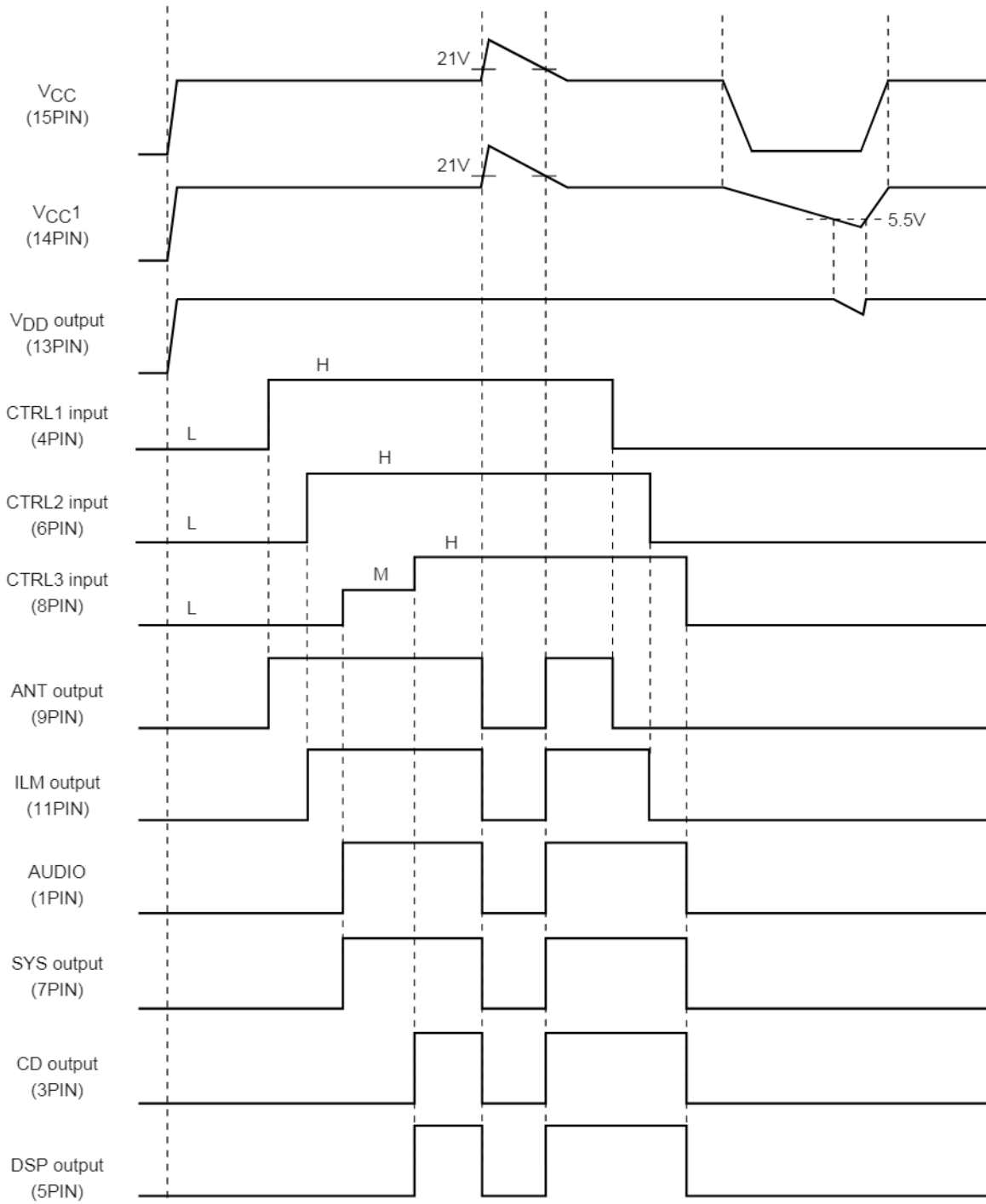
# LV5696P

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Pin No.	Pin name	Description	Equivalent Circuit
10	ILM ADJ	ILM feedback pin	
11	ILM	ILM output pin CTRL2 = H-ON 3.0 to 8.0V/0.2A	
12	IKV <sub>DD</sub>	V <sub>DD</sub> Voltage switch control input pin V <sub>CC1</sub> /GND	
13	V <sub>DD</sub>	V <sub>DD</sub> output pin 5.0V/0.2A (IKV <sub>DD</sub> = V <sub>CC1</sub> ) 3.3V/0.2A (IKCD = GND)	
14	V <sub>CC1</sub>	V <sub>DD</sub> power supply pin	
15	V <sub>CC</sub>	Power supply pin	

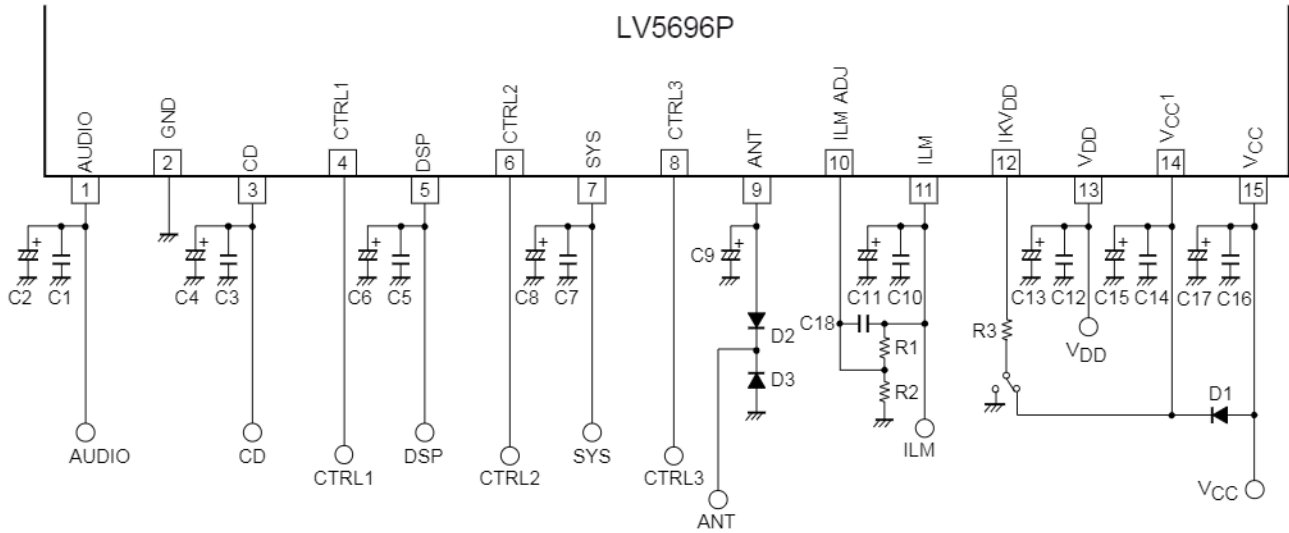
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Timing Chart



# LV5696P

## Application circuit example



## External Parts Lineup

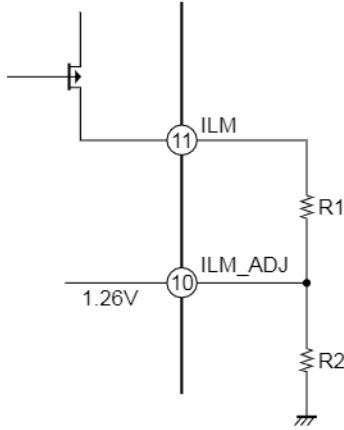
Part name	Description	Recommended value	Note
C2, C4, C6, C8, C11, C13	Output stabilization capacitor	10 $\mu$ F or more (*1)	Electrolytic capacitor
C1, C3, C5, C7, C10, C12	Output stabilization capacitor	0.22 $\mu$ F or more (*1)	Ceramic capacitor
C18	Output stabilization capacitor	20pF	Ceramic capacitor
C15, C17	Bypass capacitor	100 $\mu$ F or more	Connect a capacitor as close as possible to V <sub>CC</sub> pin and GND pin.
C14, C16	Prevent oscillation capacitor	0.22 $\mu$ F or more	
C9	Output stabilization capacitor	2.2 $\mu$ F or more	
R1, R2	Feedback resistor	ILM output voltage R1/R2: 300k $\Omega$ /56k $\Omega$ = 8.0V R1/R2: 51k $\Omega$ /36k $\Omega$ = 3.0V	A resistor with resistance accuracy as low as less $\pm$ 1% must be used.
R3	Protective resistor	10 to 100k $\Omega$	
D1	Backflow prevention diode		
D2, D3	Internal element Protection diode	SB1003M3	

(\*1) Make sure that output capacitors is 10 $\mu$ F or more and ESR 10 $\Omega$  or less in total, in which voltage and temperature fluctuation and unit differences are taken into consideration. Moreover, high frequency characteristics of electrolytic capacitor should be sufficient.

Furthermore, the values listed above do not guarantee stabilization during the over current protection operations of the regulator, so oscillation may occur during an over current protection operation.

# LV5696P

## ILM output voltage setting method



ILM\_ADJ is equal to bandgap reference voltage (typ = 1.26V).

### ILM calculating formula

$$ILM = \frac{1.26[V]}{R_2} \times R_1 + 1.26[V]$$

$$\frac{R_1}{R_2} = \frac{(ILM - 1.26)}{1.26}$$

Please design so that the ratio of R1 and R2 may fill the above-mentioned expression for the set ILM voltage.

(Ex.) Setup to ILM = 8.0V

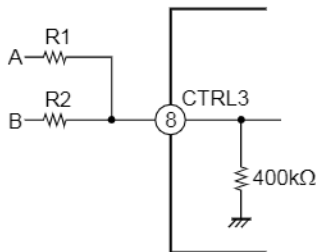
$$\frac{R_1}{R_2} = \frac{(8.0 - 1.26)}{1.26} \cong 5.349$$

$$\frac{R_1}{R_2} = \frac{300k\Omega}{56k\Omega} \cong 5.357$$

$$ILM = 1.26V \times 5.357 + 1.26V \cong 8.010V$$

Note : The above-mentioned are all the values at the typical. The error margin of output voltage is caused by the influence of the manufacturing variations of IC and external resistance.

## CTRL3 Application Circuit



Input 3.3V : R1 = R2 = 47kΩ

A	B	CTRL3
0V	0V	0V
0V	3.3V	1.56V
3.3V	0V	1.56V
3.3V	3.3V	3.12V

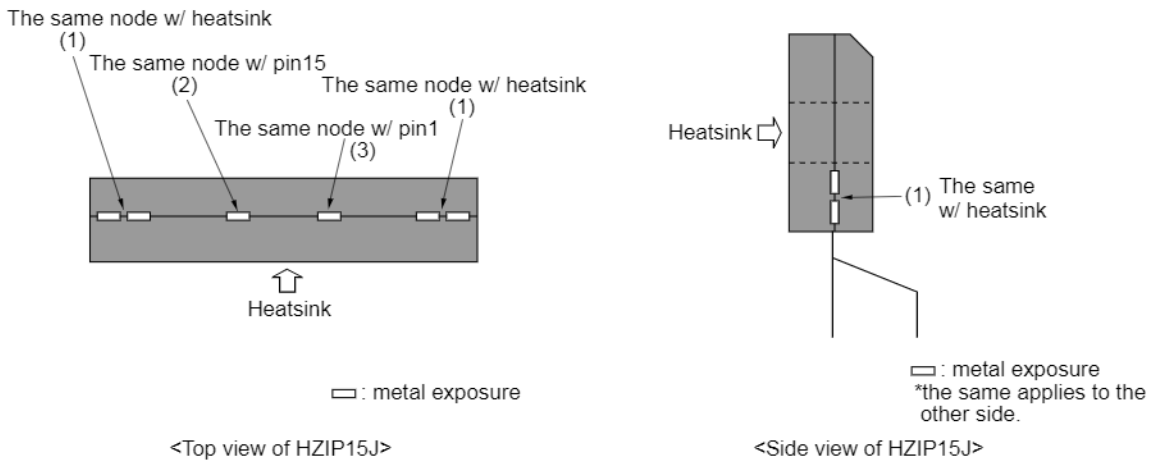
# LV5696P

## Warning: Implementing LV5696P to the set board

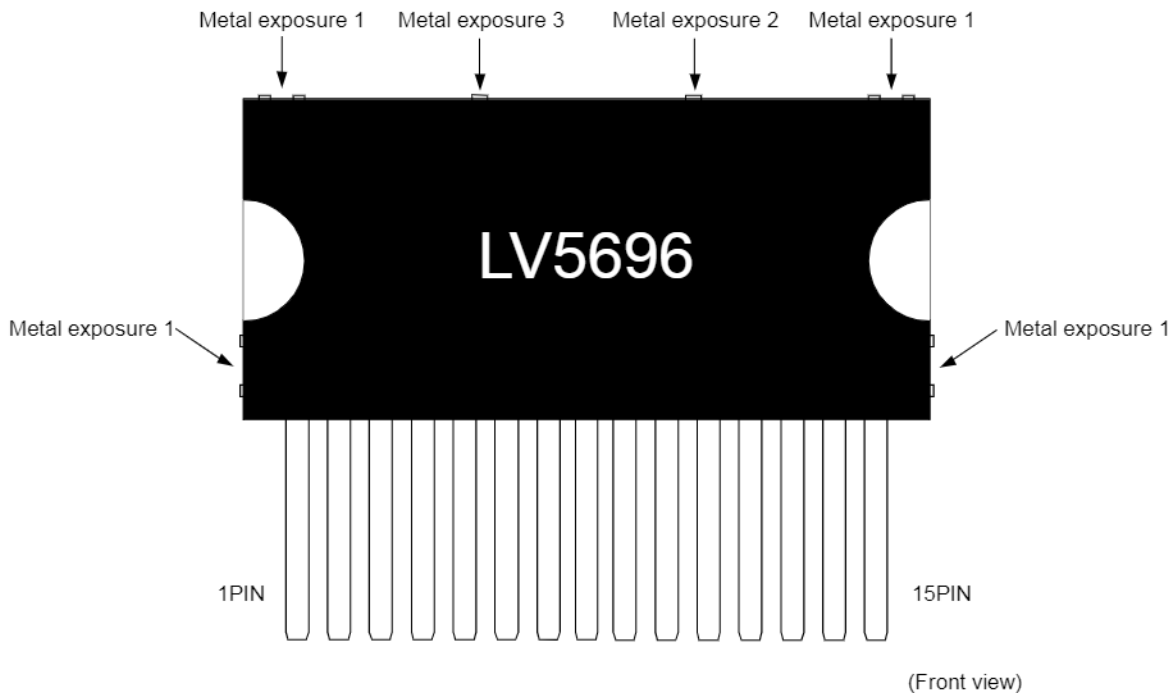
The package of LV5696P is HZIP15J which has some metal exposures other than connection pins and heatsink as shown in the diagram below. The electrical potentials of (2) and (3) are the same as those of pin15 and pin1, respectively.

(2) (= pin15) is the  $V_{CC}$  pin and (3) (= pin1) is the AUDIO (regulator) output pin. When you implement the IC to the set board, make sure that the bolts and the heatsink are out of touch from (2) and (3). If the metal exposures touch the bolts which has the same electrical potential with GND, GND short occurs in AUDIO output and  $V_{CC}$ . The exposures of (1) are connected to heatsink which has the same electrical potential with substrate of the IC chip (GND). Therefore, (1) and GND electrical potential of the set board can contact each other.

## HZIP15J outline



## Frame diagram (HZIP15J)



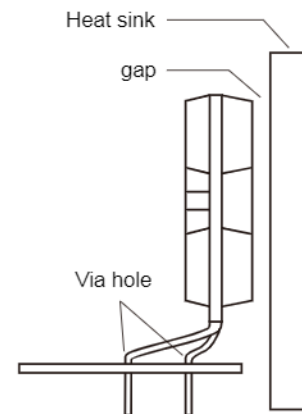
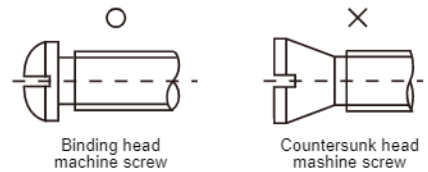
## HZIP15J Heat sink attachment

Heat sinks are used to lower the semiconductor device junction temperature by leading the heat generated by the device to the outer environment and dissipating that heat.

- a. Unless otherwise specified, for power ICs with tabs and power ICs with attached heat sinks, solder must not be applied to the heat sink or tabs.

b. Heat sink attachment

- Use flat-head screws to attach heat sinks.
- Use also washer to protect the package.
- Use tightening torques in the ranges 39-59Ncm (4-6kgcm) .
- If tapping screws are used, do not use screws with a diameter larger than the holes in the semiconductor device itself.
- Do not make gap, dust, or other contaminants to get between the semiconductor device and the tab or heat sink.
- Take care a position of via hole .
- Do not allow dirt, dust, or other contaminants to get between the semiconductor device and the tab or heat sink.
- Verify that there are no press burrs or screw-hole burrs on the heat sink.
- Warping in heat sinks and printed circuit boards must be no more than 0.05 mm between screw holes, for either concave or convex warping.
- Twisting must be limited to under 0.05 mm.
- Heat sink and semiconductor device are mounted in parallel.  
Take care of electric or compressed air drivers
- The speed of these torque wrenches should never exceed 700 rpm, and should typically be about 400 rpm.



c. Silicone grease

- Spread the silicone grease evenly when mounting heat sinks.
- Our company recommends YG-6260 (Momentive Performance Materials Japan LLC)

d. Mount

- First mount the heat sink on the semiconductor device, and then mount that assembly on the printed circuit board.
- When attaching a heat sink after mounting a semiconductor device into the printed circuit board, when tightening up a heat sink with the screw, the mechanical stress which is impossible to the semiconductor device and the pin doesn't hang.

e. When mounting the semiconductor device to the heat sink using jigs, etc.,

- Take care not to allow the device to ride onto the jig or positioning dowel.
- Design the jig so that no unreasonable mechanical stress is not applied to the semiconductor device.

f. Heat sink screw holes

- Be sure that chamfering and shear drop of heat sinks must not be larger than the diameter of screw head used.
- When using nuts, do not make the heat sink hole diameters larger than the diameter of the head of the screws used. A hole diameter about 15% larger than the diameter of the screw is desirable.
- When tap screws are used, be sure that the diameter of the holes in the heat sink are not too small. A diameter about 15% smaller than the diameter of the screw is desirable.

- g. There is a method to mount the semiconductor device to the heat sink by using a spring band. But this method is not recommended because of possible displacement due to fluctuation of the spring force with time or vibration.

# LV5696P

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## ORDERING INFORMATION

Device	Package	Shipping (Qty / Packing)
LV5696P-E	HZIP15J (Pb-Free)	20 / Fan-Fold

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