



Details are subject to change without notice.

## FOUR-CHANNEL DIGITAL STILL CAMERA POWER SUPPLY

### FEATURES

- Complete PWM Power Control Circuitry
- Input Voltage Range: 3.0V to 6.5V (CH1~CH4)
- Low Start-Up Voltage: 1.4V (CH4)
- Separate On/Off Control for CH1~CH4
- Supports Synchronous Boost/Buck Rectification (CH1)
- Supports Synchronous Boost Rectification (CH4)
- Supports Boost/Buck Conversion (CH2)
- Supports Boost Conversion (CH3)
- Supports White LED Driver (CH3)
- Totem-Pole Output
- Short Circuit Protection
- Wide Operating Frequency: 100 kHz to 1MHz
- LQFP48 and VQFN40 Package

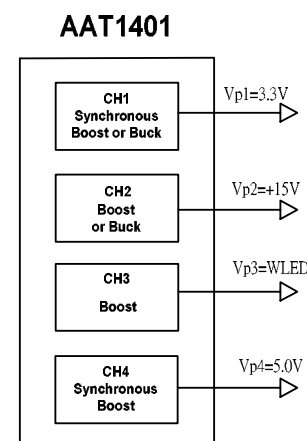
### APPLICATIONS

- Camcorders
- Digital Cameras
- CCD Imaging Devices

### GENERAL DESCRIPTION

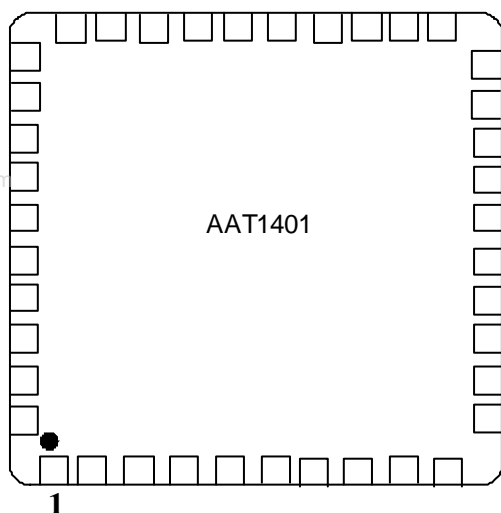
The AAT1401 provides an integrated four channel pulse-width-modulation (PWM) solution for the power supply of DC-DC converter; this device offers system engineer flexibility to tailor-make the power supply circuitry for specific applications. Each channel contains its own error amplifier, PWM comparator, dead-time control (DTC) and output driver. The under-voltage protection, oscillator, short circuit protection and voltage reference circuit are the common features for the four channels.

In addition to a boost conversion, AAT1401 also has two synchronous rectification systems with alternatives of a synchronous boost or buck on channel one (CH1) and a boost or buck conversion on channel two (CH2).

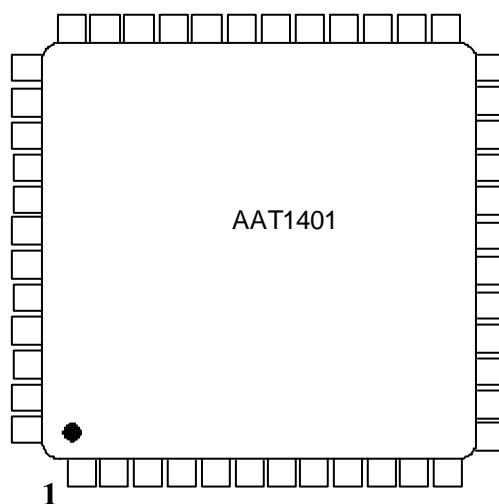




**PIN CONFIGURATION**



(VQFN-40)



(LQFP-48)

**FUNCTION TABLE**

Condition		Channel Status			
SHDN	SD –	CH1	CH2	CH3	CH4
“Lo”	X	Off	Off	Off	Off
“Hi”	SD1= “Lo”	Off			
	SD1= “Hi”	On			
	SD2= “Lo”		Off		
	SD2= “Hi”		On		
	SD3= “Lo”			Off	
	SD3= “Hi”			On	
	SD4= “Lo”				Off
	SD4= “Hi”				On



**PIN DESCRIPTION (VQFN-40)**

Pin No	Name	I/O	Function
1	MC1	I	Boost or Buck Select for CH1
2	SD1	I	ON/OFF Control for CH1
3	SD4	I	ON/OFF Control for CH4
4	SHDN	I	Power ON/OFF Control
5	IE1	I	Inverted Input for Error Amplifier 1 (EA1)
6	IE4	I	Inverted Input for Error Amplifier 4 (EA4)
7	DTC1	I	Dead Time Control of CH1
8	OE1	O	Output for Error Amplifier 1 (EA1)
9	DTC4	I	Dead Time Control of CH4
10	NC	-	
11	OE4	O	Output for Error Amplifier 4 (EA4)
12	RT	-	External Frequency Setting Resistor
13	CT	-	External Frequency Setting Capacitor
14	VB	O	Reference Voltage 2.77V Output
15	GND	P	Ground
16	VDD	P	Power Supply
17	V <sub>REF</sub>	O	Reference Voltage 1.245V Output
18	SCP	-	Short Circuit Protection Capacitor Connection Pin
19	SD3	I	ON/OFF Control for CH3
20	NC	-	
21	SD2	I	ON/OFF Control for CH2
22	IE3A	I	Inverted Input 2 for Error Amplifier 3 (EA3)
23	IE3	I	Inverted Input for Error Amplifier 3 (EA3)
24	IE2	I	Inverted Input for Error Amplifier 2 (EA2)
25	OE3	O	Output for Error Amplifier 3 (EA3)
26	OE2	O	Output for Error Amplifier 2 (EA2)
27	DTC3	I	Dead Time Control of CH3
28	DTC2	I	Dead Time Control of CH2
29	MC2	I	Boost or Buck Select for CH2
30	NC	-	
31	OUT2	O	CH2 Totem Pole Type Output
32	NC	-	
33	OUT3	O	CH3 Totem Pole Type Output
34	OUT4_2	O	CH4 Synchronous Rectifier Side Output
35	PGND	P	Output Buffer Ground
36	PVDD	P	Output Buffer Power Supply
37	OUT4_1	O	CH4 Totem Pole Type Output
38	NC	-	
39	OUT1_1	O	CH1 Totem Pole Type Output
40	OUT1_2	O	CH1 Synchronous Rectifier Side Output

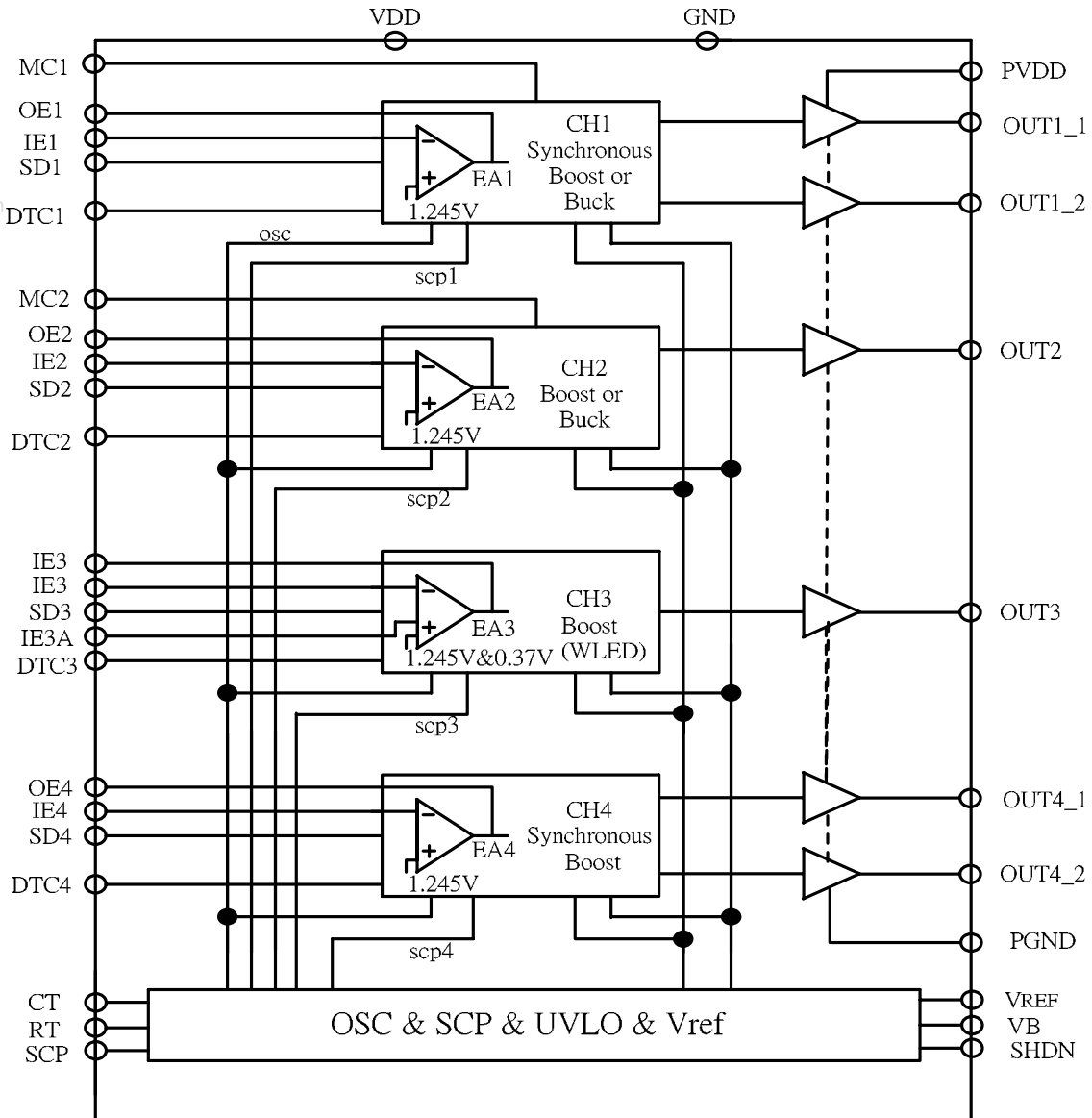


**PIN DESCRIPTION (LQFP-48)**

Pin No.	Name	I/O	Function
1	NC	-	
2	NC	-	
3	MC1	I	Boost or Buck Select for CH1
4	SD1	I	ON/OFF Control for CH1
5	SD4	I	ON/OFF Control for CH4
6	SHDN	I	Power ON/OFF Control
7	IE1	I	Inverted Input for Error Amplifier 1 (EA1)
8	IE4	I	Inverted Input for Error Amplifier 4 (EA4)
9	DTC1	I	Dead Time Control of CH1
10	OE1	O	Output for Error Amplifier 1 (EA1)
11	DTC4	I	Dead Time Control of CH4
12	NC	-	
13	OE4	O	Output for Error Amplifier 4 (EA4)
14	RT	-	External Frequency Setting Resistor
15	CT	-	External Frequency Setting Capacitor
16	NC	-	
17	VB	O	Reference Voltage 2.77V Output
18	NC	-	
19	GND	P	Ground
20	NC	-	
21	VDD	P	Power Supply
22	V <sub>REF</sub>	O	Reference Voltage 1.245V Output
23	SCP	-	Short Circuit Protection Capacitor Connection Pin
24	SD3	I	ON/OFF Control for CH3
25	NC	-	
26	SD2	I	ON/OFF Control for CH2
27	IE3A	I	Inverted Input 2 for Error Amplifier 3 (EA3)
28	IE3	I	Inverted Input for Error Amplifier 3 (EA3)
29	IE2	I	Inverted Input for Error Amplifier 2 (EA2)
30	OE3	O	Output for Error Amplifier 3 (EA3)
31	OE2	O	Output for Error Amplifier 3 (EA2)
32	DTC3	I	Dead Time Control of CH3
33	DTC2	I	Dead Time Control of CH2
34	MC2	I	Boost or Buck Select for CH2
35	NC	-	
36	NC	-	
37	OUT2	O	CH2 Totem Pole Type Output
38	NC	-	
39	OUT3	O	CH3 Totem Pole Type Output
40	NC	-	
41	OUT4_2	O	CH4 Synchronous Rectifier Side Output
42	PGND	P	Output Buffer Ground
43	NC	-	
44	PVDD	P	Output Buffer Power Supply
45	OUT4_1	O	CH4 Totem Pole Type Output
46	NC	-	
47	OUT1_1	O	CH1 Totem Pole Type Output
48	OUT1_2	O	CH1 Synchronous Rectifier Side Output



**BLOCK DIAGRAM**



**ABSOLUTE MAXIMUM RATINGS**

Parameter	Symbol	Value	Unit
Supply Voltage	$V_{DD}$	7	V
Input Voltage (IE-, DTC-, SD-, SHDN)	$V_I$	$V_{DD}$	V
Output Voltage	$V_O$	$V_{DD}+0.3$	V
Output Current	$I_O$	+20	mA
Output Peak Current ( $t_w$ 2 $\mu$ s, Duty 5%)	$I_{opeak}$	+200	mA
Operating Temperature Range	$T_C$	-20 to +85	
Storage Temperature Range	$T_{storage}$	-45 to +125	

**RECOMMENDED OPERATING CONDITIONS**

Parameter	Symbol	Min	Max	Unit
Startup Supply Voltage, CH4	$V_{DD}$	-	1.4	V
Supply Voltage, $V_{DD}$ (CH1~CH4)	$V_{DD}$	3.0	6.5	V
Input Voltage, (IE1~IE4)	$V_I$	0.28	1.55	V
Output Voltage	$V_O$	0	$V_{DD}$	V
Oscillator Capacitor	$C_{OSC}$	50	560	pF
Oscillator Resistor (Note 1)	$R_{OSC}$	10	80	k $\Omega$
Oscillator Frequency	$f_{OSC}$	100	800	kHz
Output Current, (CH1~CH4)	$I_O$	-	15	mA
Output Current of Error Amplifier	$I_{OE}$	-	-60	$\mu$ A
Operating Free-Air Temperature	$T_C$	-20	+85	



**ELECTRICAL CHARACTERISTICS,  $V_{DD} = 5.0V$  (UNLESS OTHERWISE SPECIFIED) (SEE NOTE 1)**

**OSCILLATOR**

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Frequency	$f_{OSC}$	$C_{OSC} = 100pF$ , $R_{OSC} = 35 k\Omega$	450	500	550	kHz
“Hi” Level Output Voltage	$V_{OSCH}$	$C_{OSC} = 100pF$ , $R_{OSC} = 35 k\Omega$	0.927	1.025	1.123	V
“Lo” Level Output Voltage	$V_{OSCL}$	$C_{OSC} = 100pF$ , $R_{OSC} = 35 k\Omega$	0.274	0.323	0.371	V
Frequency Change with $V_{DD}$	$f_{\Delta V}$	$V_{DD} = 3.0V$ to $6.5V$ , $T_C = 25^\circ C$ $C_{OSC} = 100pF$ , $R_{OSC} = 35 k\Omega$	-	1	5	%
Frequency Change with $T_C$	$f_{\Delta T}$		-	1	-	%

**UNDER VOLTAGE PROTECTION**

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Upper Threshold Voltage	$V_{UPH}$	$T_C = 25^\circ C$	2.53	2.72	2.91	V
Lower Threshold Voltage	$V_{UPL}$	$T_C = 25^\circ C$	-	2.47	-	V
Hysteresis ( $V_{UPH} - V_{UPL}$ )	$V_{HYS}$	$T_C = 25^\circ C$	-	0.25	-	V

**SHORT CIRCUIT PROTECTION CONTROL**

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Input Threshold Voltage	$V_t$	CH1,2,3,4	1.220	1.245	1.285	V
Latch Reset Voltage	$V_R$	$T_C = 25^\circ C$	-	2.47	-	V
Short-Circuit Detection Threshold Voltage	$V_{tscd}$		0.58	0.63	0.68	V
SCP Terminal Source Current	$I_{SCP}$		-3.5	-2.5	-1.5	$\mu A$

Note 1: Typical values of all parameters except for  $\frac{\Delta V_{REF}}{V_{REF}}$  (dev) and  $f_{\Delta T}$  are specified at  $T_C = 25^\circ C$ .



**ELECTRICAL CHARACTERISTICS,  $V_{DD} = 5.0V$  (UNLESS OTHERWISE SPECIFIED (SEE NOTE 1) (CONT.)**

**REFERENCE VOLTAGE**

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Reference Voltage	$V_{REF}$	$I_{REF} = -1mA, T_C = 25^\circ C$	1.227	1.245	1.263	V
Short-Circuit Output Current	$I_{OS}$	$V_{REF} = 0$	-35	-17	-8	mA
Input Voltage Regulation	$V_{RI}$	$I_{REF} = -1mA, V_{DD} = 3.0V \text{ to } 6.5V$	-10	-	10	mV
Output Regulation	$V_{RO}$	$I_{REF} = -0.1mA \text{ to } -1mA$	-10	-	10	mV
Reference Voltage Change with Temperature	$\Delta V_{REF} / V_{REF}$	$T_C = -20 \text{ to } +85$	-	0.5	-	%

**EA (ERROR AMPLIFIER)**

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Threshold Voltage	$V_{TH}$	CH1,2,4, OE=0.7V	1.227	1.245	1.263	V
	$V_{TH3}$	CH3	1.242	1.260	1.278	
	$V_{TH3A}$	CH3	0.352	0.370	0.398	
Input Bias Current	$I_{IB}$	CH1,4, $V_I = 0.28V \text{ to } 1.55V$	-	$\pm 10$	$\pm 20$	nA
Input Voltage Range	$V_{IR}$	CH1,4	0.28	-	1.55	V
Open-Loop Voltage Gain	$A_{VO}$		65	83	-	dB
Unity-Gain Bandwidth	$BW_1$		-	10	-	MHz
Output Voltage Swing	$V_{OS+}$		1.3	-	-	V
	$V_{OS-}$		-	-	0.2	
Output Sink Current	$I_{OS+}$	OE=0.7V	2.5	5.0	-	mA
Output Source Current	$I_{OS-}$	OE=0.7V	-	-106	-60	$\mu A$





**ELECTRICAL CHARACTERISTICS,  $V_{DD} = 5.0V$  (UNLESS OTHERWISE SPECIFIED) (SEE NOTE 1) (CONT.)**

**DEAD-TIME CONTROL**

Parameter		Test Condition	Min	Typ	Max	Unit
Input Bias Current (DTC1~DTC4)	$I_{BDTC}$	$V_{DTC} = 0.2V$ to $1.3V$	-	-	200	nA
Input Threshold Voltage (DTC1,2,3)	$V_{d0}$	Duty = 0%, $f_{OSC} = 500kHz$	0.323	0.423	-	V
	$V_{d100}$	Duty = 100%, $f_{OSC} = 500kHz$	-	1.125	1.225	
Input Threshold Voltage (DTC4)	$V_{4d0}$	Duty = 0%, $f_{OSC} = 500kHz$	0.223	0.323	-	V
	$V_{4d100}$	Duty = 100%, $f_{OSC} = 500kHz$	-	1.025	1.125	

**OUTPUT STAGE**

Parameter		Test Condition	Min	Typ	Max	Unit
Output ON Resistor	$R_{OH}$	$I_O = -15mA$ (CH1~CH3)	-	18	30	$\Omega$
		$I_O = -15mA$ (CH4)	-	9	15	
	$R_{OL}$	$I_O = 15mA$ (CH1~CH3)	-	16	25	$\Omega$
		$I_O = 15mA$ (CH4)	-	9	15	

**SHUTDOWN (SD -)**

Parameter		Test Condition	Min	Typ	Max	Unit
High Level SD -	$H_{SD}$	Active Mode	1.4	-	-	V
Low Level SD -	$L_{SD}$	Stand-by Mode	-	-	0.6	V
Input Current		CH1~CH4	-	$\pm 10$	$\pm 20$	nA

**OPERATING CURRENT**

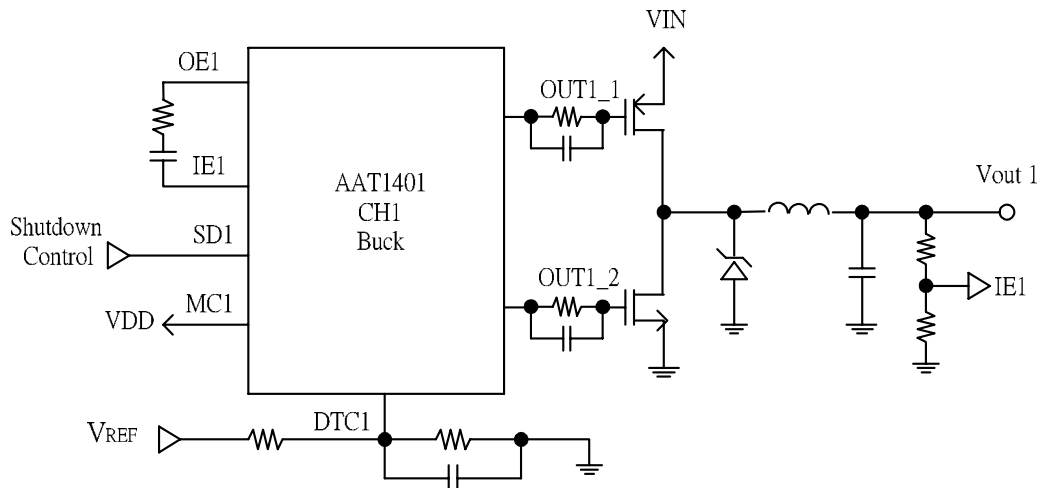
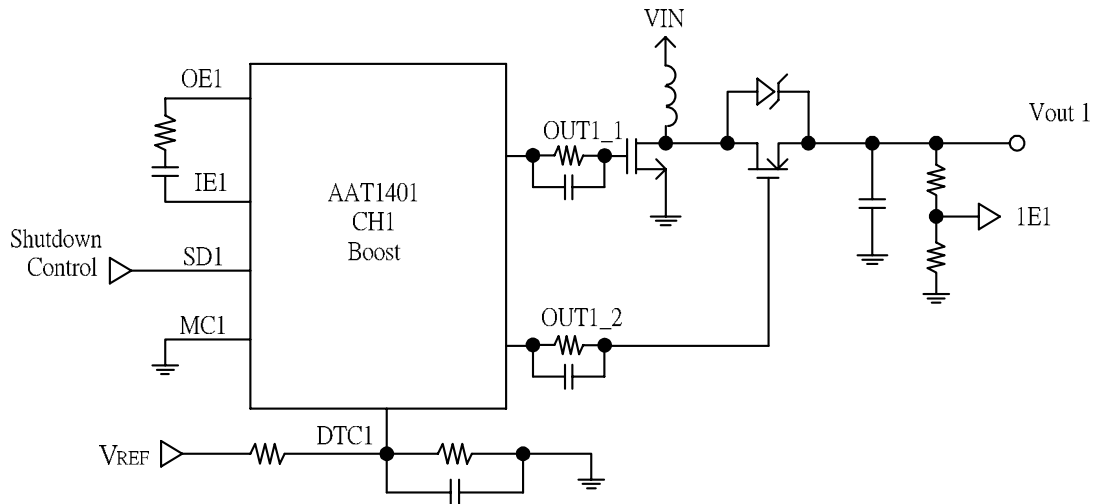
Parameter		Test Condition	Min	Typ	Max	Unit
Supply Current	$I_{DD-OFF}$	SHDN=0V	-	-	10	$\mu A$
	$I_{DD-ON}$	SHDN="Hi"; SD1~SD4="Hi"	-	4.8	7.0	mA



APPLICATION CIRCUIT

CH1 Synchronous Solution

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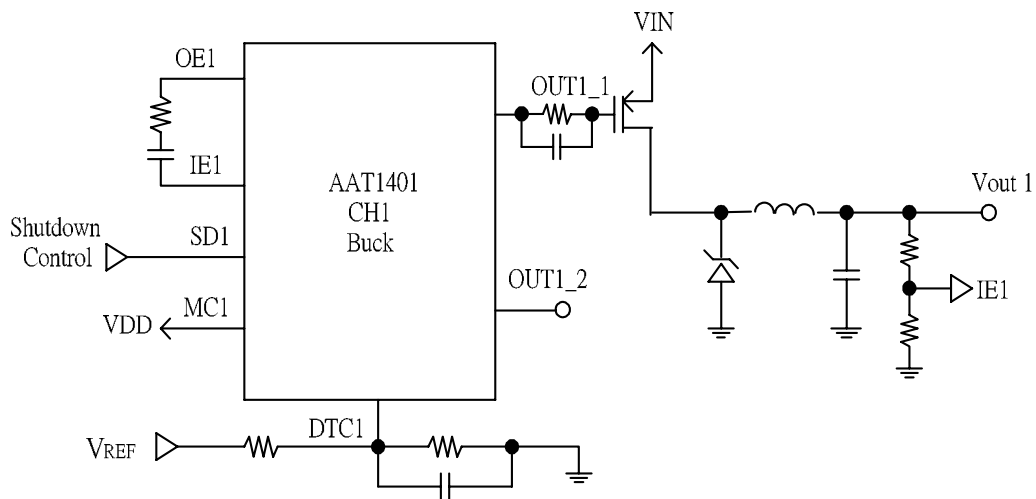
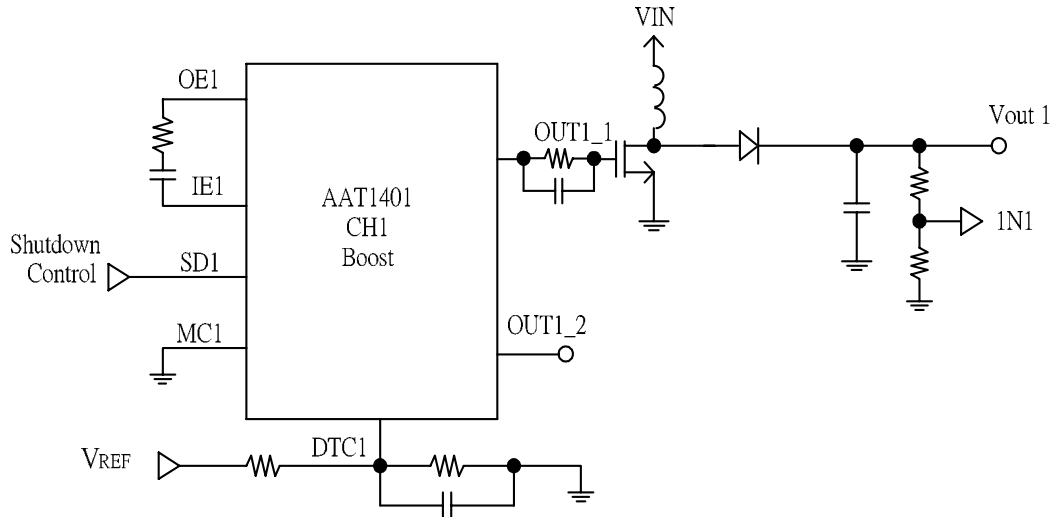




APPLICATION CIRCUIT

CH1 Non-Synchronous Solution

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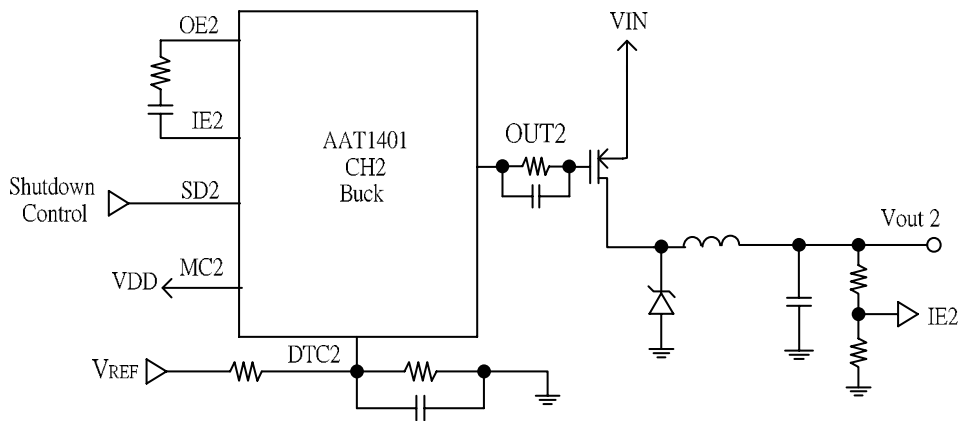
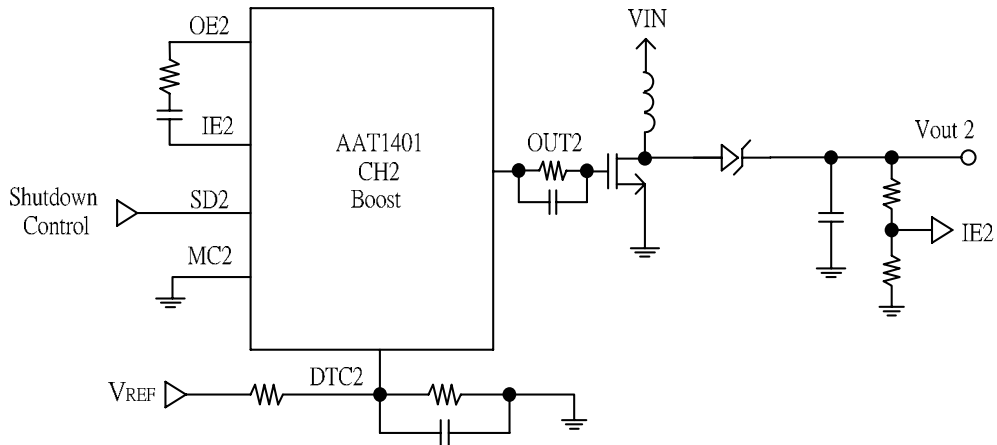




APPLICATION CIRCUIT

CH2 Solution

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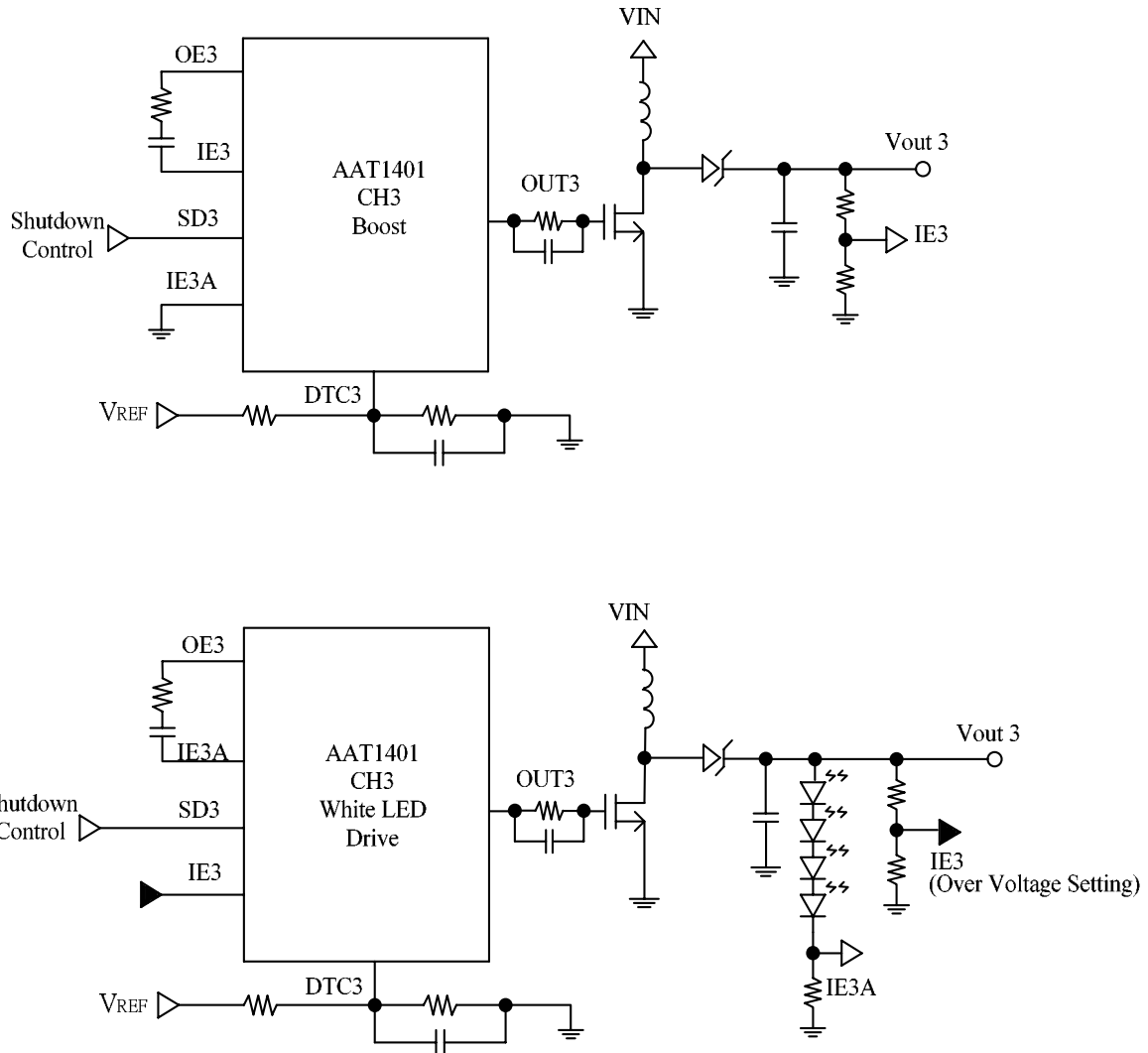




APPLICATION CIRCUIT

CH3 Solution

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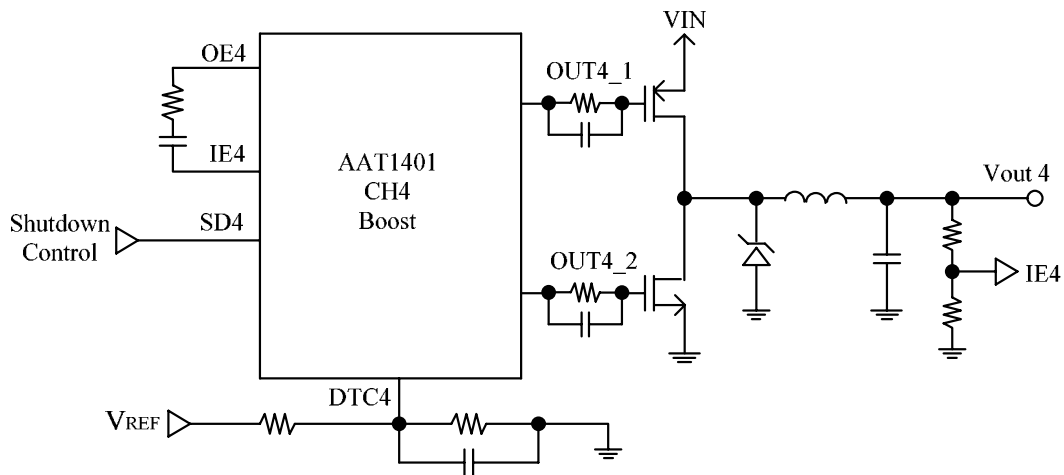




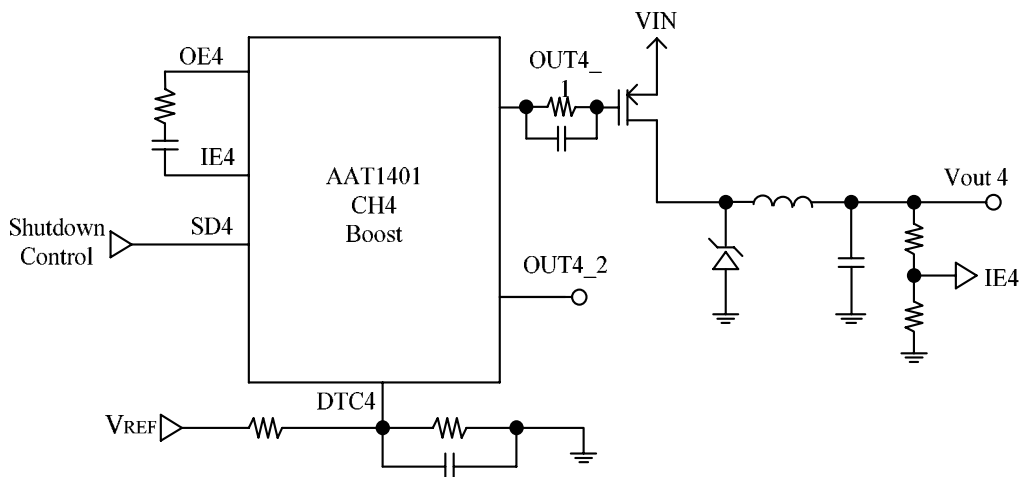
**APPLICATION CIRCUIT**

**CH4 Synchronous Solution**

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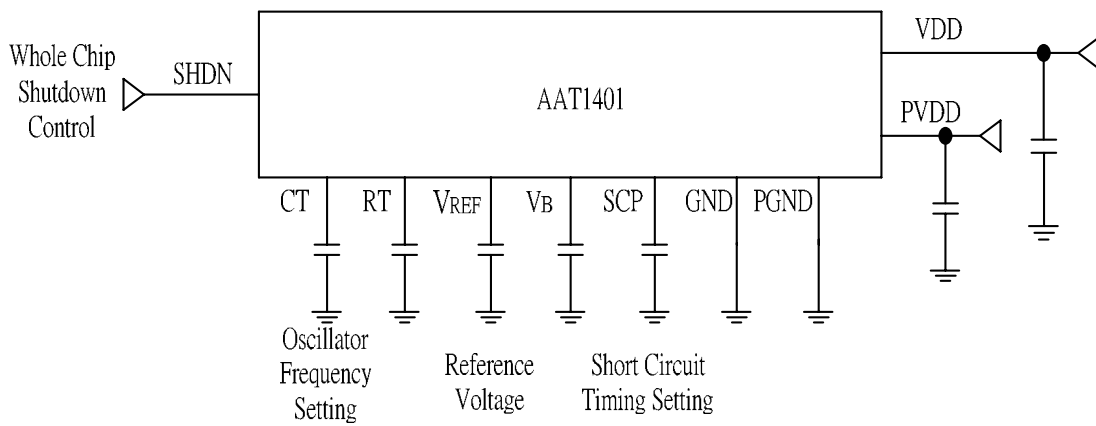
**CH4 Non-Synchronous Solution**





OPERATION CONDITION SETTING

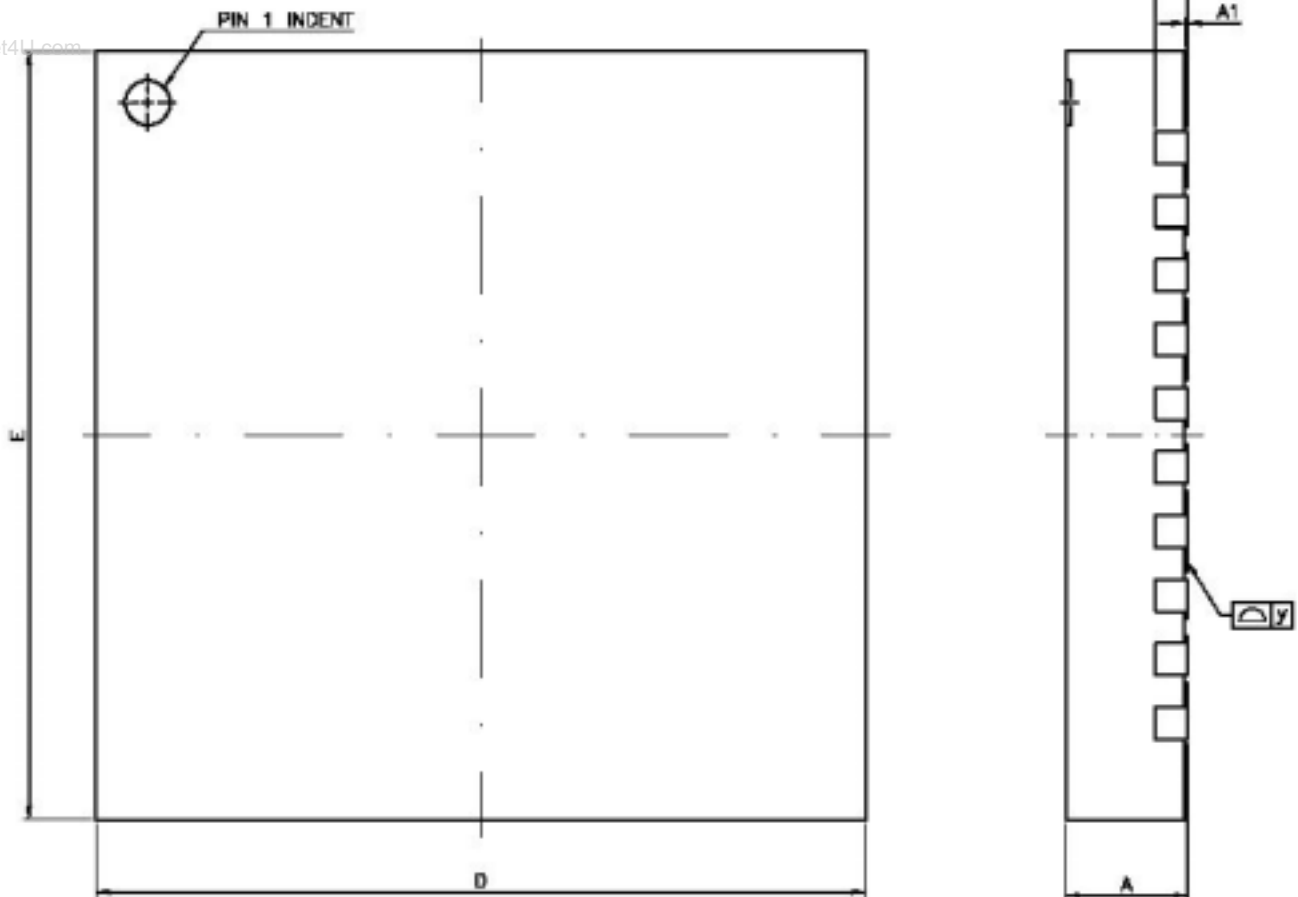
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**PACKAGE DIMENSION**

**VQFN40 PACKAGE**

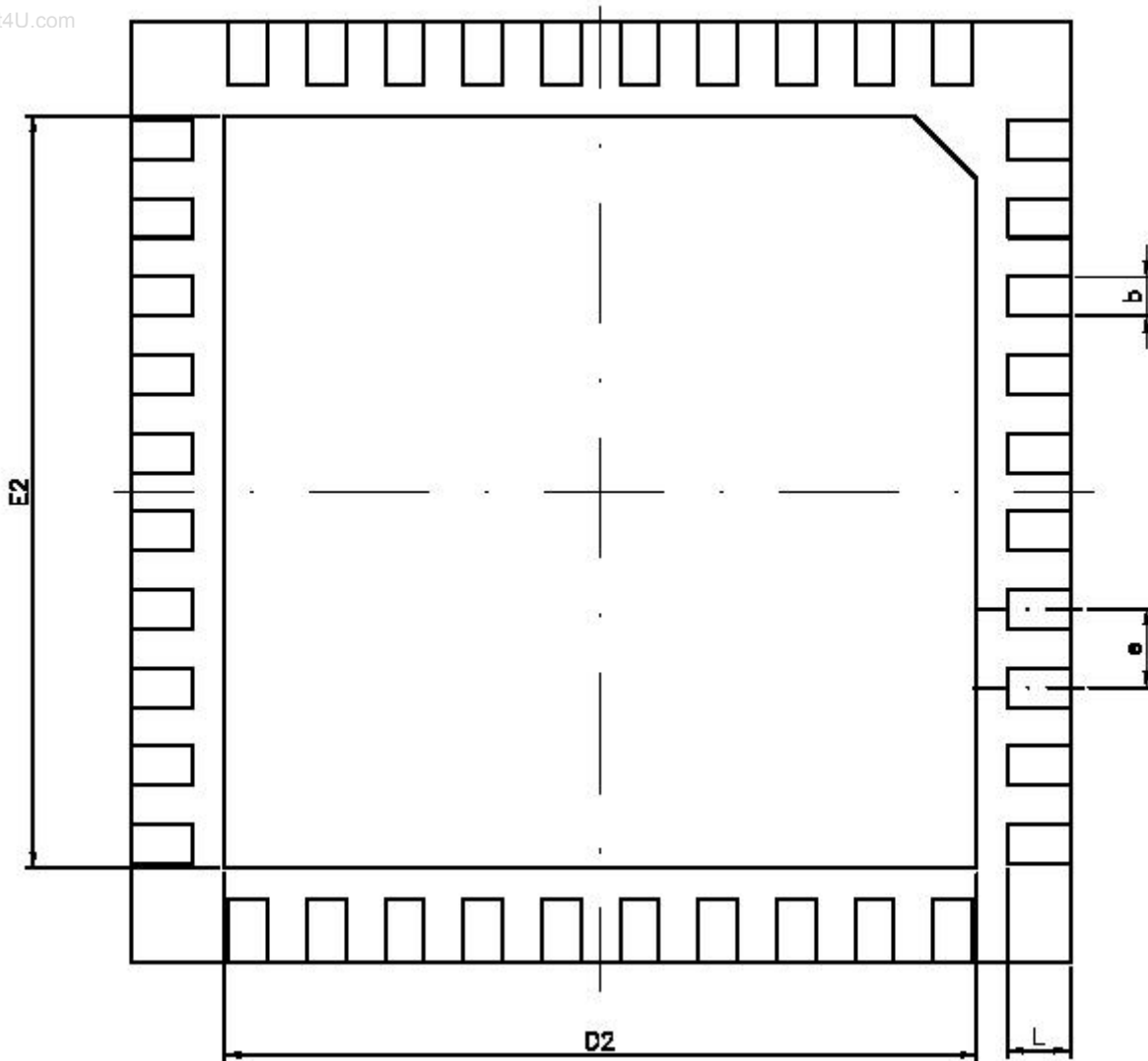






**PACKAGE DIMENSION**  
**VQFN40 PACKAGE (CONT.)**

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**PACKAGE DIMENSION (CONT.)**

**VQFN40 PACKAGE (CONT.)**

SYMBOL	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	TYP	MAX	MIN	TYP	MAX
A	0.80	0.90	1.00	0.031	0.035	0.039
A1	0.00	0.02	0.05	0	0.0008	0.0020
b	0.225	0.250	0.275	0.009	0.010	0.011
C	0.19	0.20	0.25	0.0075	0.0080	0.0100
D	5.90	6.00	6.10	0.232	0.236	0.240
D2	4.650	4.800	4.950	0.183	0.189	0.195
E	5.90	6.00	6.10	0.232	0.236	0.240
E2	4.650	4.800	4.950	0.183	0.189	0.195
e	-----	0.50	-----	-----	0.020	-----
L	0.35	0.40	0.45	0.014	0.016	0.018
y	0	-----	0.076	0	-----	0.003

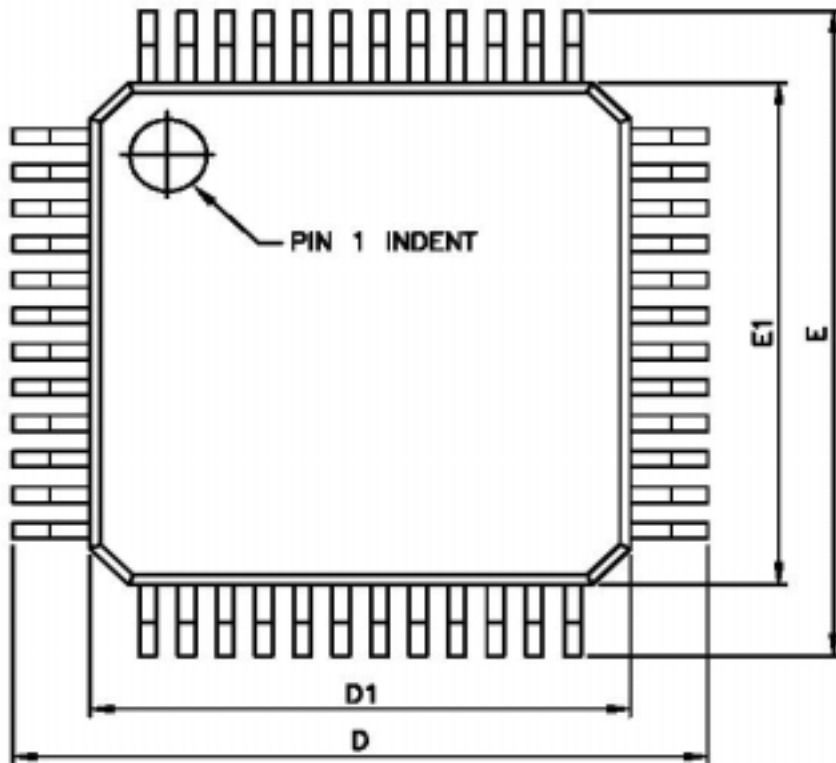
NOTE: THE TERMINAL #1 IDENTIFIER IS A LASER MARKED FEATURE.



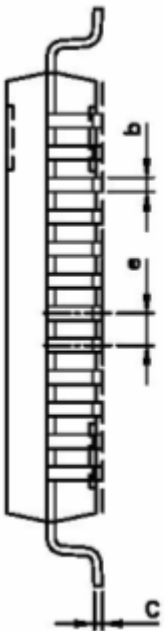
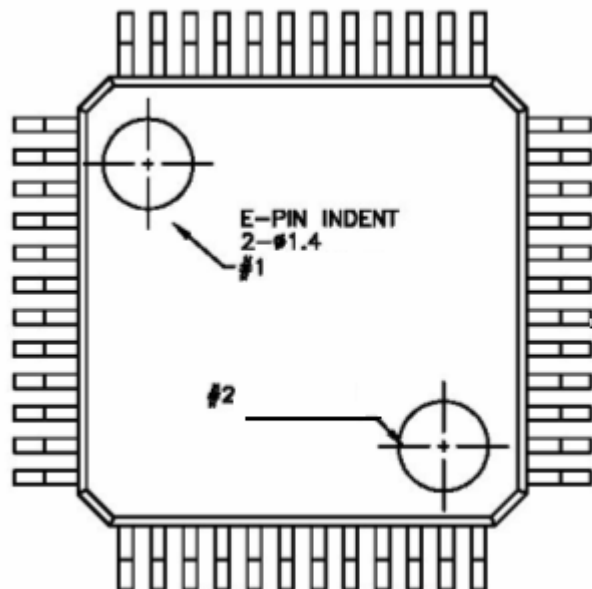
**PACKAGE DIMENSION**

**LQFP48 PACKAGE**

**TOP VIEW**



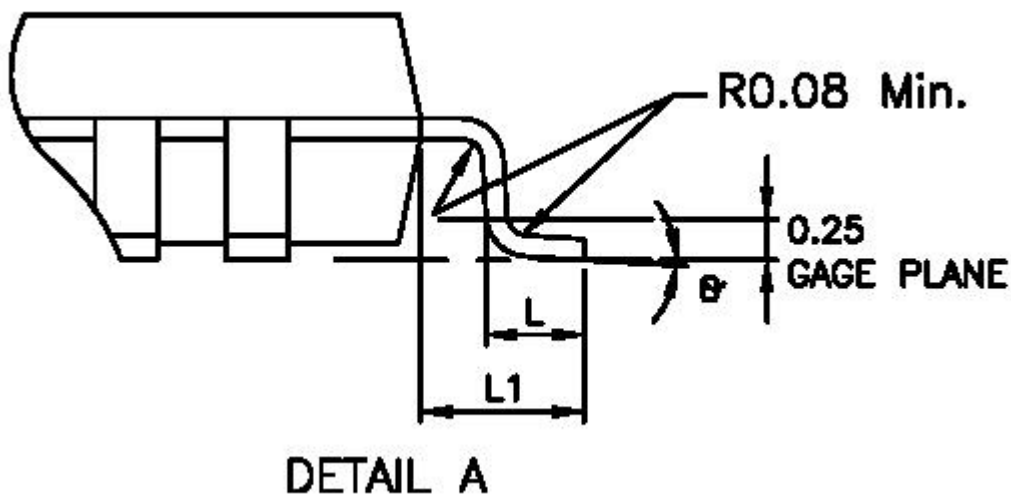
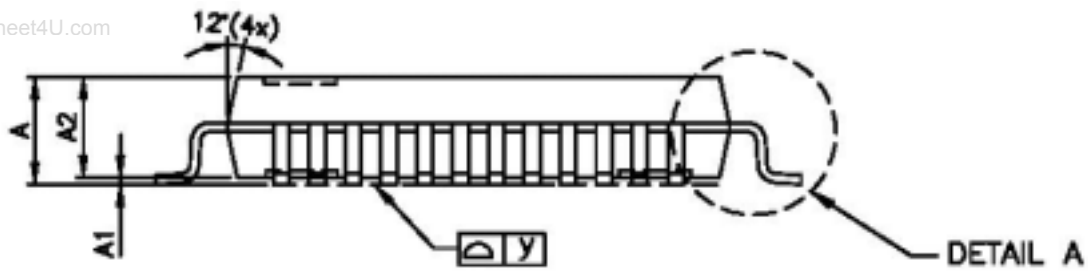
**BOTTOM VIEW**





**PACKAGE DIMENSION**  
**LQFP48 PACKAGE (CONT.)**

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**PACKAGE DIMENSION**

**LQFP48 PACKAGE (CONT.)**

SYMBOL	DIMENSION IN MILLIMETERS		
	MIN	TYP	MAX
A	-----	-----	1.60
A1	0.05	-----	0.15
A2	1.35	1.40	1.45
b	0.17	0.22	0.27
C	0.09	-----	0.20
E	8.80	9.00	9.20
E1	6.90	7.00	7.10
D	8.80	9.00	9.20
D1	6.90	7.00	7.10
e	-----	0.50	-----
L	0.45	0.60	0.75
L1	-----	1.00	-----
θ	0° C	3.5° C	7.0° C
y	0	-----	0.08