



Advanced Analog Technology, Inc.

AAT1401

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

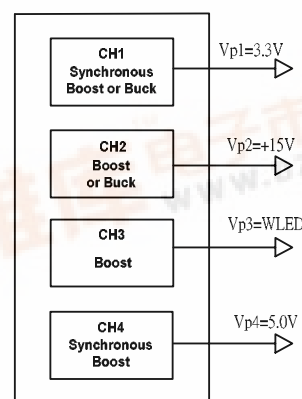
- Camcorders
- Digital Cameras
- CCD Imaging Devices

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.

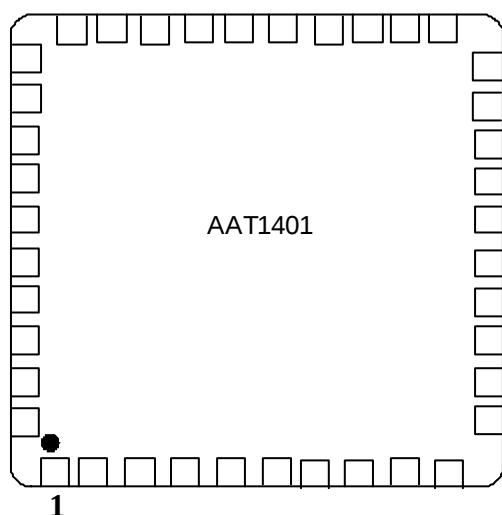
In addition to a boost conversion, AAT1401 also has two synchronous rectification systems with alternatives of a synchronous boost or buck on channel one (CH1) and a boost or buck conversion on channel two (CH2).

AAT1401

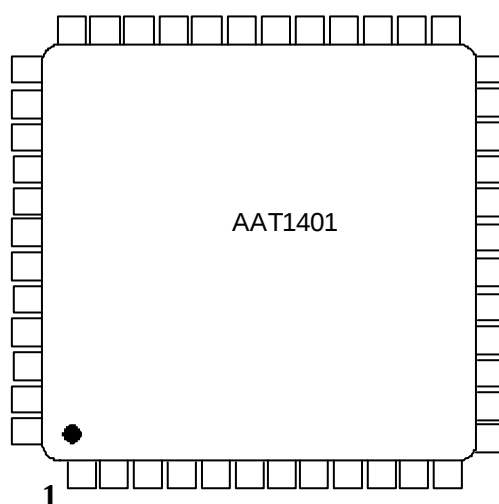




PIN CONFIGURATION



(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 _{REF}	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

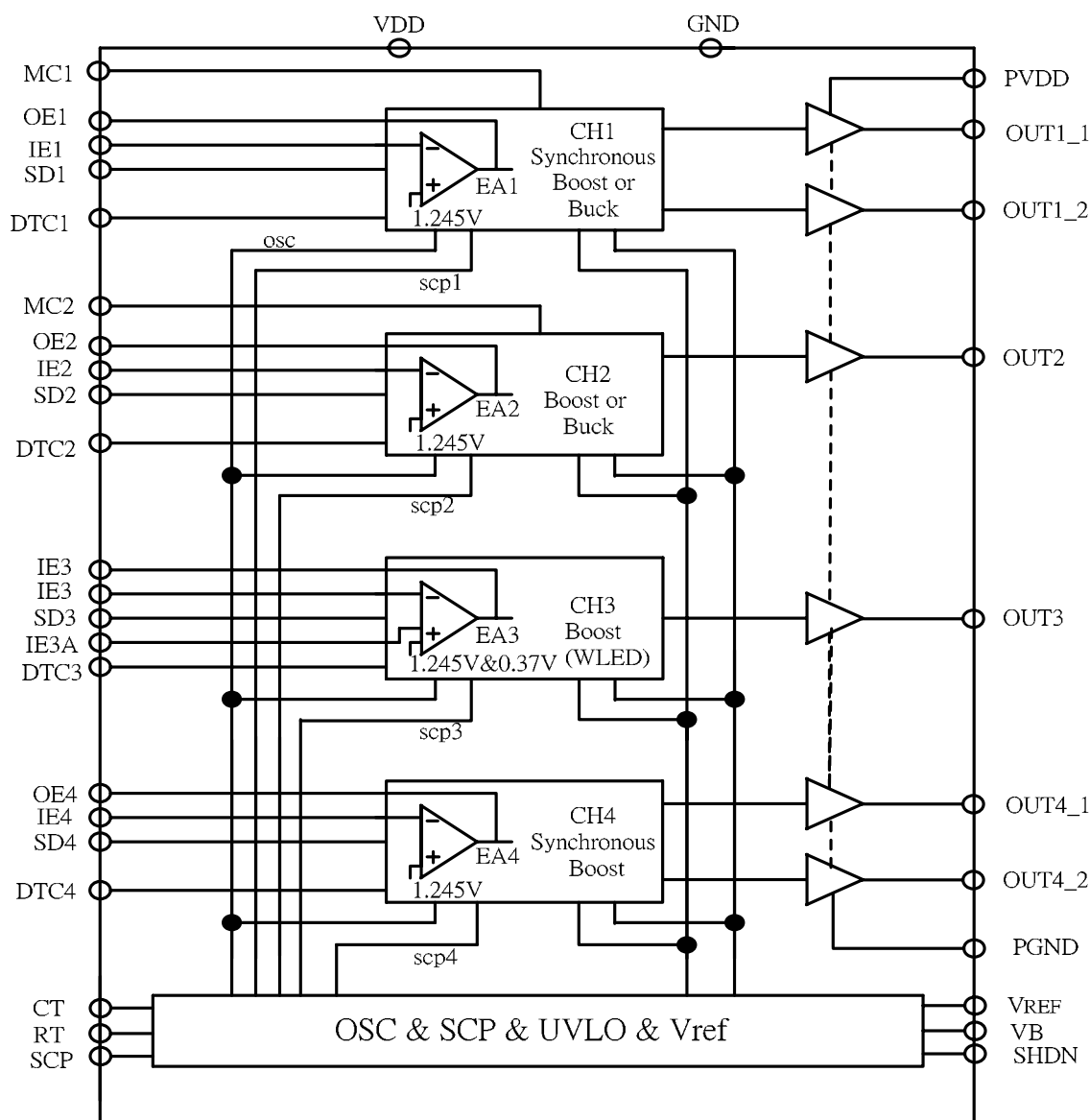


PIN DESCRIPTION (LQFP-48)

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 _{REF}	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 μ 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 Ω
Oscillator Frequency	f_{OSC}	100	800	kHz
Output Current, (CH1~CH4)	I_O	-	15	mA
Output Current of Error Amplifier	I_{OE}	-	– 60	μ 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	μA

Note 1: Typical values of all parameters except for $\Delta V_{REF}/V_{REF}$ (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}	$I_{REF} = -1mA$, $V_{DD} = 3.0V$ to $6.5V$	-10	-	10	mV
Output Regulation	V_{RO}	$I_{REF} = -0.1mA$ to $-1mA$	-10	-	10	mV
Reference Voltage Change with Temperature	$\Delta V_{REF}/V_{REF}$	$T_C = -20$ 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, $V_I = 0.28V$ to $1.55V$	-	± 10	± 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	μA



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	Ω
		$I_O = -15mA$ (CH4)	-	9	15	
	R_{OL}	$I_O = 15mA$ (CH1~CH3)	-	16	25	Ω
		$I_O = 15mA$ (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	-	± 10	± 20	nA

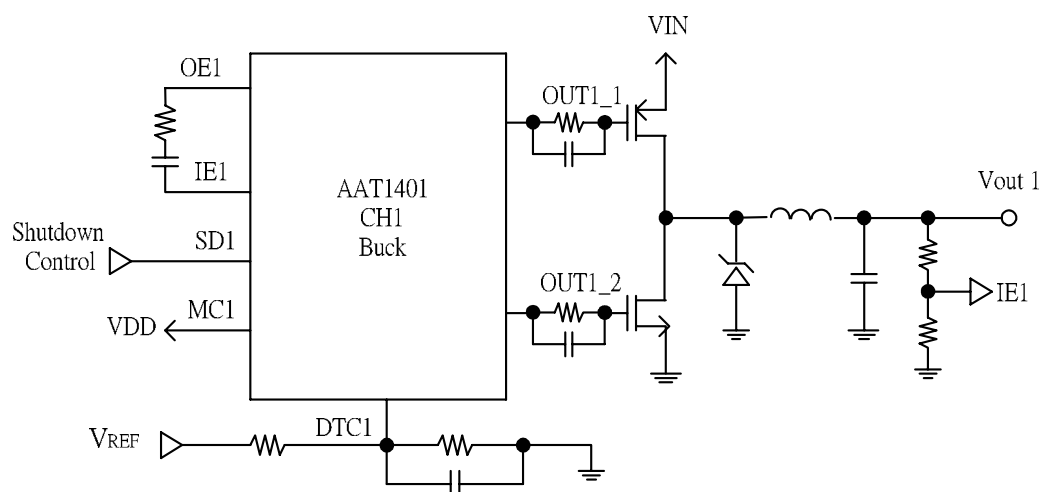
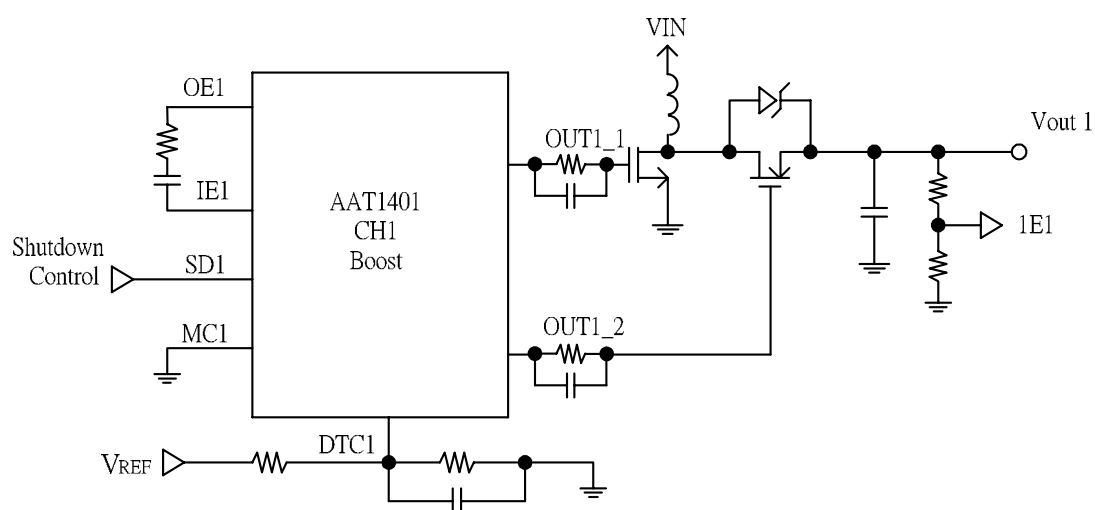
OPERATING CURRENT

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



APPLICATION CIRCUIT

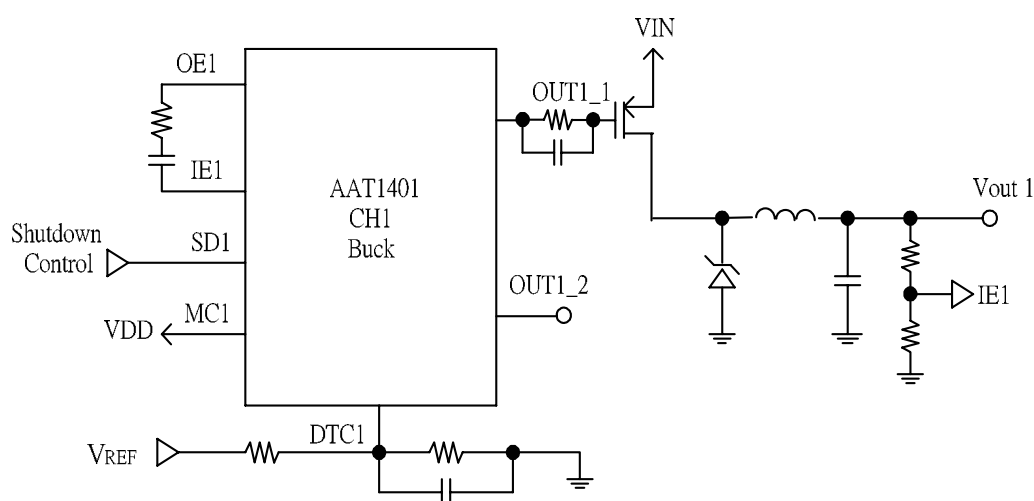
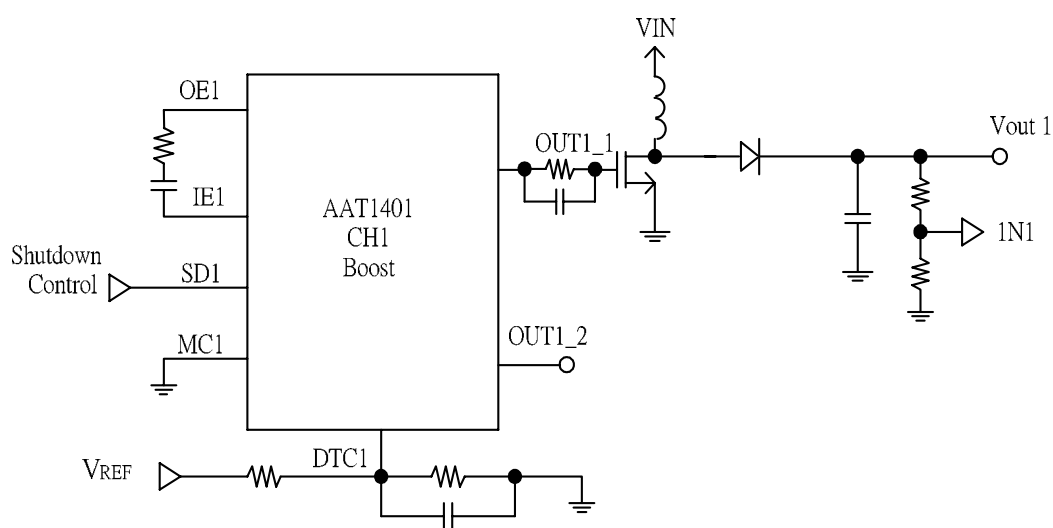
CH1 Synchronous Solution





APPLICATION CIRCUIT

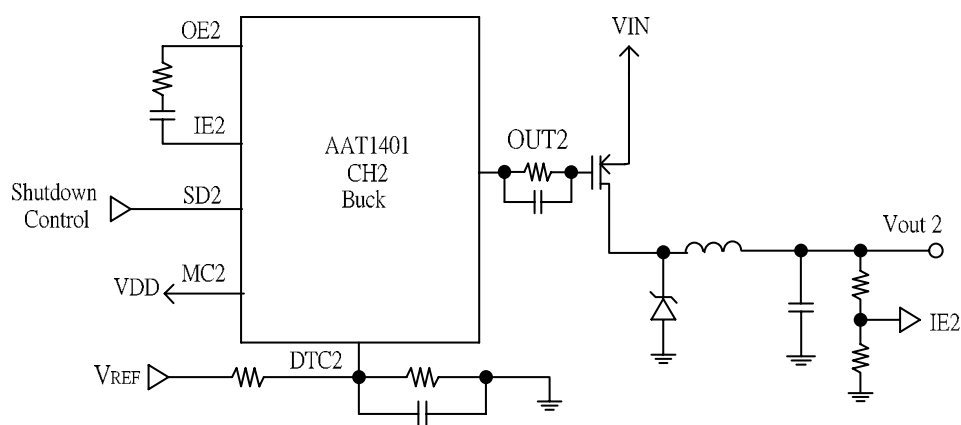
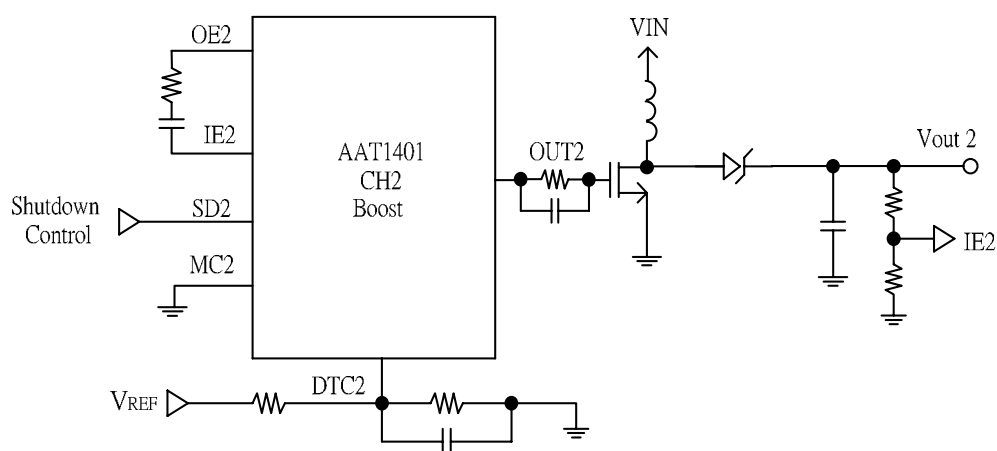
CH1 Non-Synchronous Solution





APPLICATION CIRCUIT

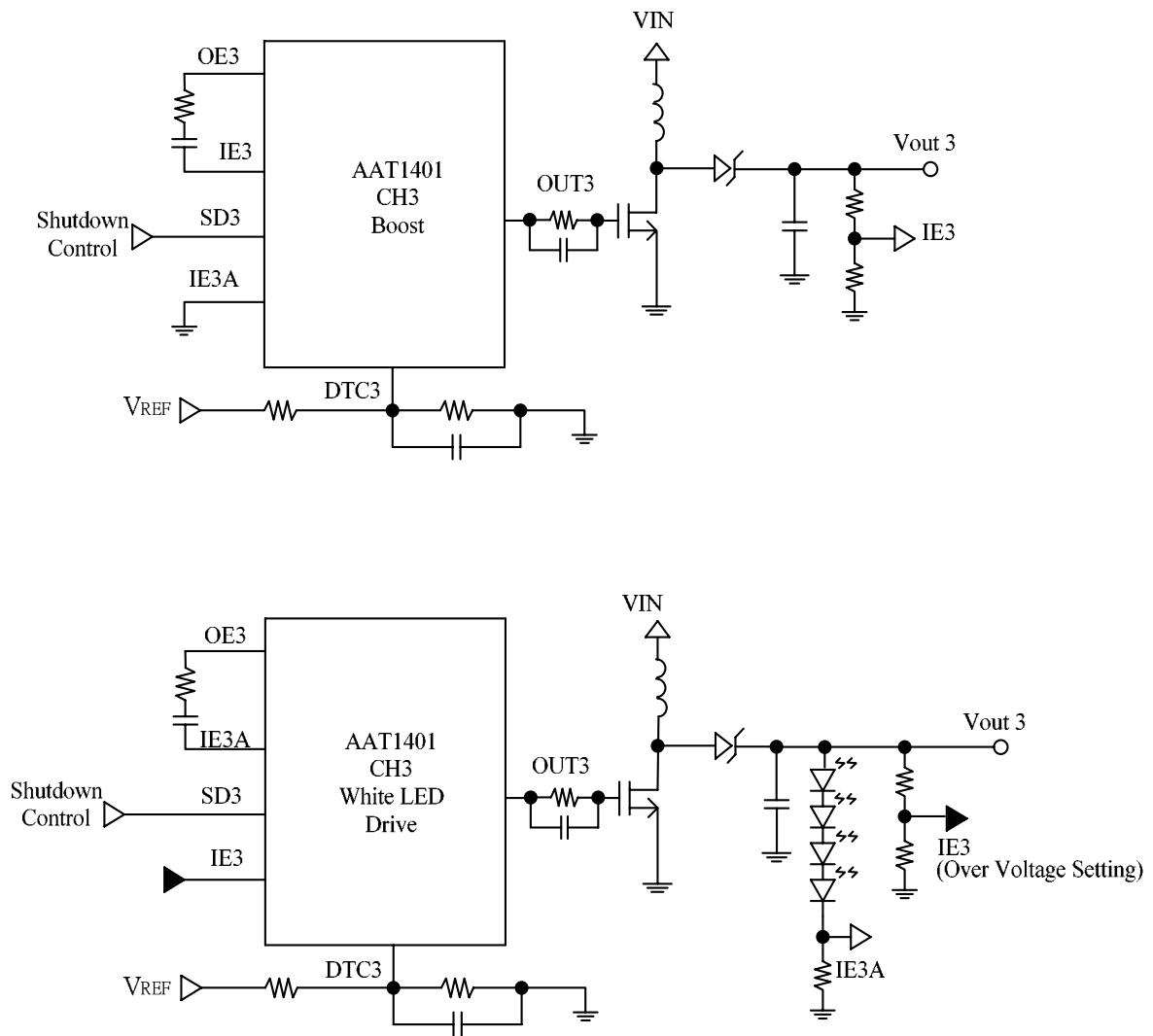
CH2 Solution





APPLICATION CIRCUIT

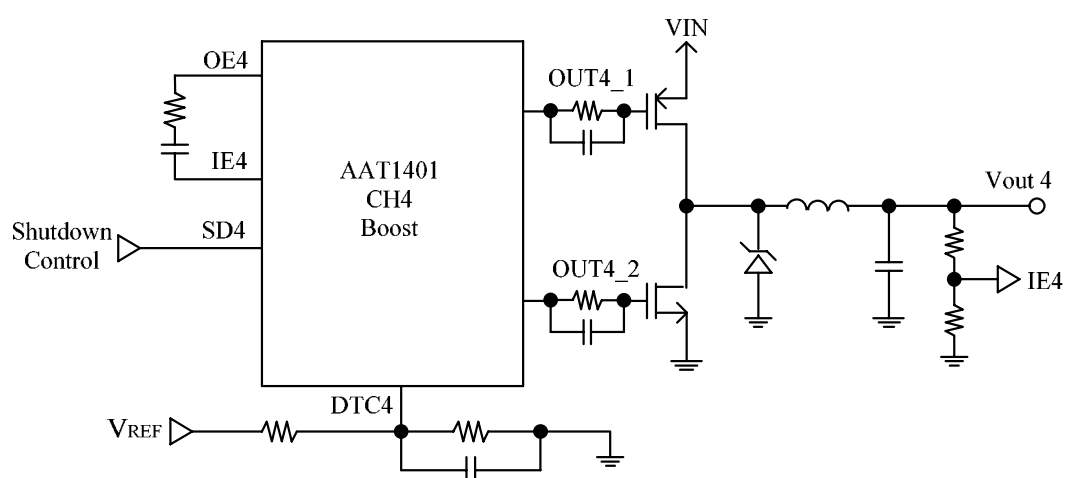
CH3 Solution



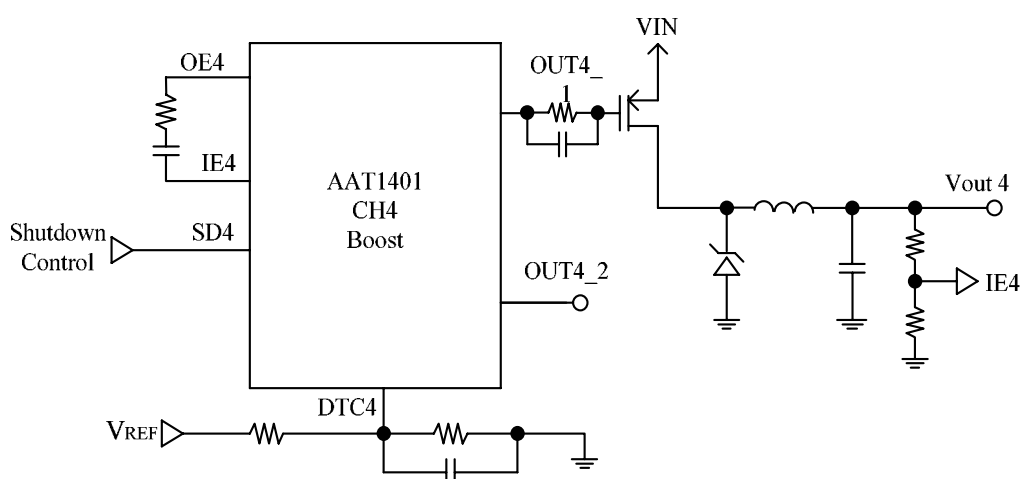


APPLICATION CIRCUIT

CH4 Synchronous Solution

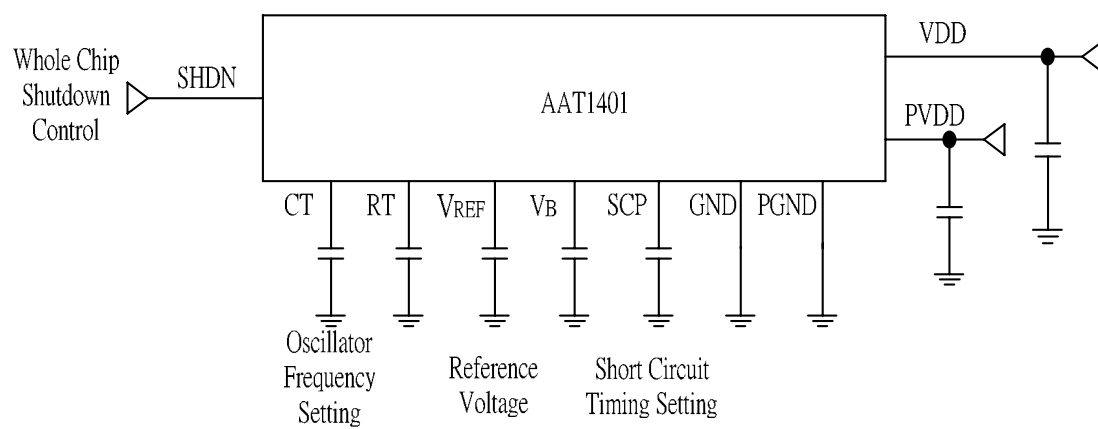


CH4 Non-Synchronous Solution





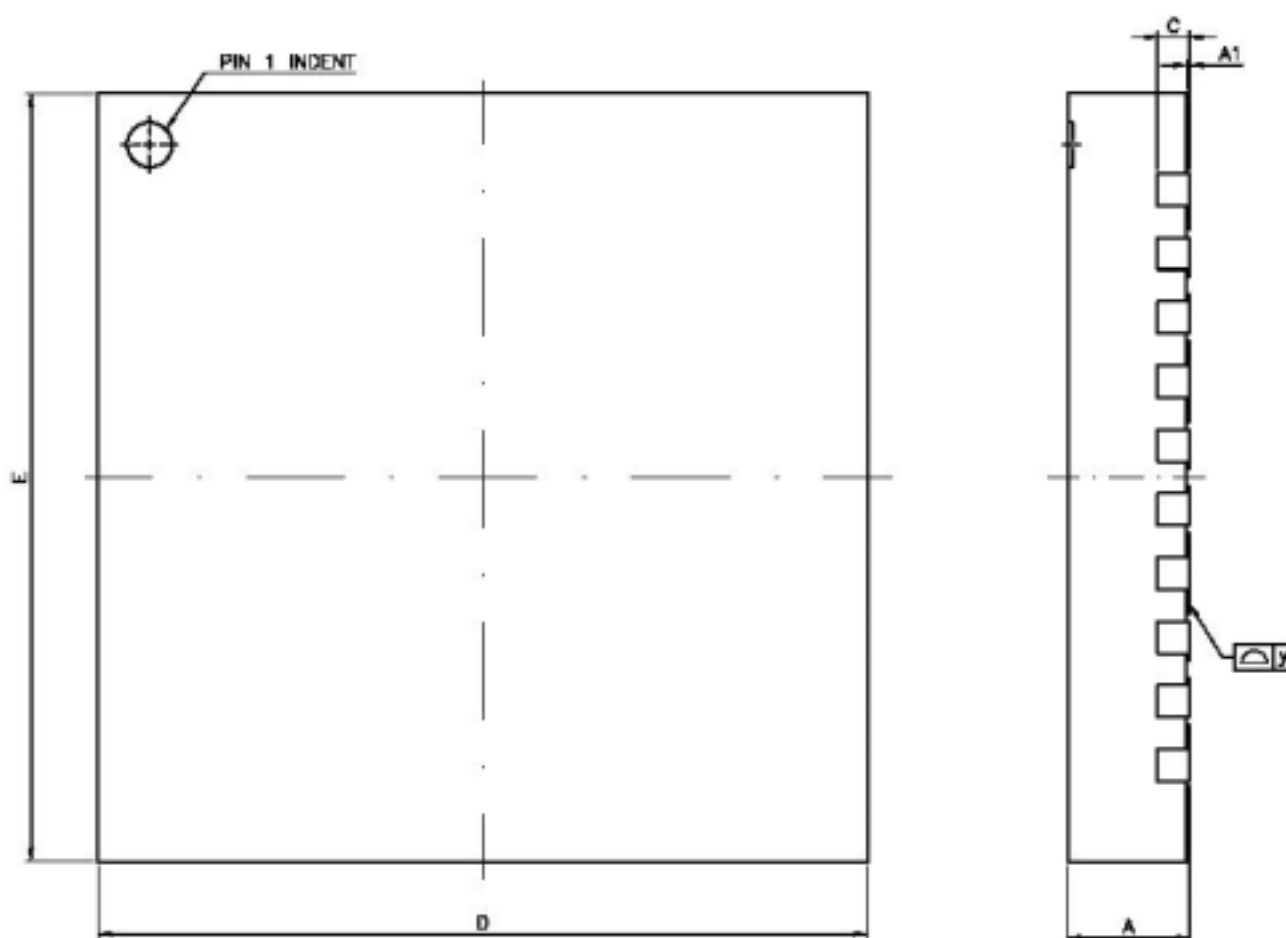
OPERATION CONDITION SETTING





PACKAGE DIMENSION

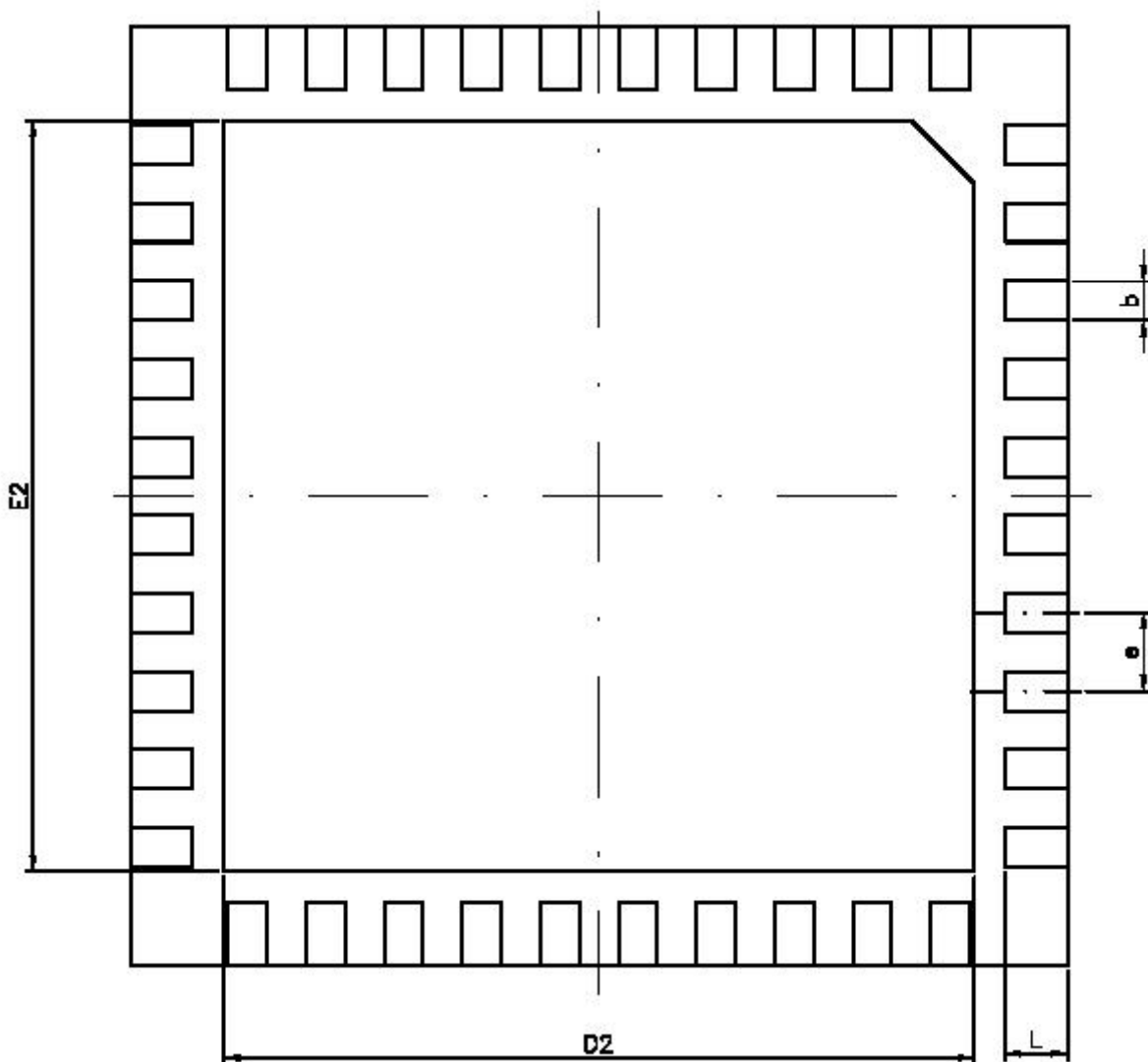
VQFN40 PACKAGE





PACKAGE DIMENSION

VQFN40 PACKAGE (CONT.)





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

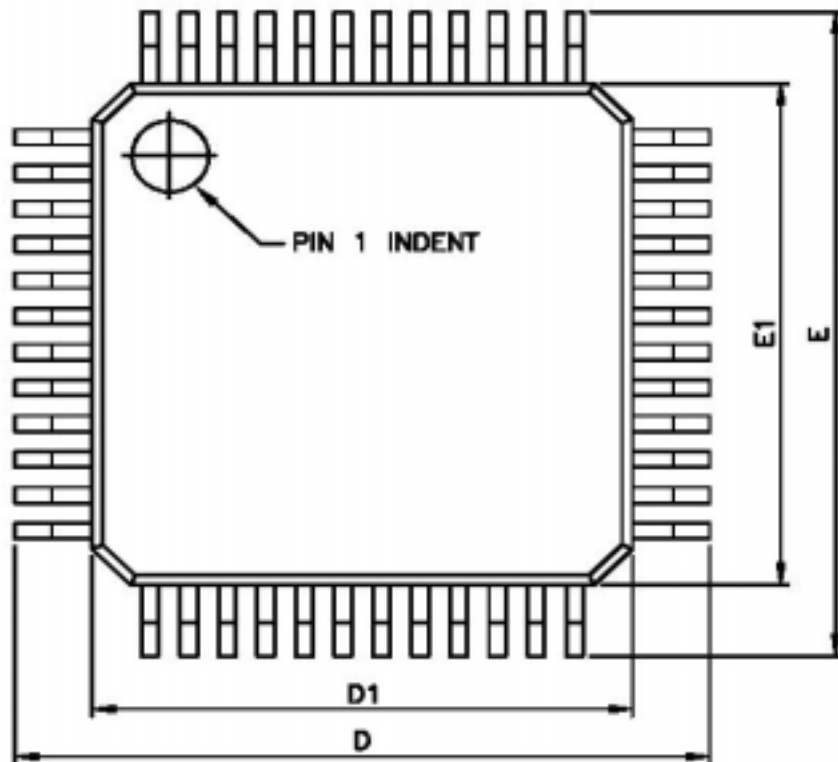
NOTE: THE TERMINAL #1 IDENTIFIER IS A LASER MARKED FEATURE.



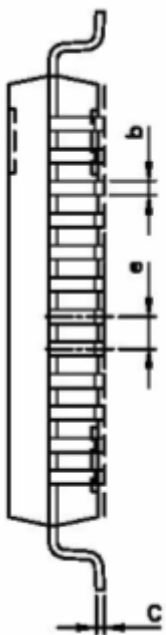
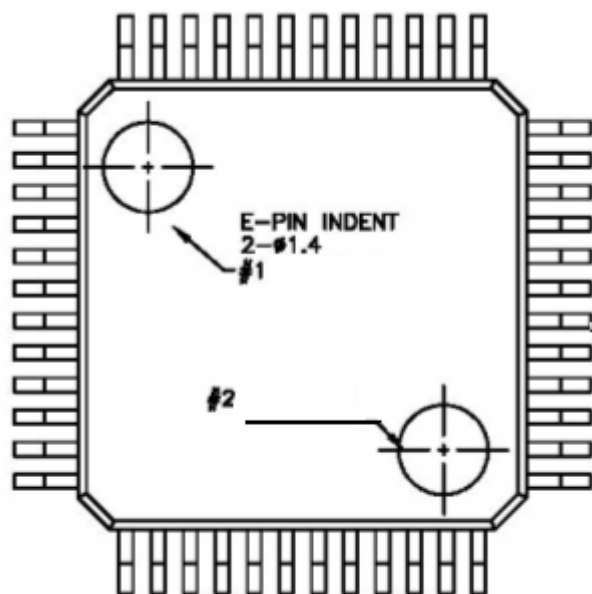
PACKAGE DIMENSION

LQFP48 PACKAGE

TOP VIEW



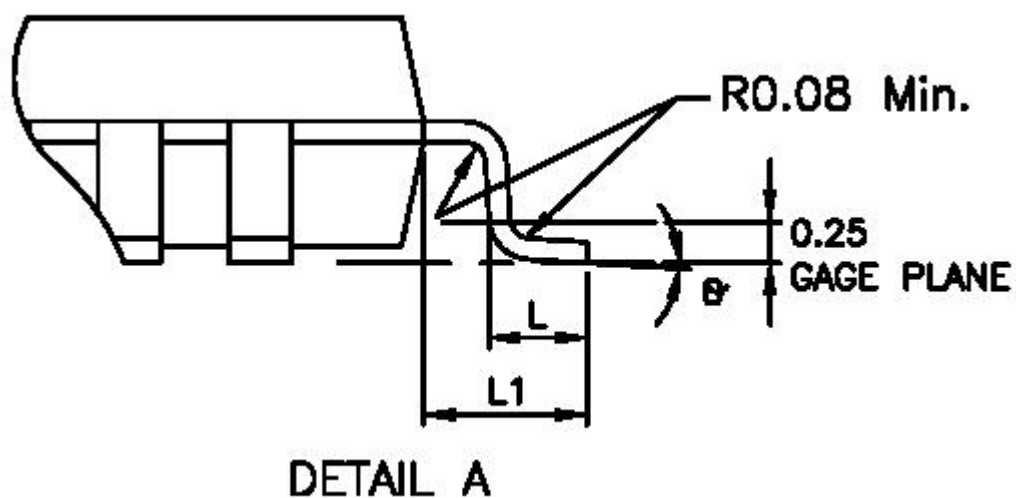
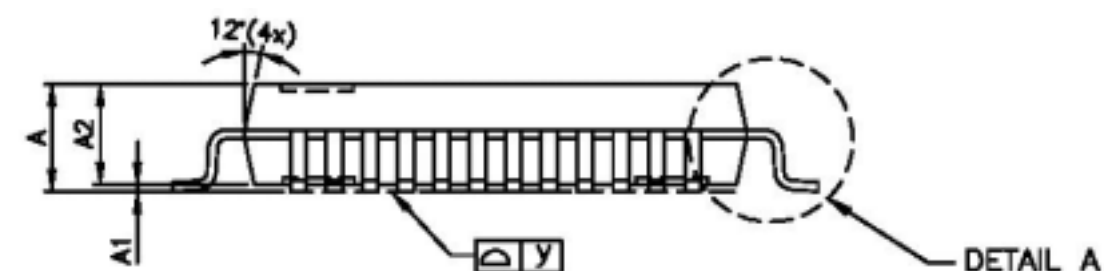
BOTTOM VIEW





PACKAGE DIMENSION

LQFP48 PACKAGE (CONT.)





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