



Details are subject to change without notice

## SIX-CHANNEL DIGITAL STILL CAMERA POWER SUPPLY

### FEATURES

- Complete PWM Power Control Circuitry
- Input Voltage Range: 1.4V to 6.5V
- Low Start-Up Voltage: 1.4V (CH6)
- Separate On/Off Control for CH1~CH6
- Supports Synchronous Boost Rectification (CH6)
- Supports Synchronous Buck Rectification (CH1, 5)
- Supports Boost Conversion (CH2, 4)
- Supports White LED Driver (CH4)
- Supports Inverting Conversion (CH3)
- Totem Pole Output
- Short Circuit Protection
- VQFN40 and LQFP48 Package
- Oscillator Frequency: 500 kHz ( $\pm 15\%$ )

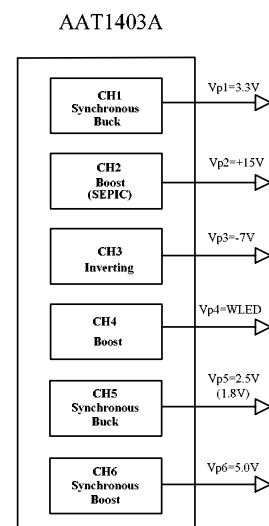
### APPLICATIONS

- Digital Cameras
- CCD Imaging Devices
- Camcorders

### GENERAL DESCRIPTION

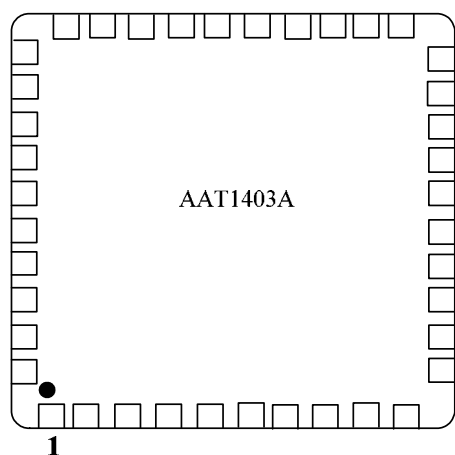
The AAT1403A provides an integrated six-channel pulse-width-modulation (PWM) solution for the power supply of DC-DC converter; this device offers system engineer flexibility to tailor-make the power supply circuitry for specific applications. Each channel contains its own error amplifier, PWM comparator, dead-time control and output driver. The under-voltage protection, oscillator, short circuit protection and voltage reference circuit are the common features for the six channels.

In addition to two boost conversions and one inverting conversion, AAT1403A also has three synchronous rectifiers.

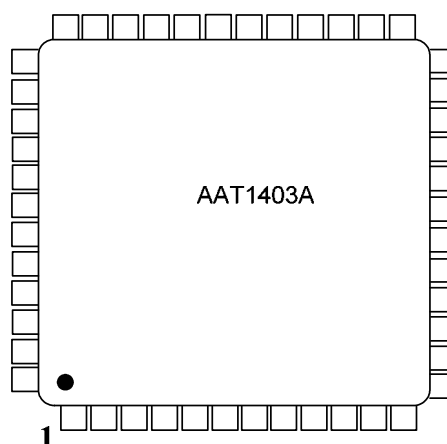




**PIN CONFIGURATION**



(VQFN-40)



(LQFP-48)

**FUNCTION TABLE**

Condition	Channel Status					
	CH1	CH2	CH3	CH4	CH5	CH6
SD –						
SD1= “Lo”	Off					
SD1= “Hi”	On					
SD2= “Lo”		Off				
SD2= “Hi”		On				
SD3= “Lo”			Off			
SD3= “Hi”			On			
SD4= “Lo”				Off		
SD4= “Hi”				On		
SD5= “Lo”					Off	
SD5= “Hi”					On	
SD6= “Lo”						Off
SD6= “Hi”						On



**PIN DESCRIPTION (VQFN-40)**

Pin No	Name	I/O	Function
1	SD1	I	ON/OFF Control for Channel 1 (CH1)
2	SD5	I	ON/OFF Control for Channel 5 (CH5)
3	SD6	I	ON/OFF Control for Channel 6 (CH6)
4	IE1	I	Inverted Input for Error Amplifier 1 (EA1)
5	IE5	I	Inverted Input for Error Amplifier 5 (EA5)
6	IE6	I	Inverted Input for Error Amplifier 6 (EA6)
7	DTC1	I	Dead Time Control of Channel 1 (CH1)
8	OE1	O	Output for Error Amplifier 1 (EA1)
9	DTC5	I	Dead Time Control of Channel 5 (CH5)
10	OE5	O	Output for Error Amplifier 5 (EA5)
11	DTC6	I	Dead Time Control of Channel 6 (CH6)
12	OE6	O	Output for Error Amplifier 6 (EA6)
13	VB	O	Reference Voltage 2.77V Output
14	GND	P	Ground
15	V <sub>DD</sub>	P	Power Supply
16	V <sub>REF</sub>	O	Reference Voltage 1.26V Output
17	SCP	-	Short Circuit Protect Capacitor Connection Pin
18	SD4	I	ON/OFF Control for Channel 4 (CH4)
19	SD3	I	ON/OFF Control for Channel 3 (CH3)
20	SD2	I	ON/OFF Control for Channel 2 (CH2)
21	IE4A	I	Inverted Input 2 for Error Amplifier 4 (EA4)
22	IE4	I	Inverted Input for Error Amplifier 4 (EA4)
23	IE3	I	Inverted Input for Error Amplifier 3 (EA3)
24	IE2	I	Inverted Input for Error Amplifier 2 (EA2)
25	OE4	O	Output for Error Amplifier 4 (EA4)
26	OE3	O	Output for Error Amplifier 3 (EA3)
27	OE2	O	Output for Error Amplifier 2 (EA2)
28	DTC4	I	Dead Time Control of Channel 4 (CH4)
29	DTC3	I	Dead Time Control of Channel 3 (CH3)
30	DTC2	I	Dead Time Control of Channel 2 (CH2)
31	OUT2	O	CH2 Totem Pole Type Output
32	OUT3	O	CH3 Totem Pole Type Output
33	OUT4	O	CH4 Totem Pole Type Output
34	OUT6_2	O	CH6 Synchronous Rectifier Side Output
35	PVDD	P	Output Buffer Power Supply
36	OUT6_1	O	CH6 Totem Pole Type Output
37	OUT5_1	O	CH5 Totem Pole Type Output
38	OUT5_2	O	CH5 Synchronous Rectifier Side Output
39	OUT1_1	O	CH1 Totem Pole Type Output
40	OUT1_2	O	CH1 Synchronous Rectifier Side Output

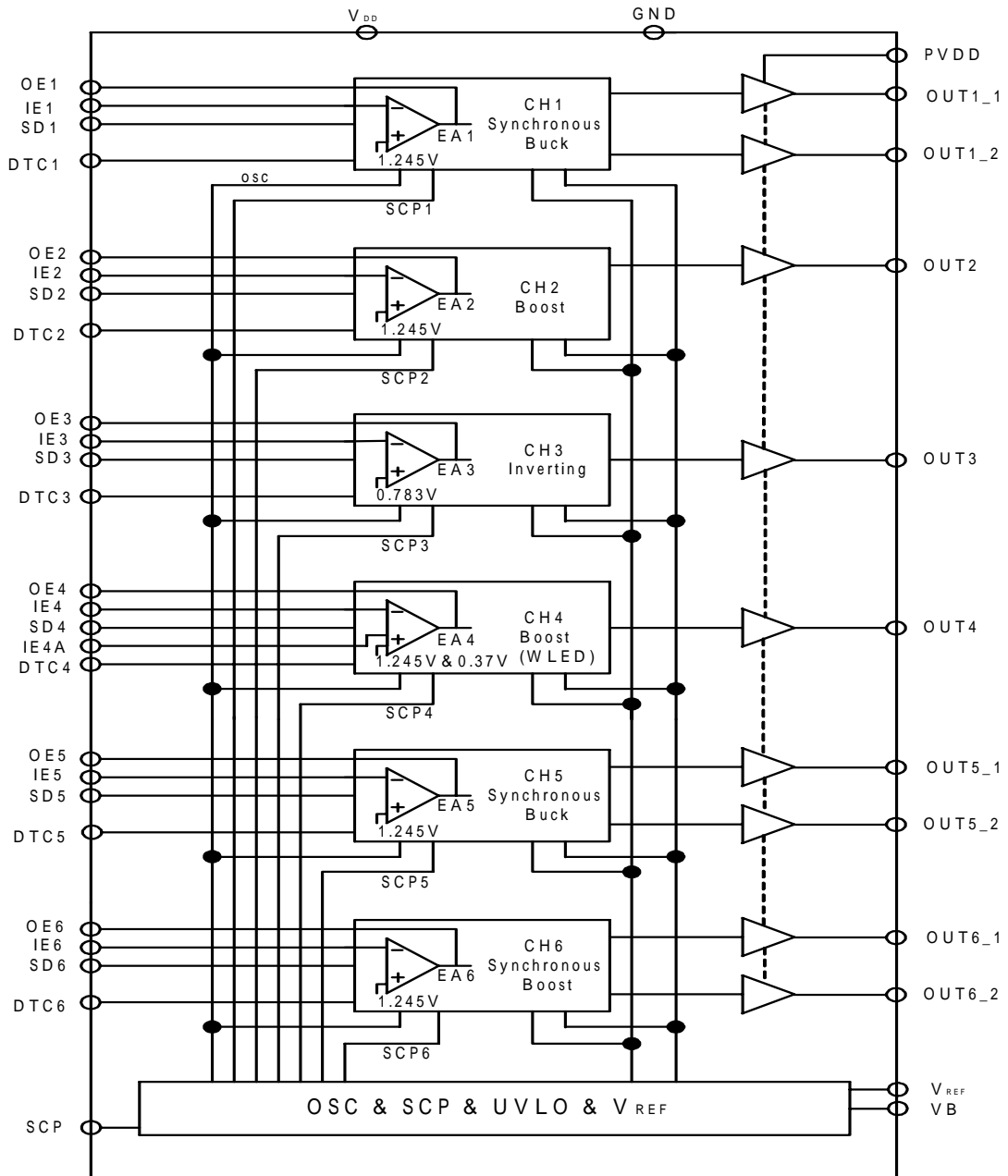


## PIN DESCRIPTION (LQFP-48)

Pin No	Name	I/O	Function
1	NC	-	
2	SD1	I	ON/OFF Control for Channel 1 (CH1)
3	SD5	I	ON/OFF Control for Channel 5 (CH5)
4	SD6	I	ON/OFF Control for Channel 6 (CH6)
5	IE1	I	Inverted Input for Error Amplifier 1 (EA1)
6	IE5	I	Inverted Input for Error Amplifier 5 (EA5)
7	IE6	I	Inverted Input for Error Amplifier 6 (EA6)
8	DTC1	I	Dead Time Control of Channel 1 (CH1)
9	OE1	O	Output for Error Amplifier 1 (EA1)
10	DTC5	I	Dead Time Control of Channel 5 (CH5)
11	OE5	O	Output for Error Amplifier 5 (EA5)
12	NC	-	
13	NC	-	
14	DTC6	I	Dead Time Control of Channel 6 (CH6)
15	OE6	O	Output for Error Amplifier 6 (EA6)
16	VB	O	Reference Voltage 2.77V Output
17	GND	P	Ground
18	V <sub>DD</sub>	P	Power Supply
19	V <sub>REF</sub>	O	Reference Voltage 1.26V Output
20	SCP	-	Short Circuit Protect Capacitor Connection Pin
21	SD4	I	ON/OFF Control for Channel 4 (CH4)
22	SD3	I	ON/OFF Control for Channel 3 (CH3)
23	SD2	I	ON/OFF Control for Channel 2 (CH2)
24	NC	-	
25	NC	-	
26	IE4A	I	Inverted Input 2 for Error Amplifier 4 (EA4)
27	IE4	I	Inverted Input for Error Amplifier 4 (EA4)
28	IE3	I	Inverted Input for Error Amplifier 3 (EA3)
29	IE2	I	Inverted Input for Error Amplifier 2 (EA2)
30	OE4	O	Output for Error Amplifier 4 (EA4)
31	OE3	O	Output for Error Amplifier 3 (EA3)
32	OE2	O	Output for Error Amplifier 2 (EA2)
33	DTC4	I	Dead Time Control of Channel 4 (CH4)
34	DTC3	I	Dead Time Control of Channel 3 (CH3)
35	DTC2	I	Dead Time Control of Channel 2 (CH2)
36	NC	-	
37	NC	-	
38	OUT2	O	CH2 Totem Pole Type Output
39	OUT3	O	CH3 Totem Pole Type Output
40	OUT4	O	CH4 Totem Pole Type Output
41	OUT6_2	O	CH6 Synchronous Rectifier Side Output
42	PVDD	P	Output Buffer Power Supply
43	OUT6_1	O	CH6 Totem Pole Type Output
44	OUT5_1	O	CH5 Totem Pole Type Output
45	OUT5_2	O	CH5 Synchronous Rectifier Side Output
46	OUT1_1	O	CH1 Totem Pole Type Output
47	OUT1_2	O	CH1 Synchronous Rectifier Side Output
48	NC	-	



**BLOCK DAIGRAM**



**ABSOLUTE MAXIMUM RATINGS**

Parameter	Symbol	Value	Unit
Supply Voltage	$V_{DD}$	7	V
Input Voltage (IE <sub>-</sub> , DTC <sub>-</sub> , SD <sub>-</sub> )	$V_I$	$V_{DD}$	V
Output Voltage	$V_O$	$V_{DD}+0.3$	V
Output Current	$I_O$	+20	mA
Output Peak Current (t <sub>w</sub> 2μs, 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, CH6	$V_{DD}$	1.4	6.5	V
Operating Voltage, $V_{DD}$ (CH1~CH6)	$V_{DD}$	3.0	6.5	V
Input Voltage, IE <sub>-</sub> , (IE1~IE6)	$V_I$	0.28	1.55	V
Output Voltage	$V_O$	0	$V_{DD}$	V
Output Current, (CH1~CH6)	$I_O$	-	15	mA
Output Current of Error Amplifier	$I_{OE}$	-	- 60	μA
Operating Free-Air Temperature	$T_C$	- 20	+ 85	



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

**UNDER VOLTAGE PROTECTION**

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

**SHORT CIRCUIT PROTECTION CONTROL**

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Input Threshold Voltage	$V_t$	CH1, 2, 4,5,6,	1.220	1.245	1.285	V
		CH3	0.28	0.33	0.38	
Latch Reset Voltage	$V_R$	$T_C = 25$	-	-	1.4	V
Short-Circuit Detect Threshold Voltage	$V_{tscd}$		0.58	0.63	0.68	V
SCP Terminal Source Current	$I_{SCP}$		-3.5	-2.5	-1.5	$\mu A$

**REFERENCE VOLTAGE**

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Reference Voltage	$V_{REF}$	$I_{REF} = -1mA, T_C = 25$	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	-	%

Note 1: Typical values of all parameters except for  $\Delta V_{REF}/V_{REF}$  is specified at  $T_C = 25$  .



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

**EA (ERROR AMPLIFIER)**

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Threshold Voltage	$V_{TH}$	CH1,2,5,6	1.227	1.245	1.263	V
	$V_{TH3}$	CH3	0.768	0.783	0.798	
	$V_{TH4}$	CH4	1.227	1.245	1.263	
	$V_{TH4A}$	CH4	0.352	0.370	0.388	
Input Bias Current	$I_{IB}$	CH1~6 $V_I = 0.28V$ to $1.55V$	-	$\pm 10$	$\pm 20$	nA
Input Voltage Range	$V_{IR}$	CH1~6	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	$\mu A$

**DEAD-TIME CONTROL**

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Input Bias Current	$I_{BDTC}$	$V_{DTC} = 0.2V$ to $1.3V$	-	-	200	nA
Input Threshold Voltage (DTC1,2,4,5)	$V_{d0}$	Duty = 0%, $f_{OSC} = 500kHz$	0.323	0.423	-	V
	$V_{d100}$	Duty = 100%, $f_{OSC} = 500kHz$	-	1.125	1.225	
Input Threshold Voltage (DTC6)	$V_{6d0}$	Duty = 0%, $f_{OSC} = 500kHz$	0.223	0.323	-	V
	$V_{6d100}$	Duty = 100%, $f_{OSC} = 500kHz$	-	1.025	1.125	
Input Threshold Voltage (DTC3)	$V_{3d0}$	Duty=0%, $f_{OSC}=500kHz$	-	1.125	1.225	V
	$V_{3d100}$	Duty=100%, $f_{OSC}=500kHz$	0.323	0.423	-	



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

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Output ON Resistor	$R_{OH}$	$I_o = -15mA$ (CH1~CH5)	-	18	30	$\Omega$
		$I_o = -15mA$ (CH6)	-	9	15	
	$R_{OL}$	$I_o = 15mA$ (CH1~CH5)	-	16	25	$\Omega$
		$I_o = 15mA$ (CH6)	-	9	15	

**SHUTDOWN (SD-)**

Parameter	Symbol	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~CH6	-	$\pm 10$	$\pm 20$	nA

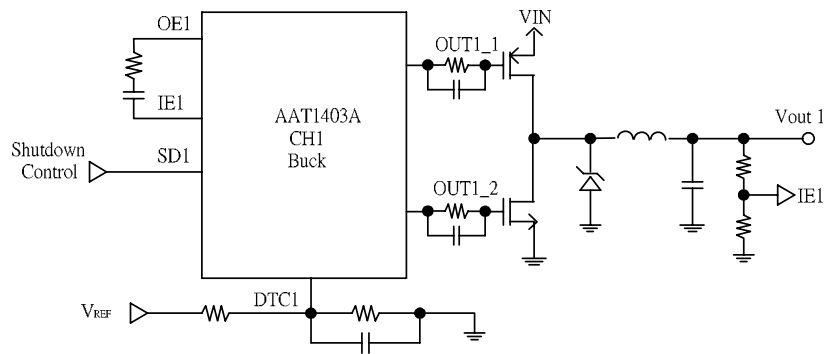
**OPERATING CURRENT**

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Supply Current	$I_{DD-OFF}$	SD1~SD6= 0V	-	-	10	$\mu A$
	$I_{DD-ON}$	SD1~SD6= "Hi"	-	4.8	7.0	mA

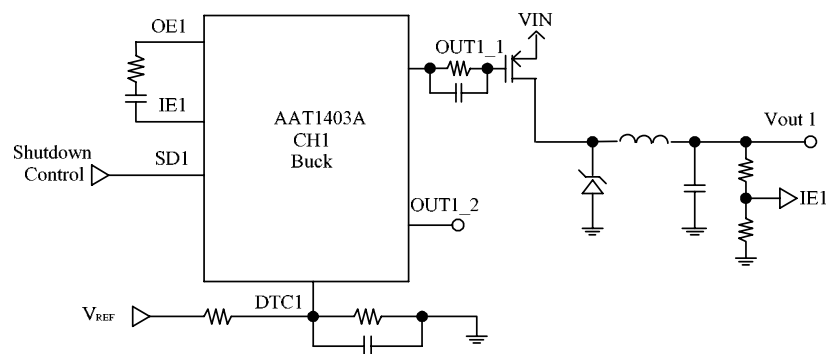


### APPLICATION CIRCUIT

#### CH1 Synchronous Solution



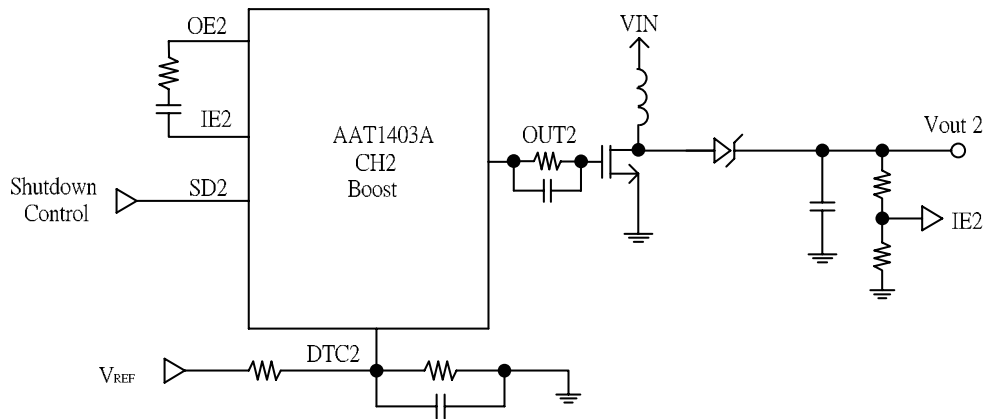
#### CH1 Non-Synchronous Solution



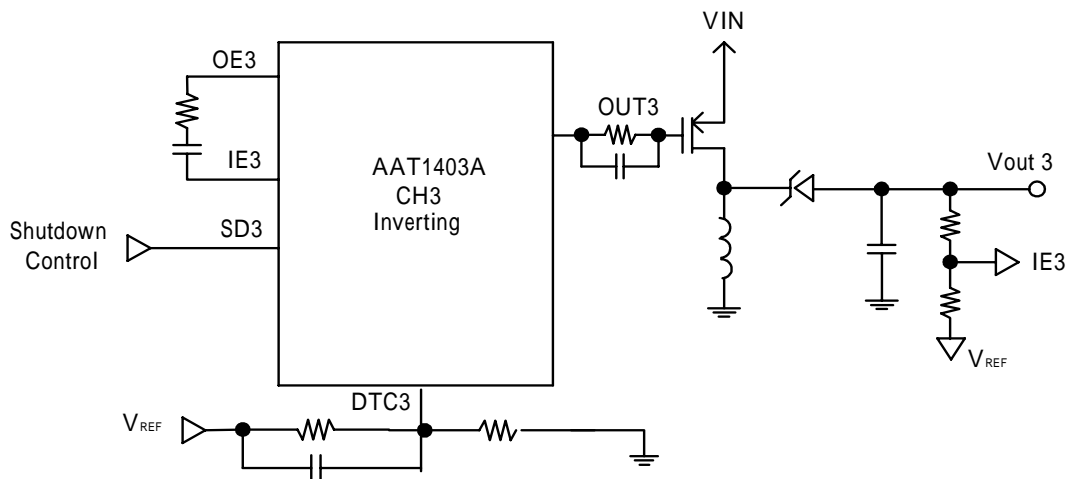


## APPLICATION CIRCUIT

### CH2 Solution



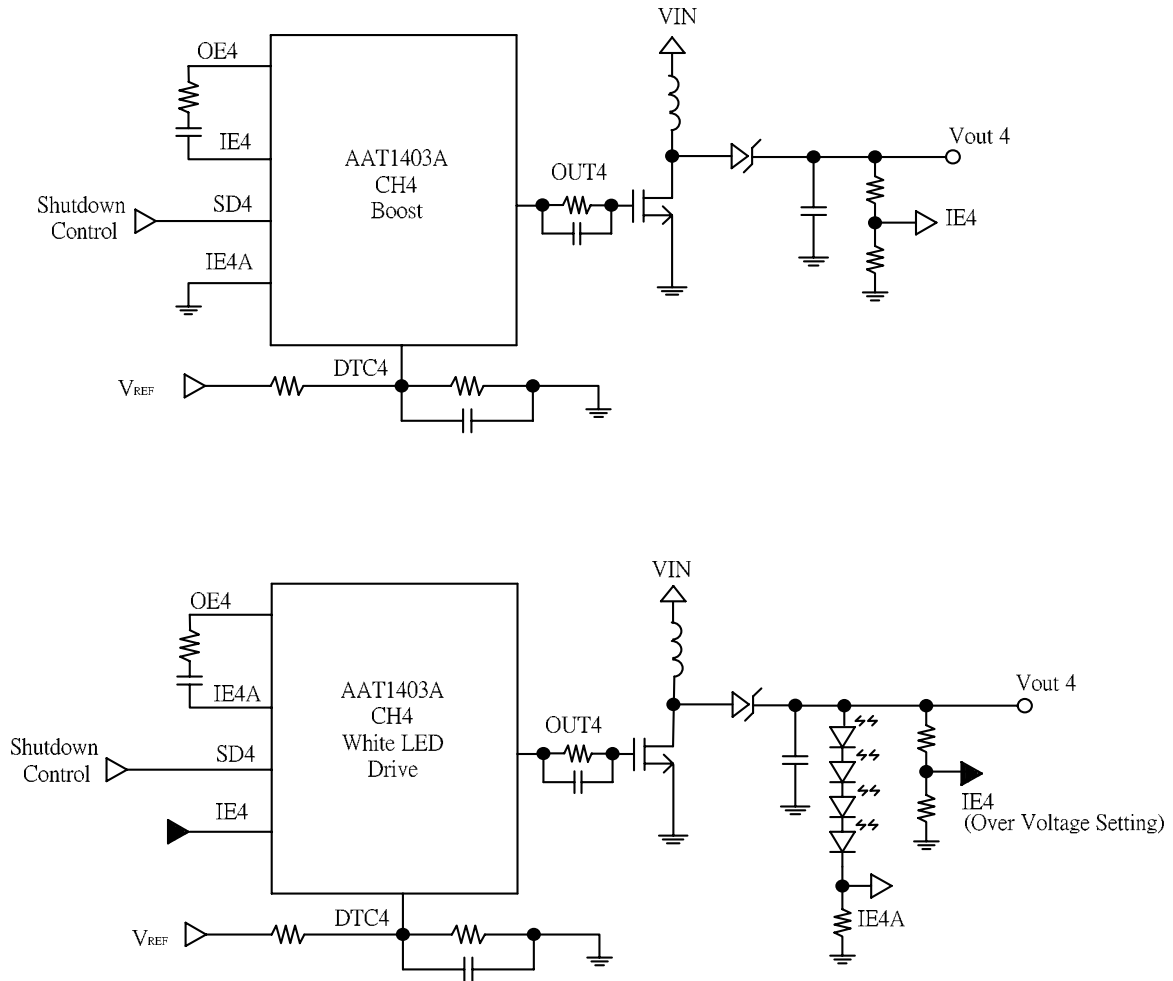
### CH3 Solution





APPLICATION CIRCUIT

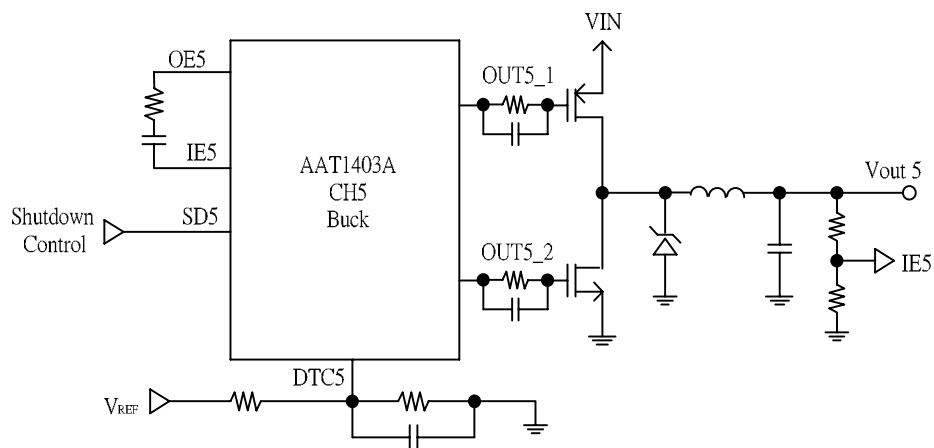
CH4 Solution



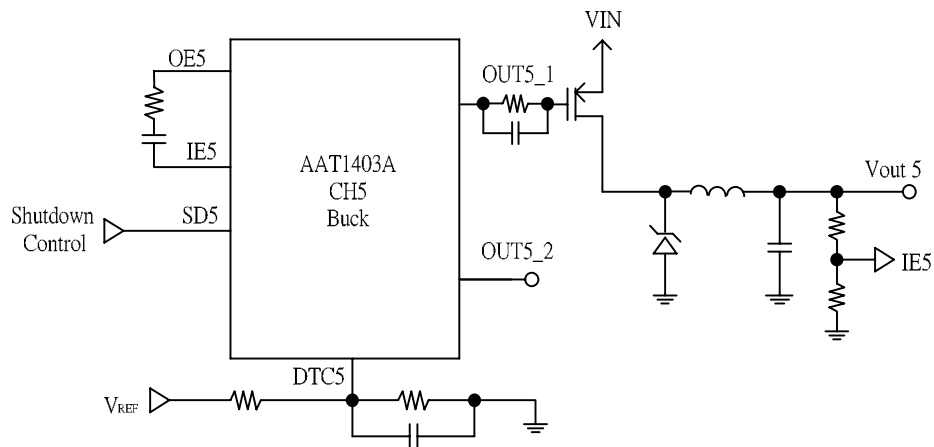


## APPLICATION CIRCUIT

### CH5 Synchronous Solution



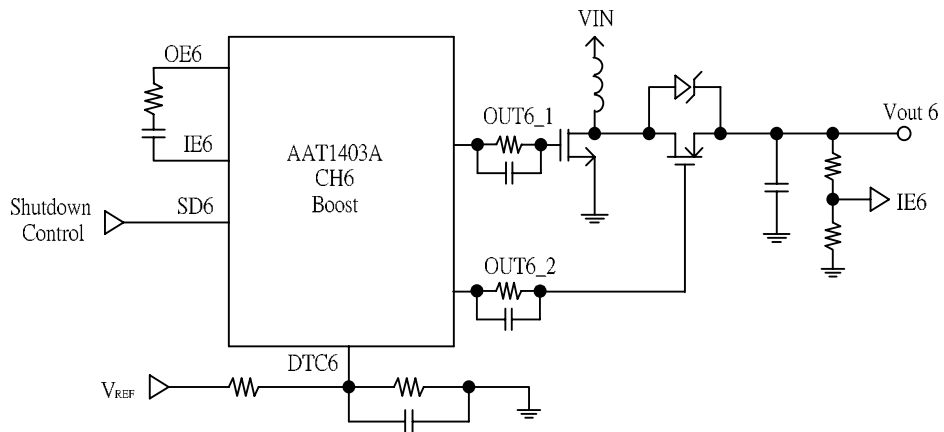
### CH5 Non-Synchronous Solution



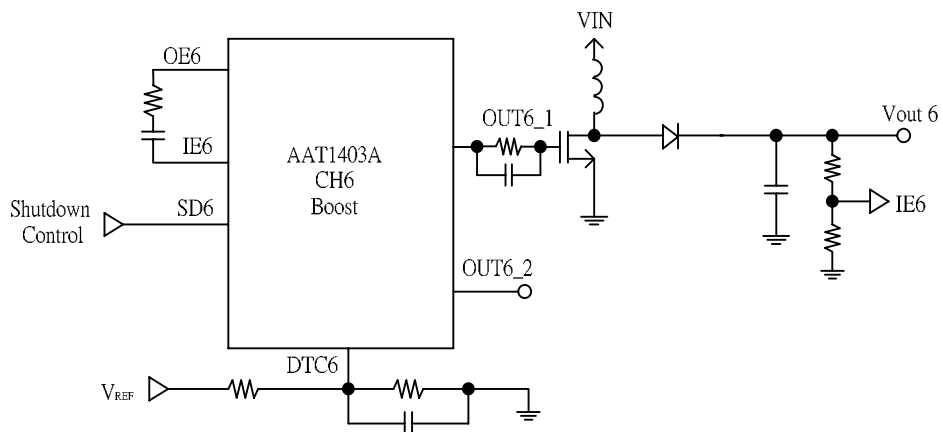


## APPLICATION CIRCUIT

### CH6 Synchronous Solution

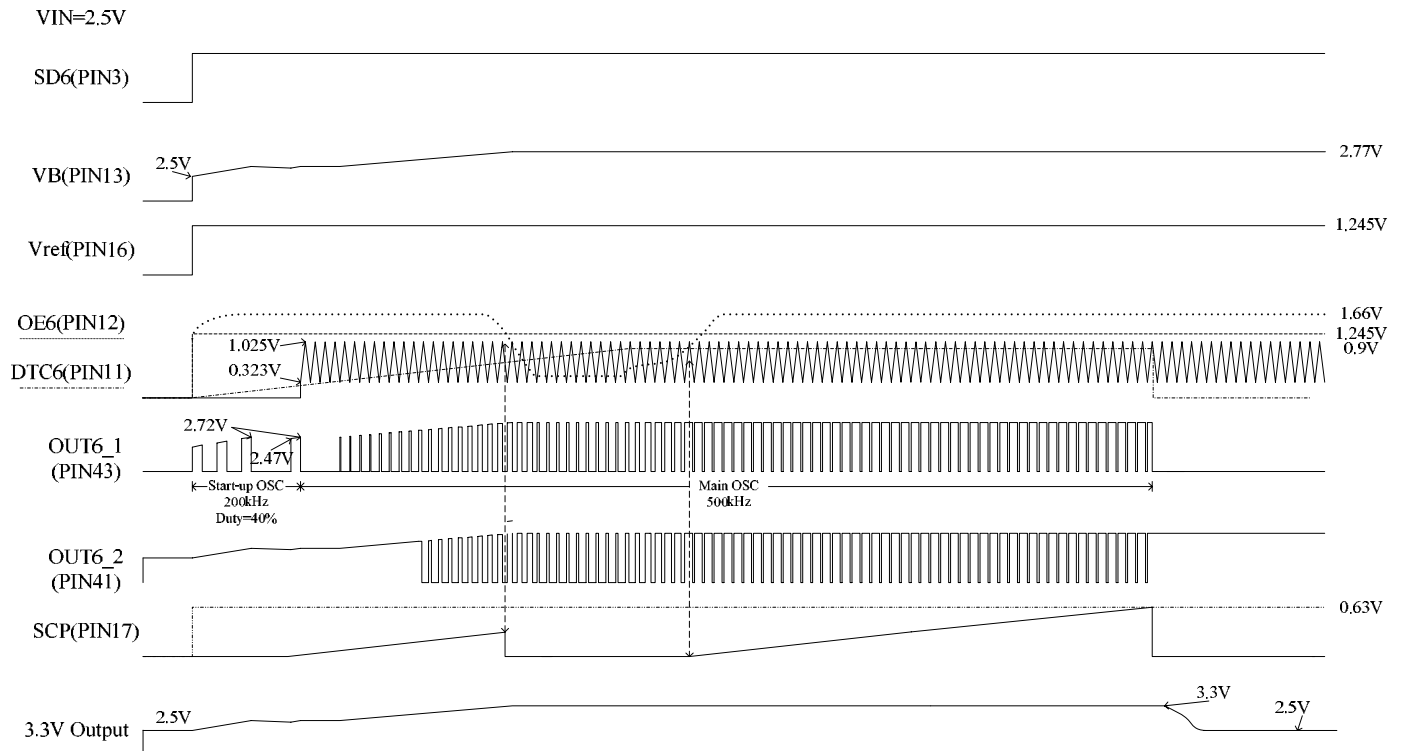


### CH6 Non-Synchronous Solution



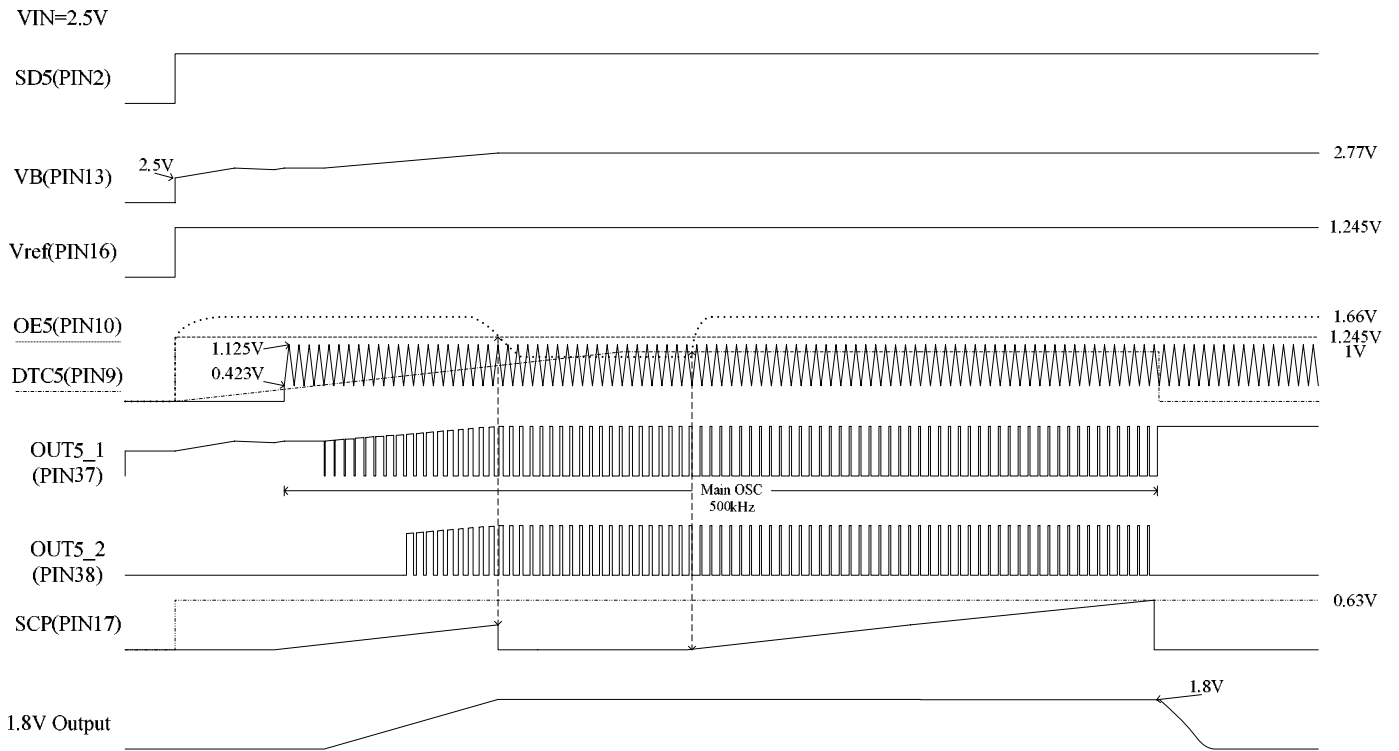


### CH6 Timing Chart





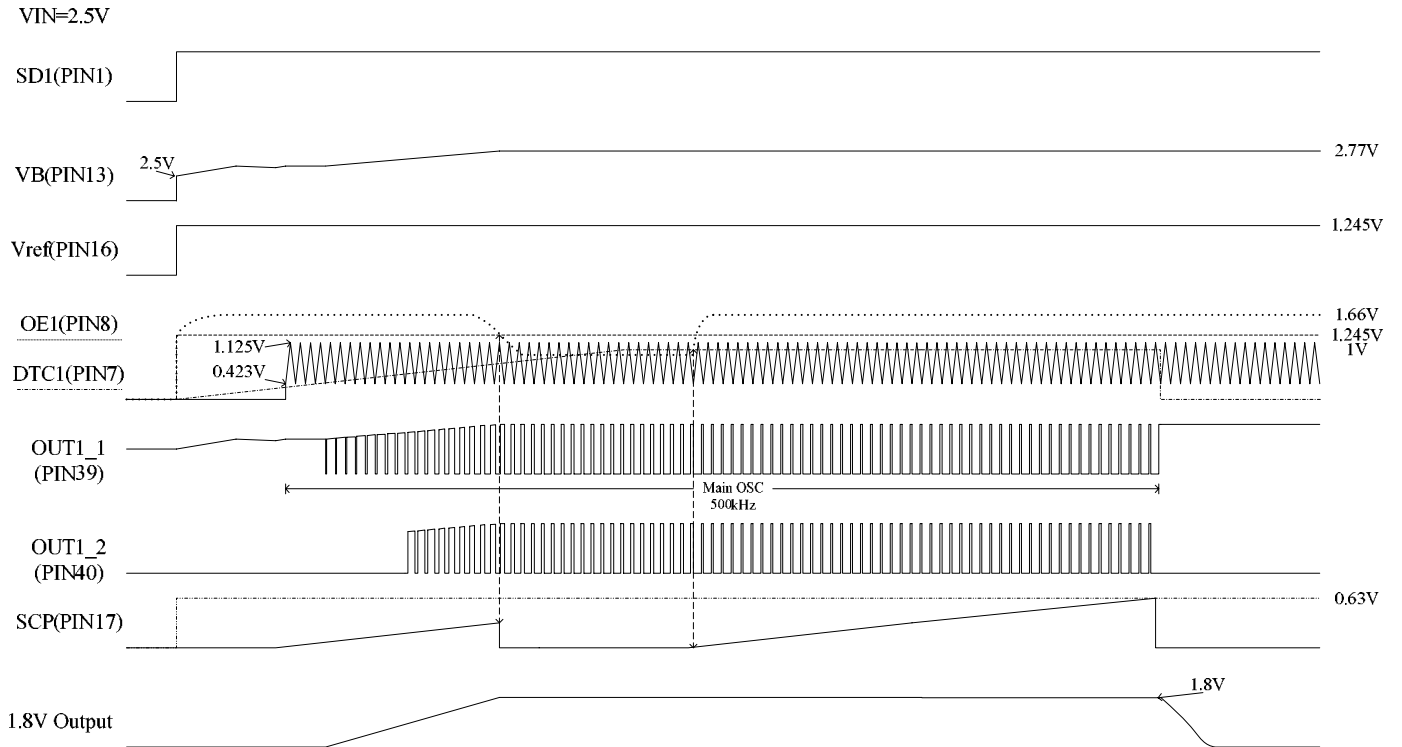
### CH5 Timing Chart





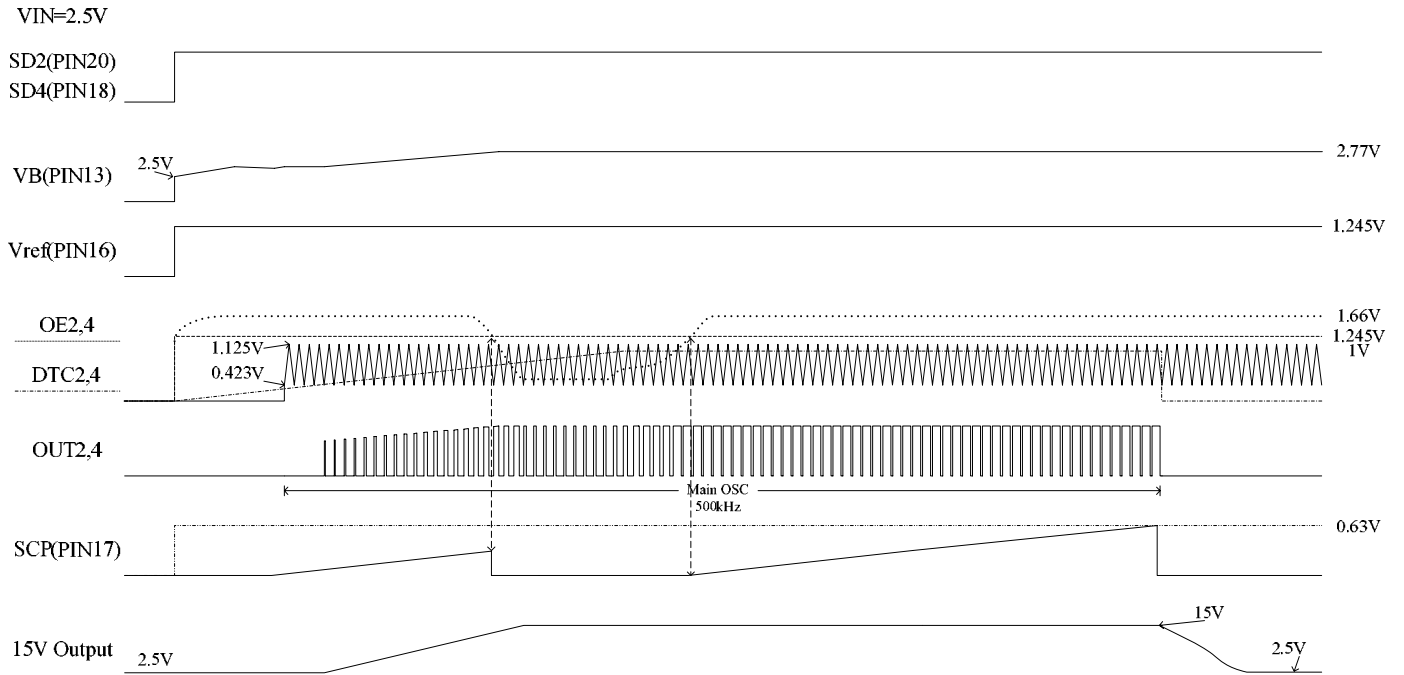


### CH1 Timing Chart



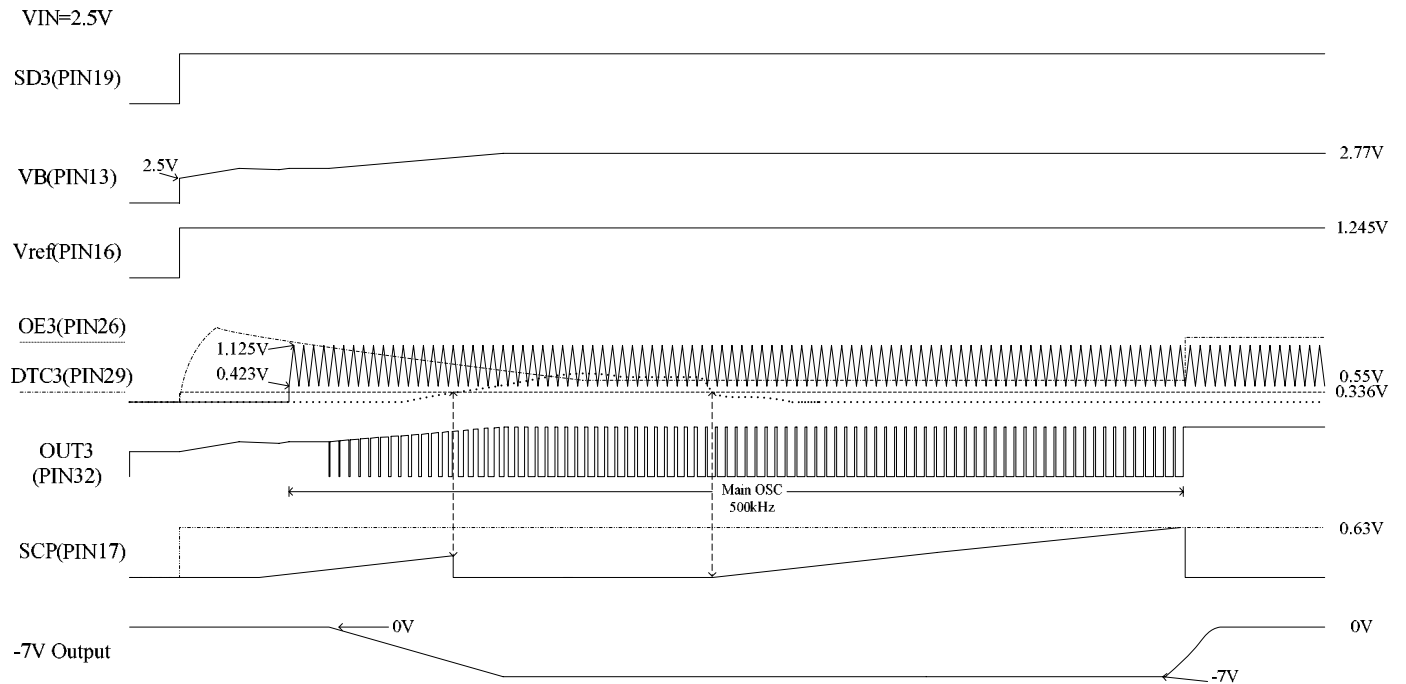


### CH2,4 Timing Chart



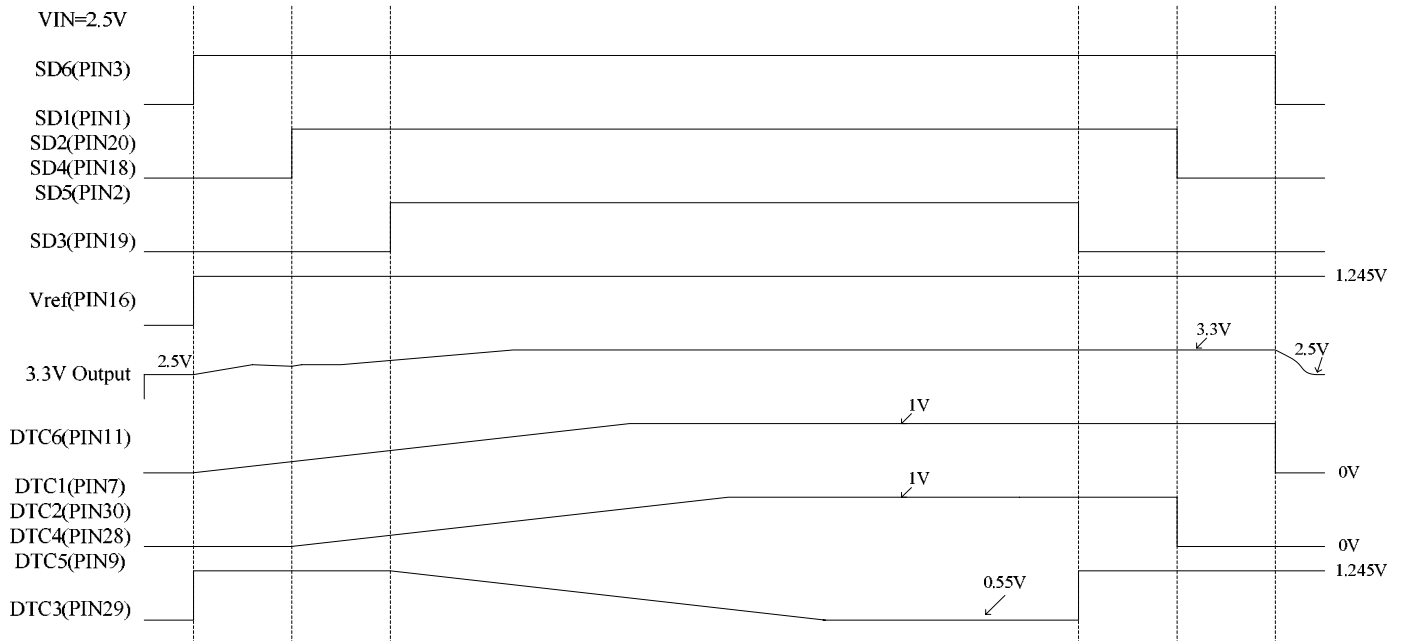


### CH3 Timing Chart



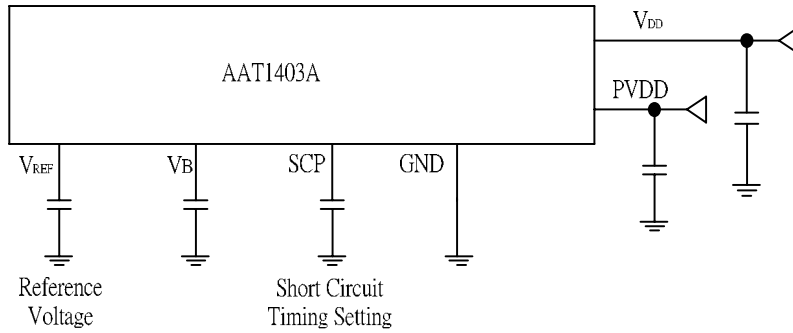


### Soft-Start and Shutdown Operation





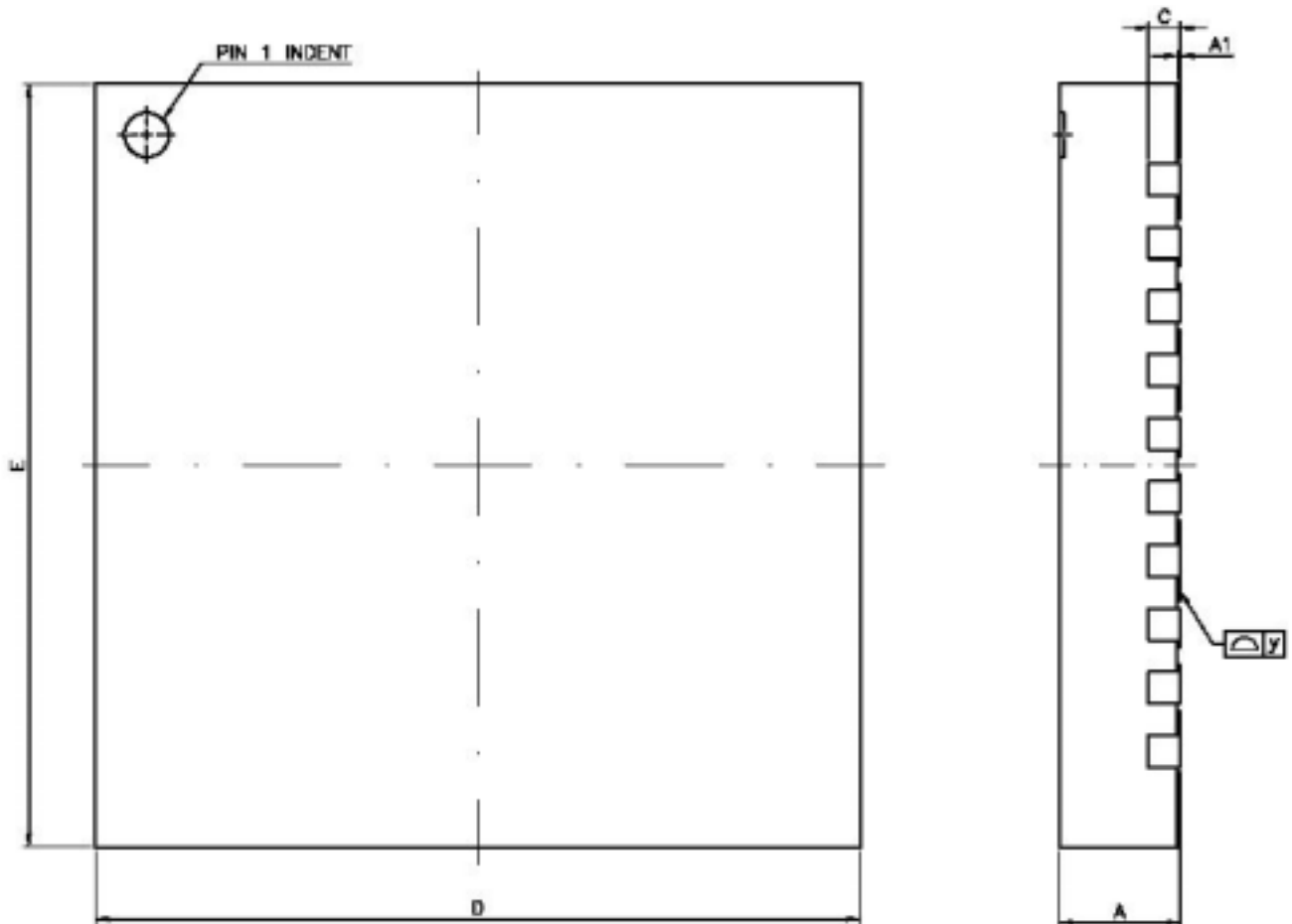
**OPERATION CONDITION SETTING**





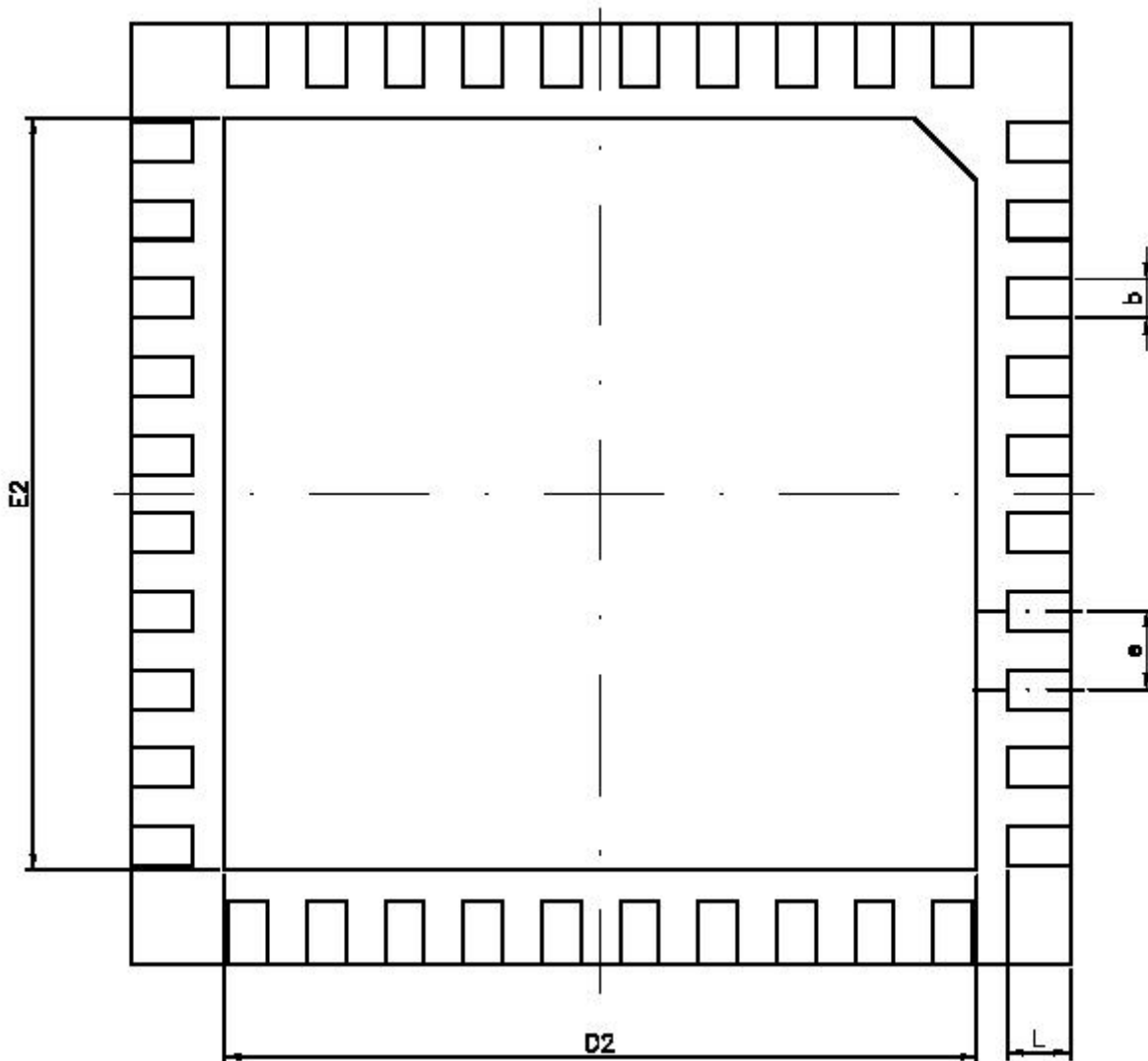
**PACKAGE DIMENSION**

**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.

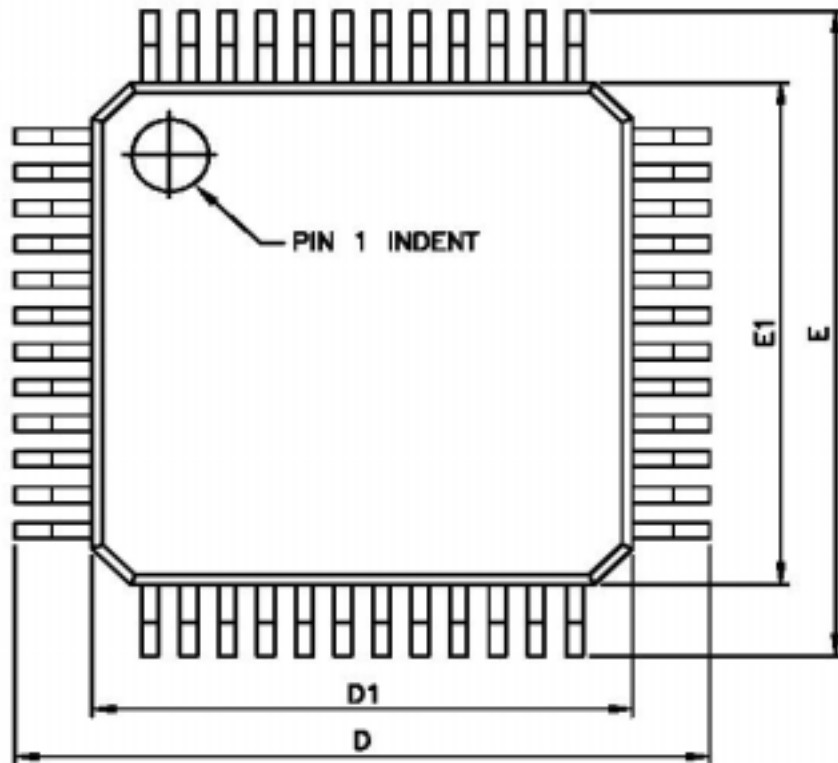




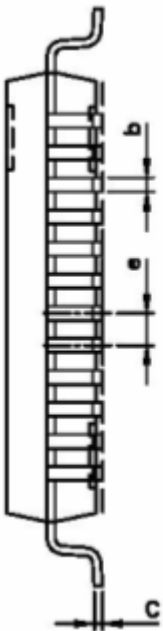
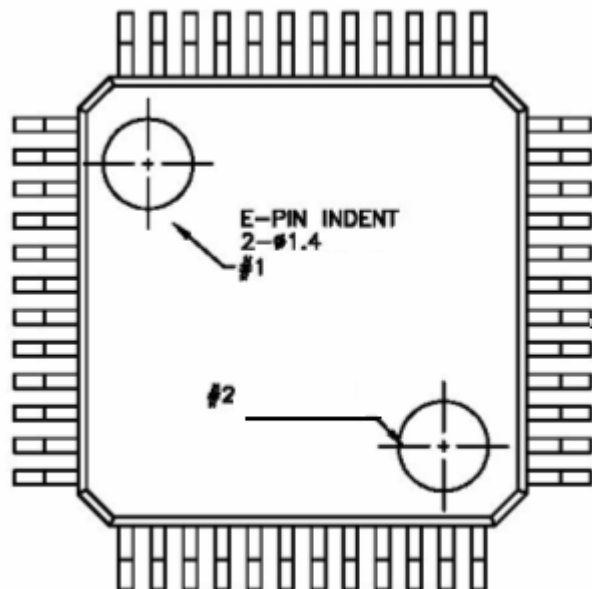
**PACKAGE DIMENSION**

**LQFP48 PACKAGE**

**TOP VIEW**



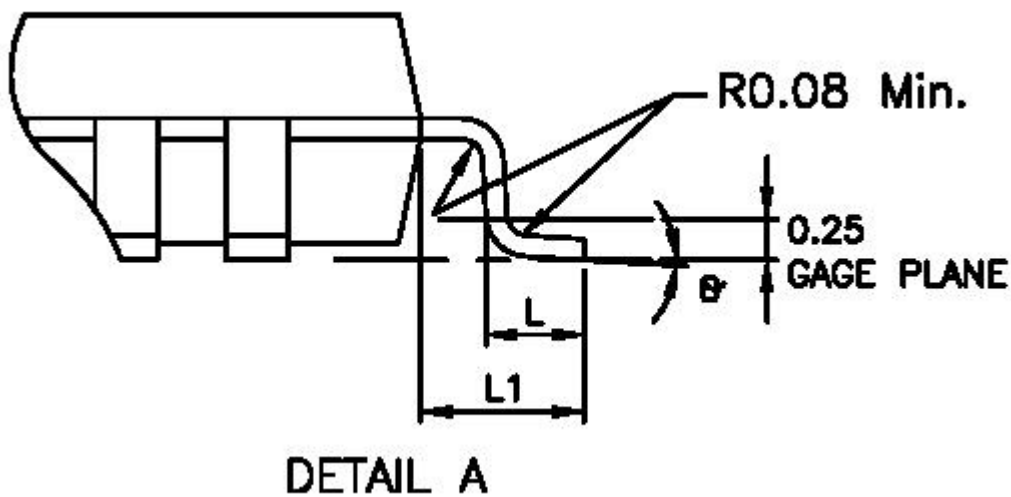
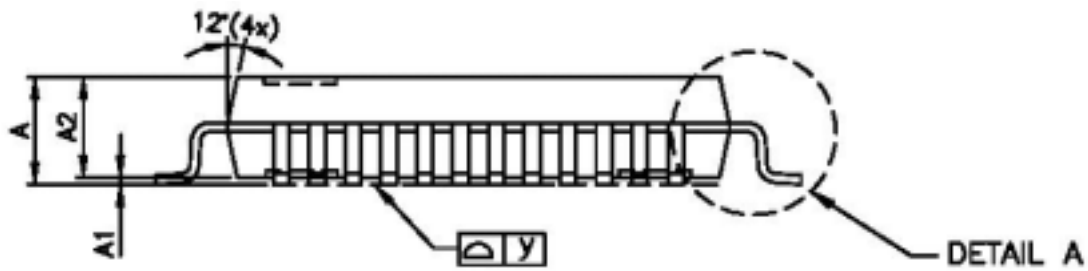
**BOTTOM VIEW**





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	-----
$\theta$	0°C	3.5°C	7.0°C
y	0	-----	0.08