



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 (CH1,6)
- Supports Synchronous Buck Rectification (CH5)
- 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 ( $\pm 15\%$ )

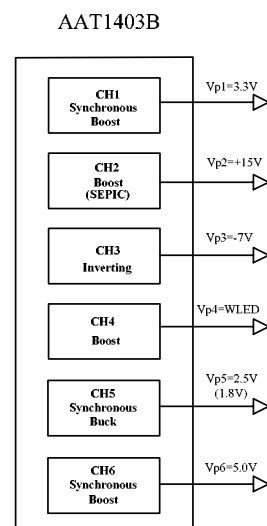
### APPLICATIONS

- Digital Cameras
- CCD Imaging Devices
- Camcorders

### GENERAL DESCRIPTION

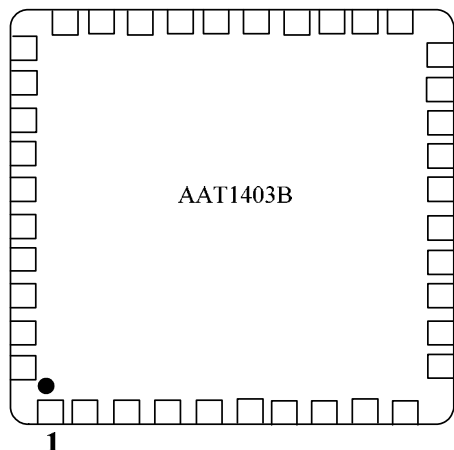
The AAT1403B provides an integrated six-channel pulse-width-modulation (PWM) solution for the power supply of DC-DC converter; this device offers system engineer flexibility to tailor-make the power supply circuitry for specific applications. Each channel contains its own error amplifier, PWM comparator, 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, AAT1403B also has three synchronous rectifiers.

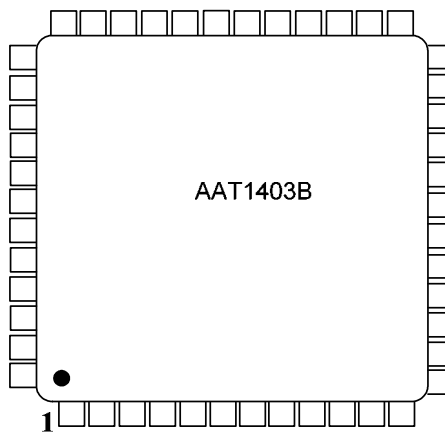




**PIN CONFIGURATION**



(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)**

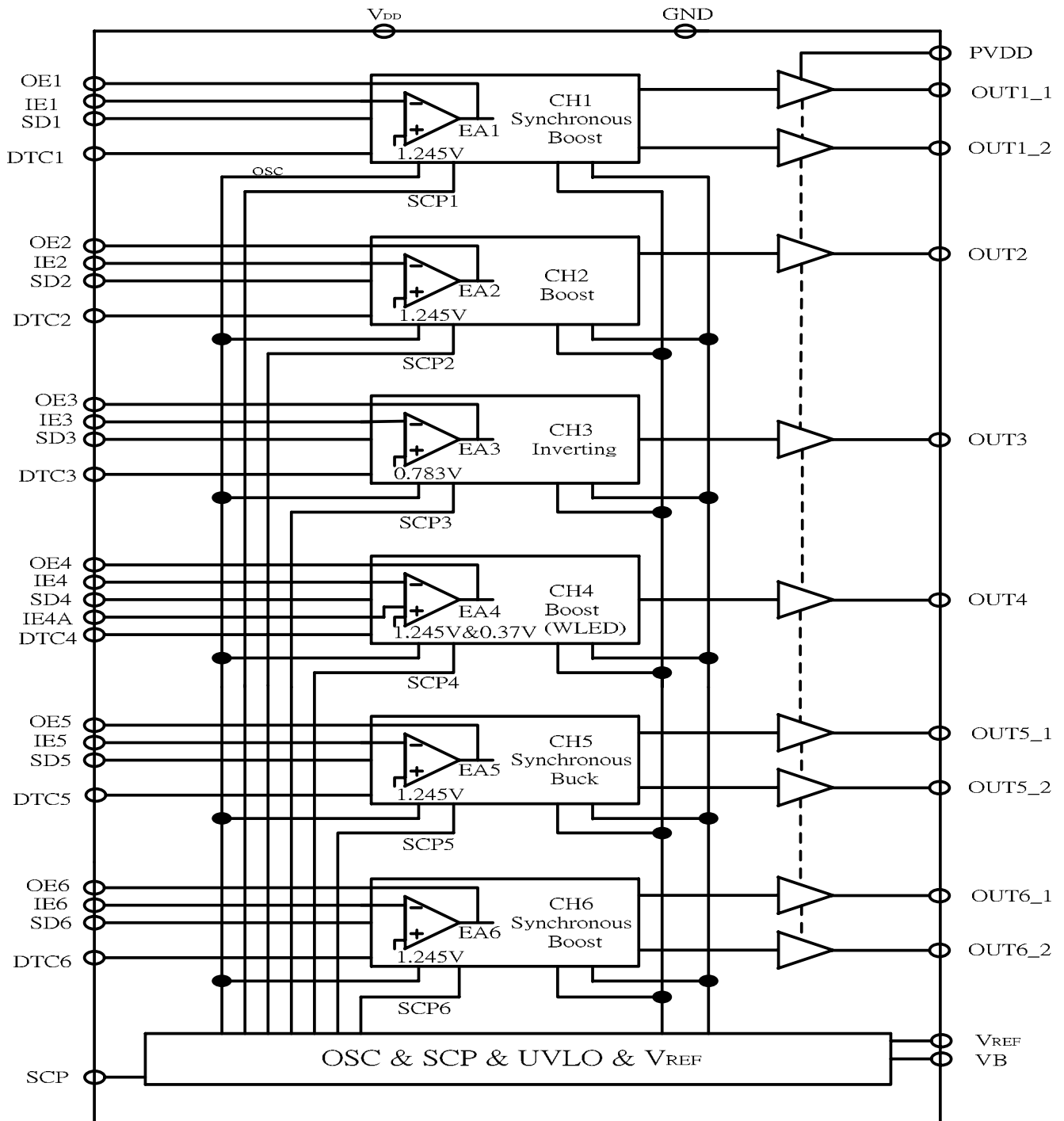
| Pin No | Name             | I/O | Function                                       |
|--------|------------------|-----|--|
| 1      | SD1              | I   | ON/OFF Control for Channel 1 (CH1)             |
| 2      | SD5              | I   | ON/OFF Control for Channel 5 (CH5)             |
| 3      | 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   | Negative 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 (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-, DTC-, SD-)                    | $V_I$         | $V_{DD}$     | 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                         | $T_{storage}$ | -40 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- (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                  | $V_{RI}$                   | $I_{REF} = -1mA, V_{DD} = 3.0V \text{ to } 6.5V$ | -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   | -     | %    |

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<br>$V_I = 0.28V$ to $1.55V$ | -     | $\pm 10$ | $\pm 20$ | nA      |
| Input Voltage Range             | $V_{IR}$   | CH1~6                             | 0.28  | -        | 1.55     | V       |
| Open-Loop Voltage Amplification | $A_{VO}$   |                                   | 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%,<br>$f_{OSC} = 500kHz$ | -     | 1.125 | 1.225 |      |
| Input Threshold Voltage (DTC6)       | $V_{6d0}$   | Duty = 0%, $f_{OSC} = 500kHz$      | 0.223 | 0.323 | -     | V    |
|                                      | $V_{6d100}$ | Duty = 100%,<br>$f_{OSC} = 500kHz$ | -     | 1.025 | 1.125 |      |
| Input Threshold Voltage (DTC3)       | $V_{3d0}$   | Duty=0%, $f_{OSC} = 500kHz$        | -     | 1.125 | 1.225 | V    |
|                                      | $V_{3d100}$ | Duty=100%,<br>$f_{OSC} = 500kHz$   | 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 <sub>OH</sub> | I <sub>O</sub> = -15mA (CH1~CH5) | -   | 18  | 30  | Ω    |
|                    |                 | I <sub>O</sub> = -15mA (CH6)     | -   | 9   | 15  |      |
|                    | R <sub>OL</sub> | I <sub>O</sub> = 15mA (CH1~CH5)  | -   | 16  | 25  | Ω    |
|                    |                 | I <sub>O</sub> = 15mA (CH6)      | -   | 9   | 15  |      |

**SHUTDOWN (SD -)**

| Parameter       | Symbol          | Test Condition | Min | Typ | Max | Unit |
|-----------------|-----------------|----------------|-----|-----|-----|------|
| High Level SD - | H <sub>SD</sub> | Active Mode    | 1.4 | -   | -   | V    |
| Low Level SD -  | L <sub>SD</sub> | Stand-by Mode  | -   | -   | 0.6 | V    |
| Input Current   |                 | CH1~CH6        | -   | ±10 | ±20 | nA   |

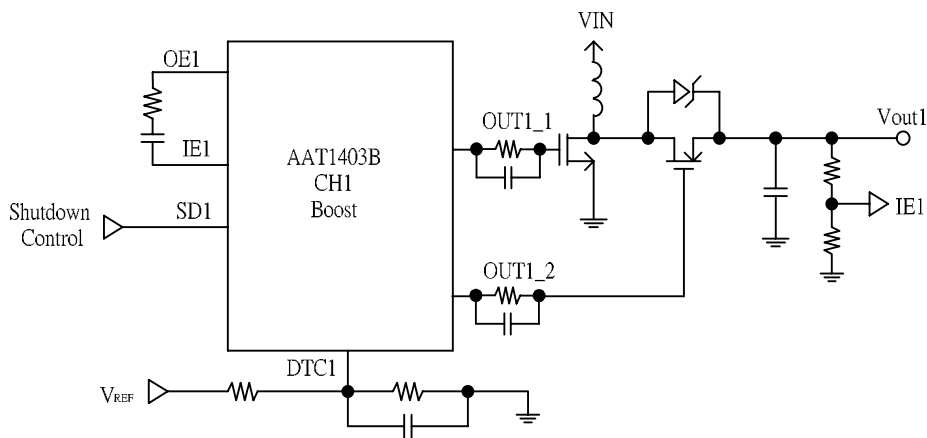
**OPERATING CURRENT**

| Parameter      | Symbol              | Test Condition | Min | Typ | Max | Unit |
|----------------|---------------------|----------------|-----|-----|-----|------|
| Supply Current | I <sub>DD-OFF</sub> | SD1~SD6= 0V    | -   | -   | 10  | μA   |
|                | I <sub>DD-ON</sub>  | SD1~SD6= "Hi"  | -   | 4.8 | 7.0 | mA   |

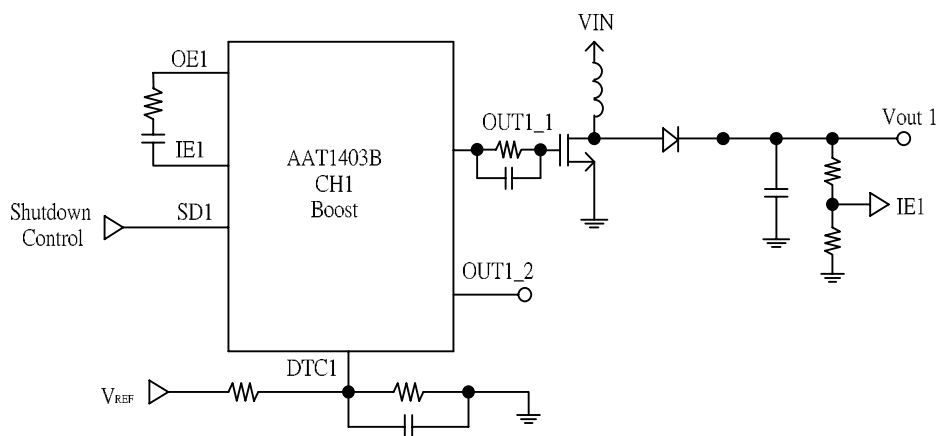


**APPLICATION CIRCUIT**

**CH1 Synchronous Solution**



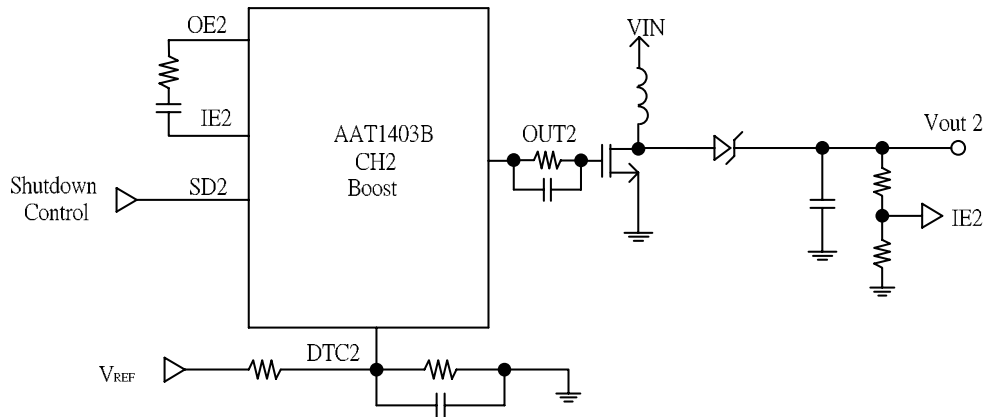
**CH1 Non-Synchronous Solution**



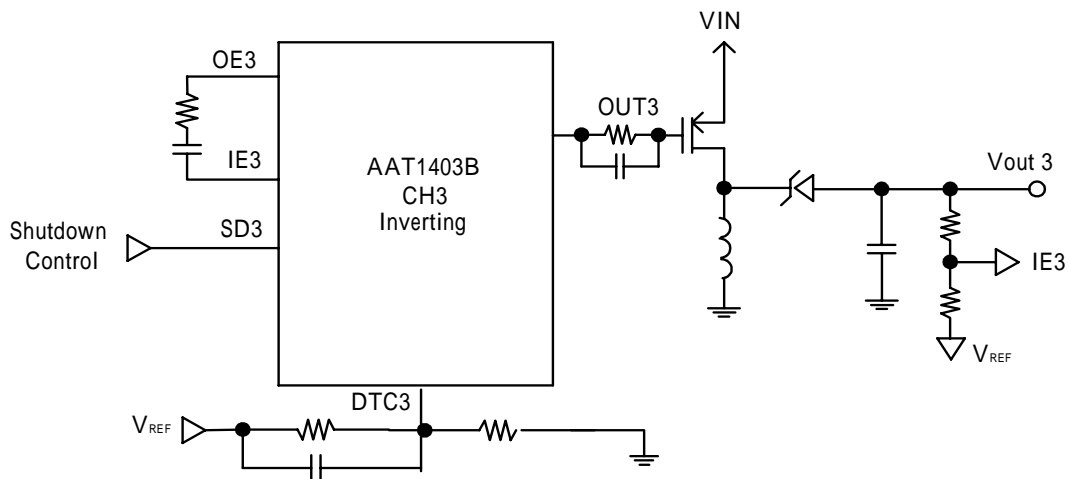


## APPLICATION CIRCUIT

### CH2 Solution



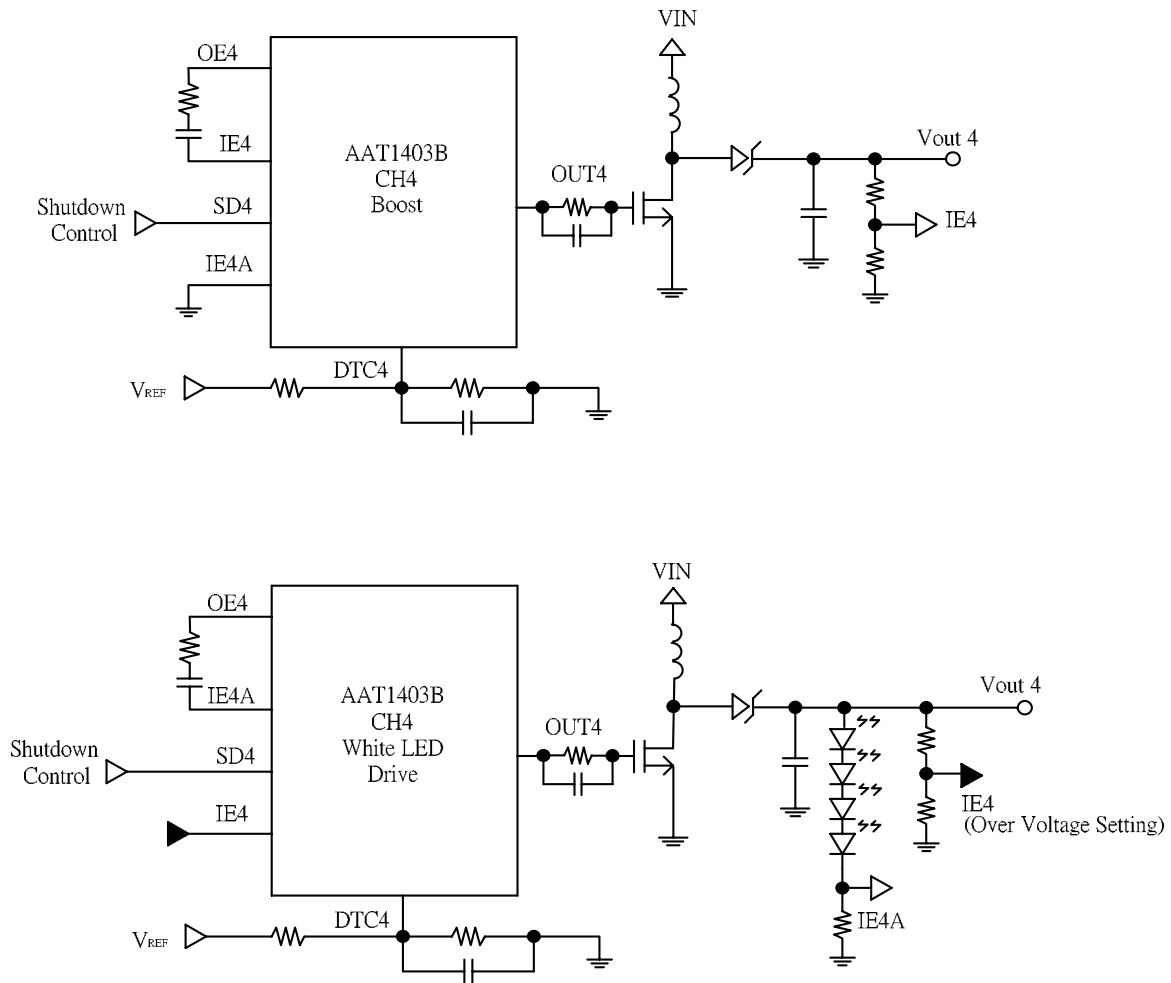
### CH3 Solution





APPLICATION CIRCUIT

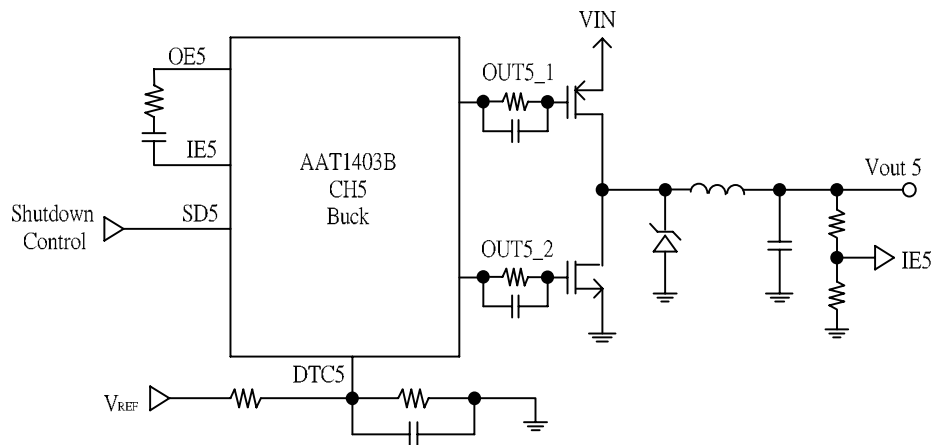
CH4 Solution



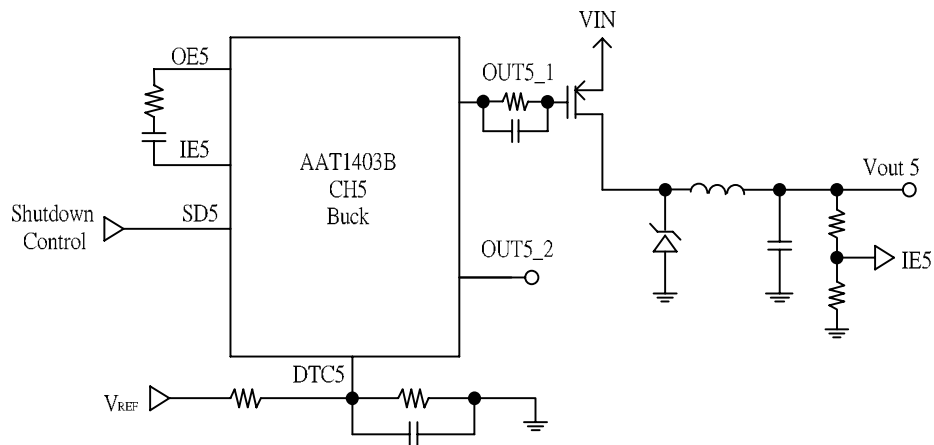


## APPLICATION CIRCUIT

### CH5 Synchronous Solution



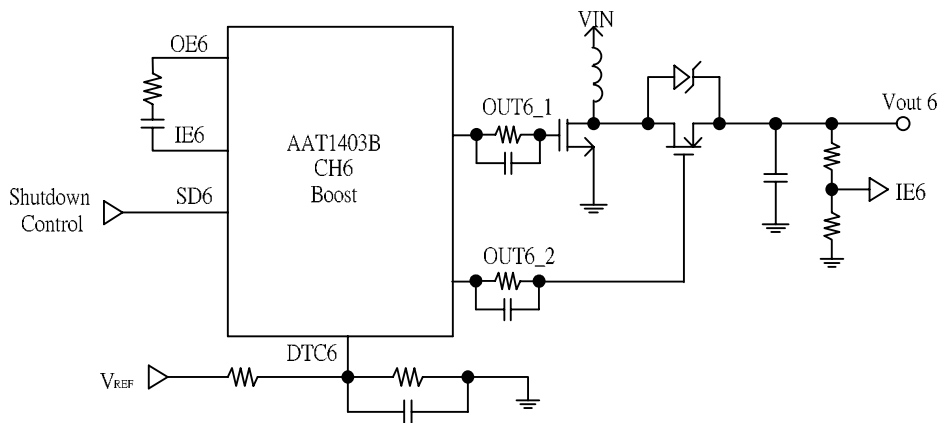
### CH5 Non-Synchronous Solution



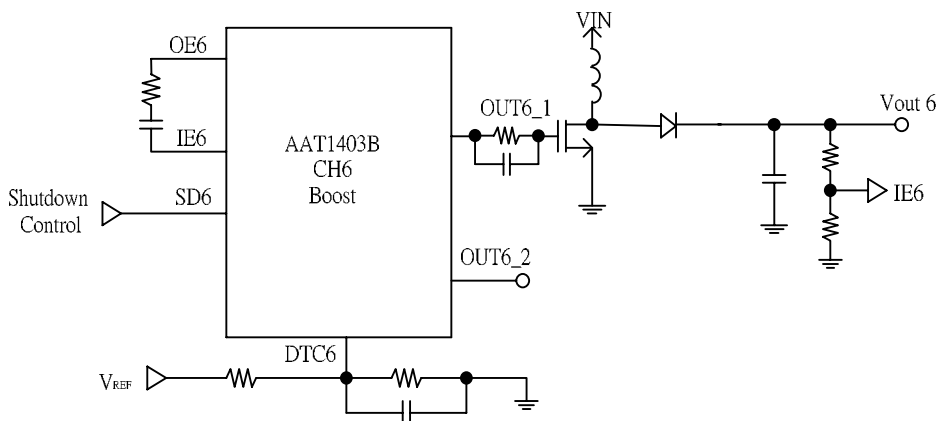


**APPLICATION CIRCUIT**

**CH6 Synchronous Solution**

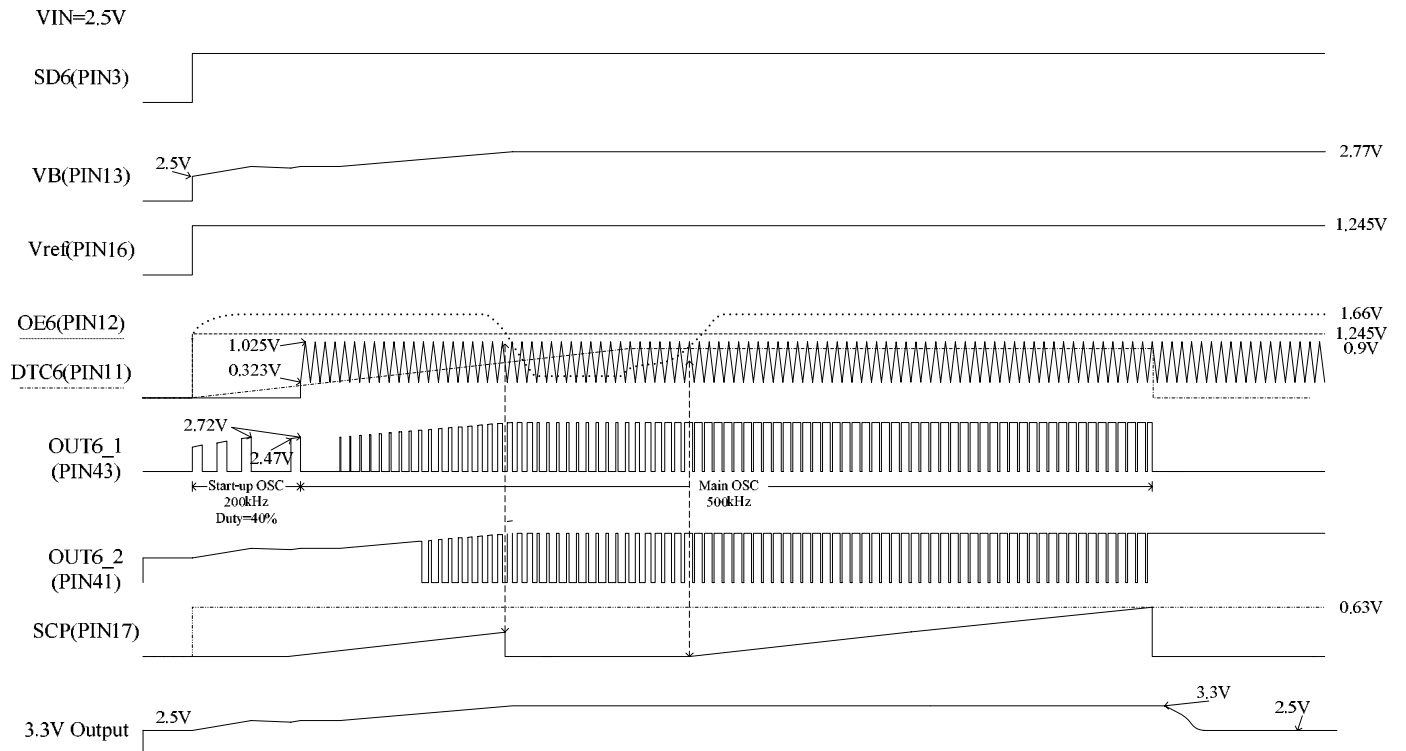


**CH6 Non-Synchronous Solution**



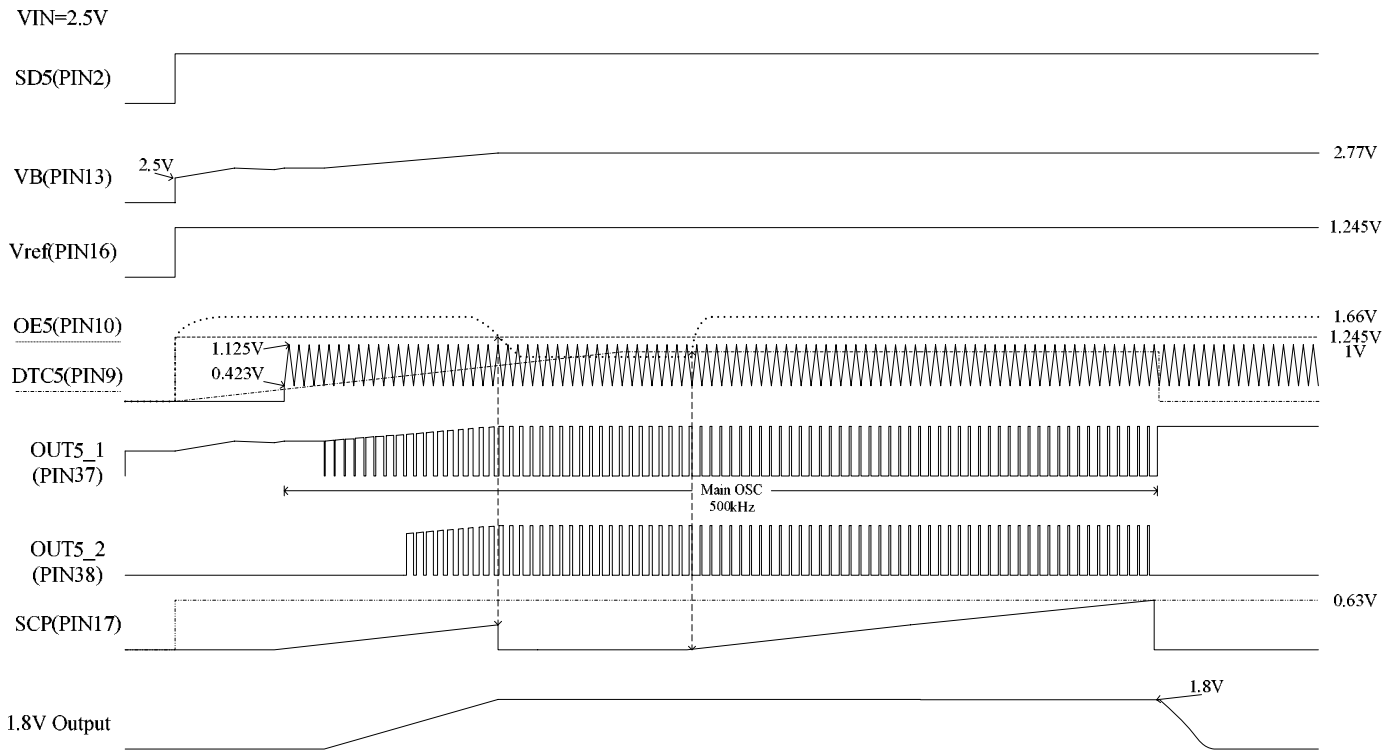


### CH6 Timing Chart





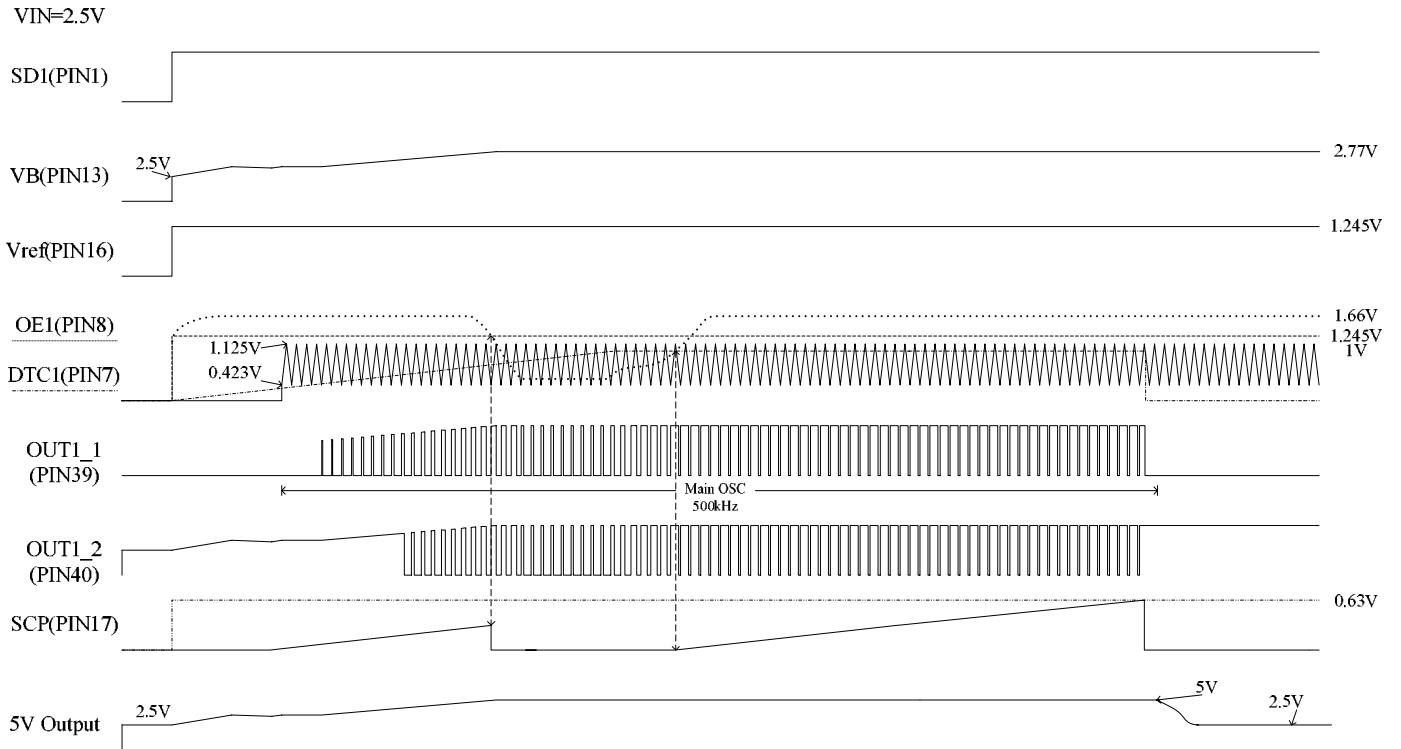
### CH5 Timing Chart





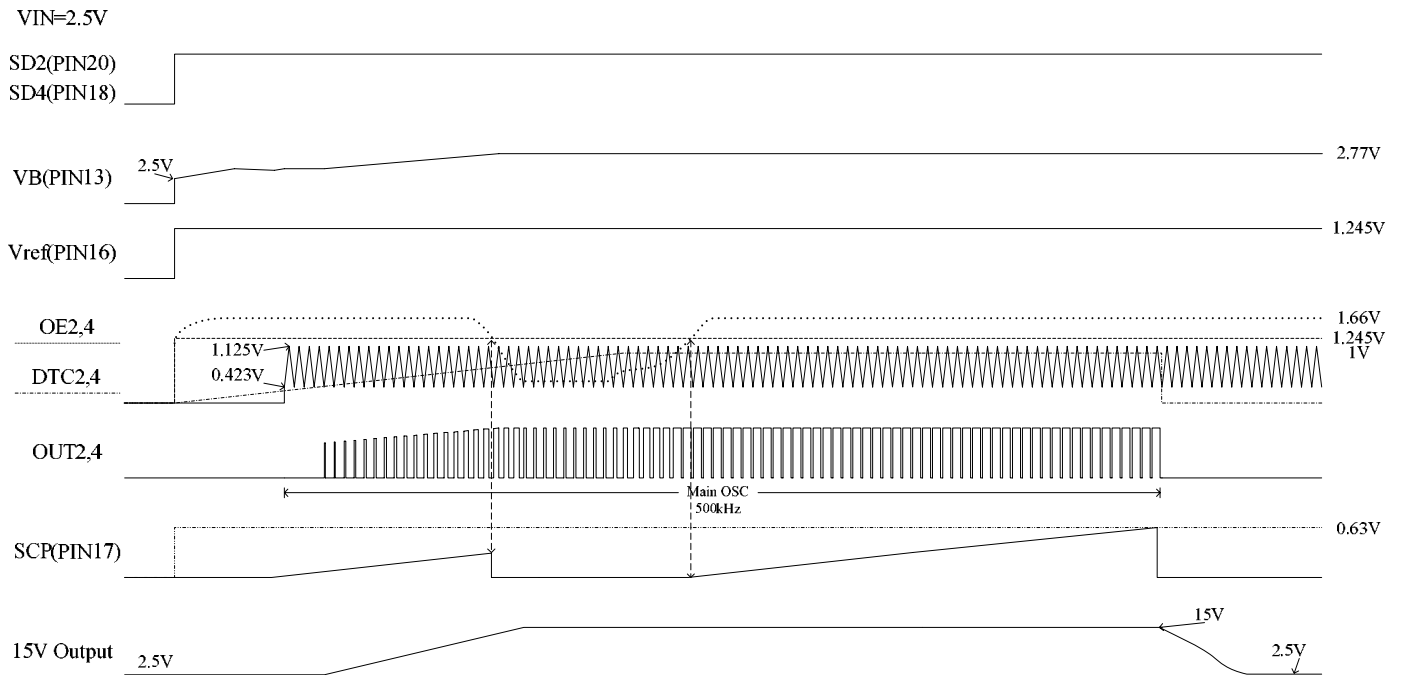


### CH1 Timing Chart



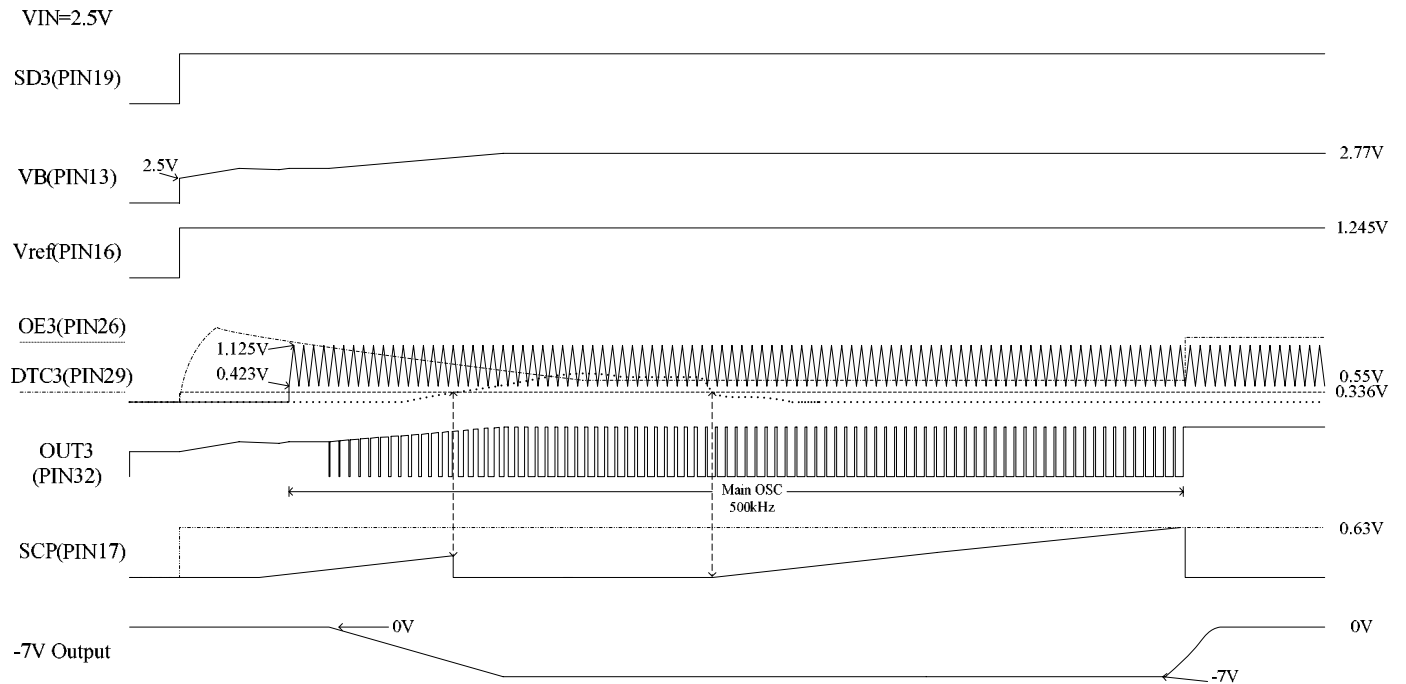


### CH2,4 Timing Chart



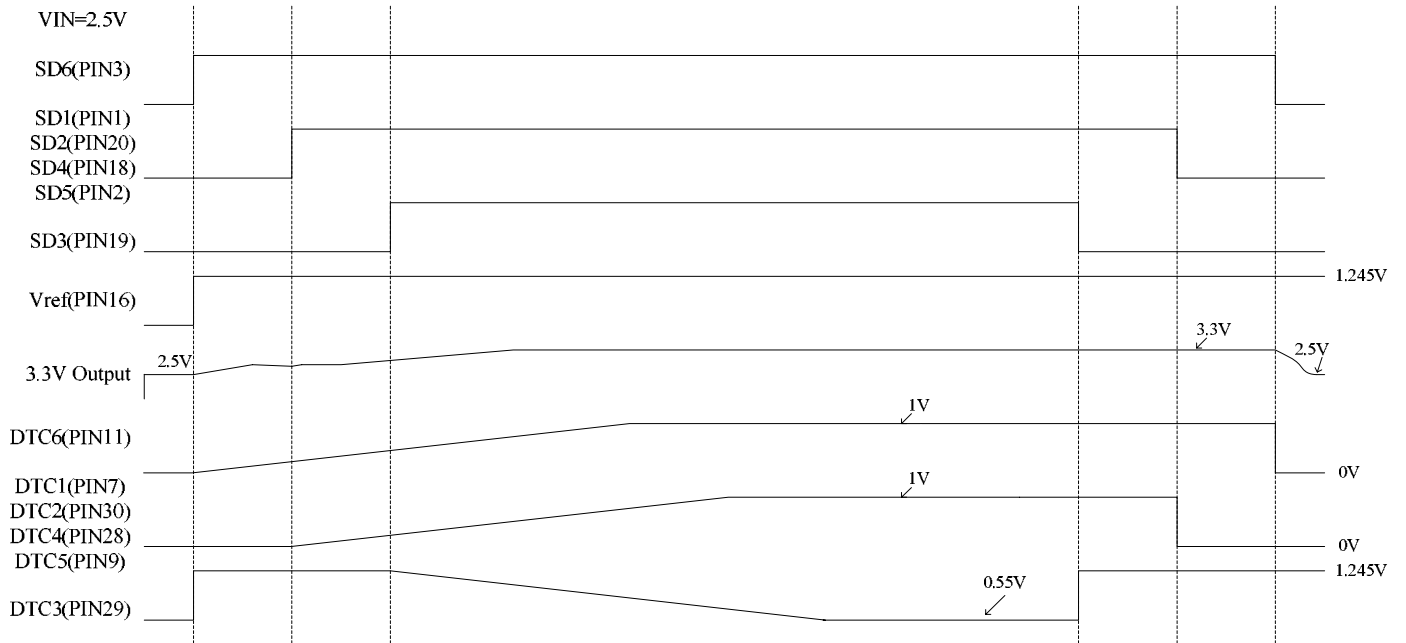


### CH3 Timing Chart



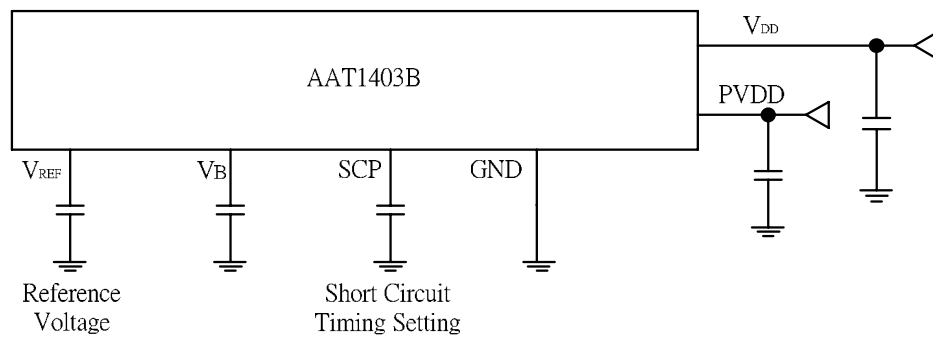


### Soft-Start and Shunt-Down Operation





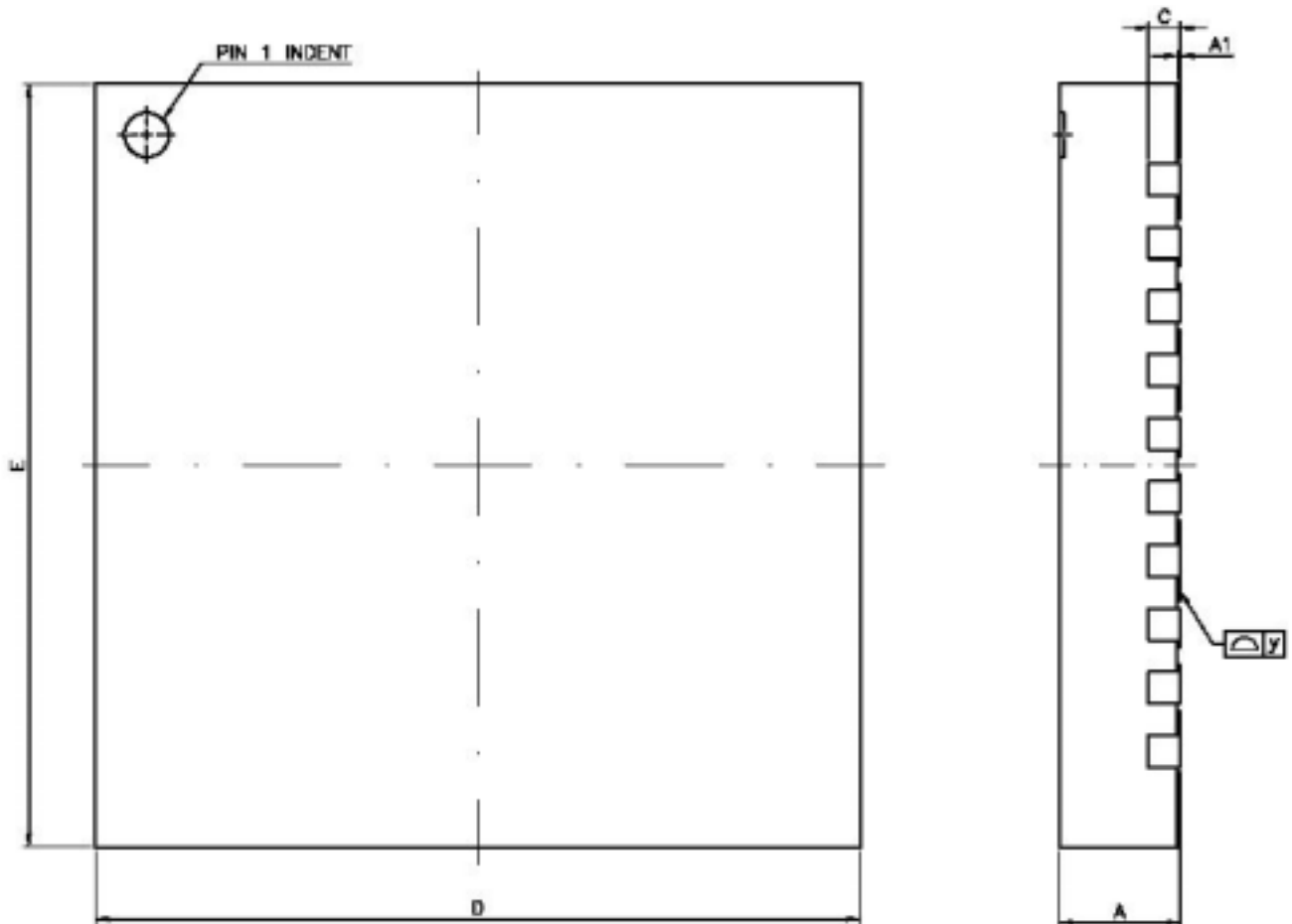
**OPERATION CONDITION SETTING**





**PACKAGE DIMENSION**

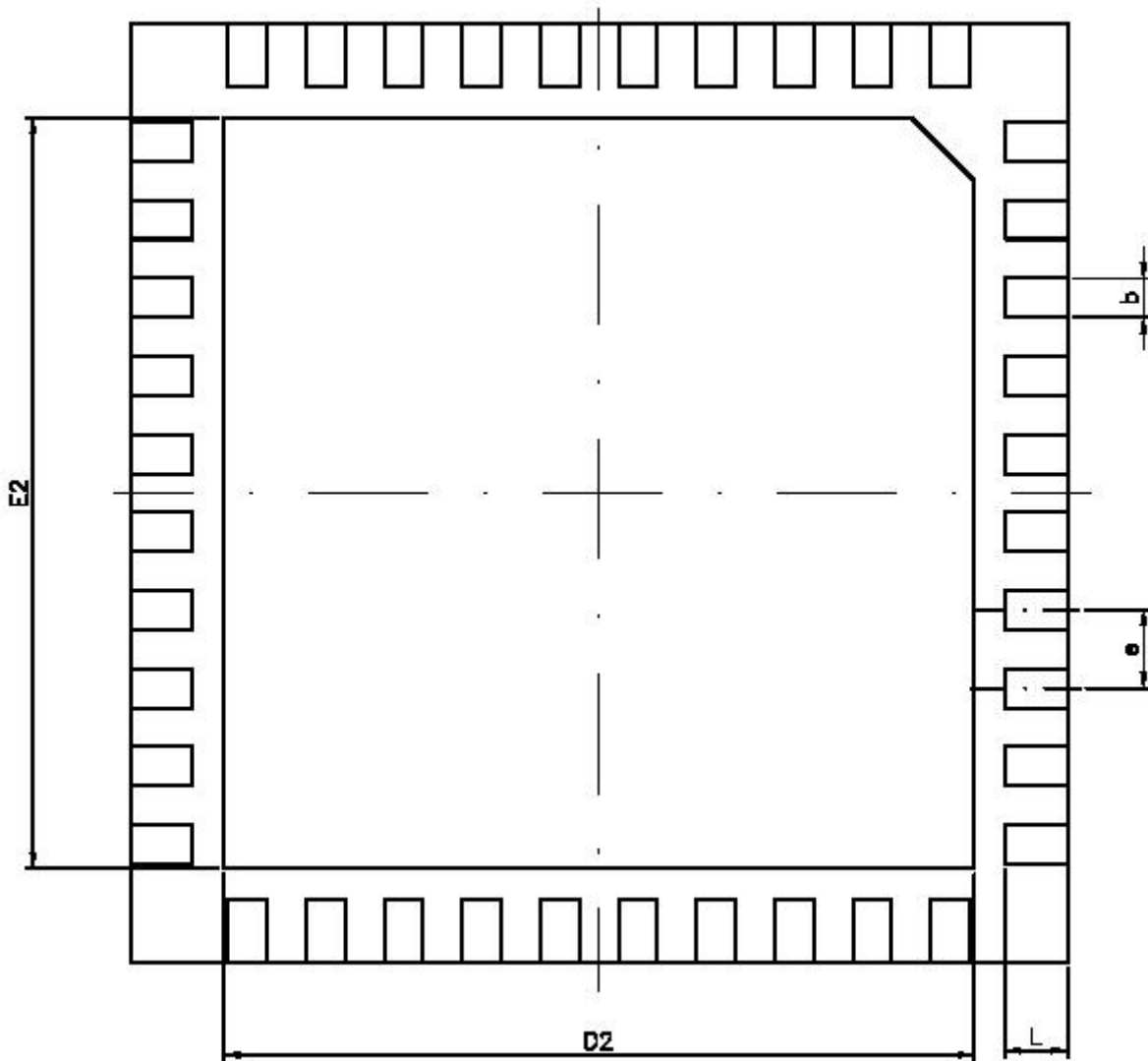
**VQFN40 PACKAGE**





**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.

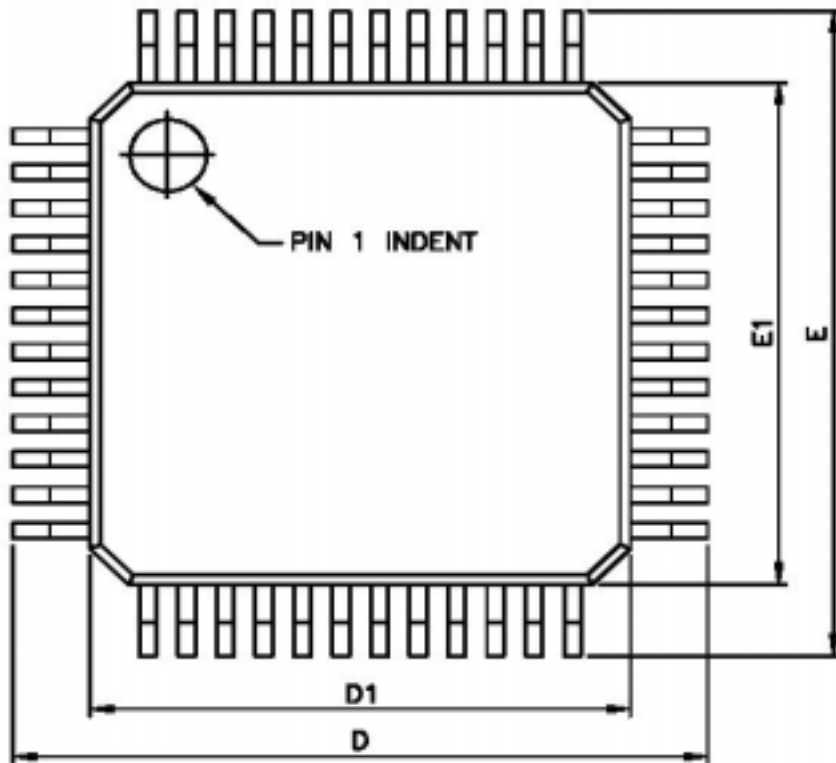




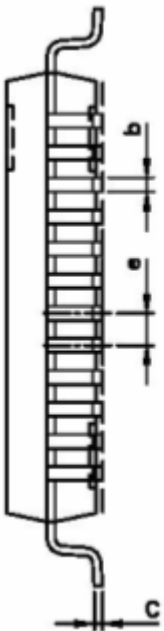
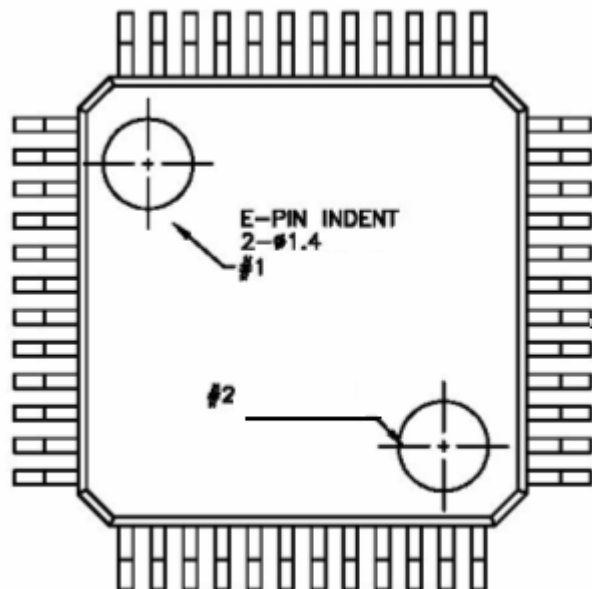
**PACKAGE DIMENSION**

**LQFP48 PACKAGE**

**TOP VIEW**



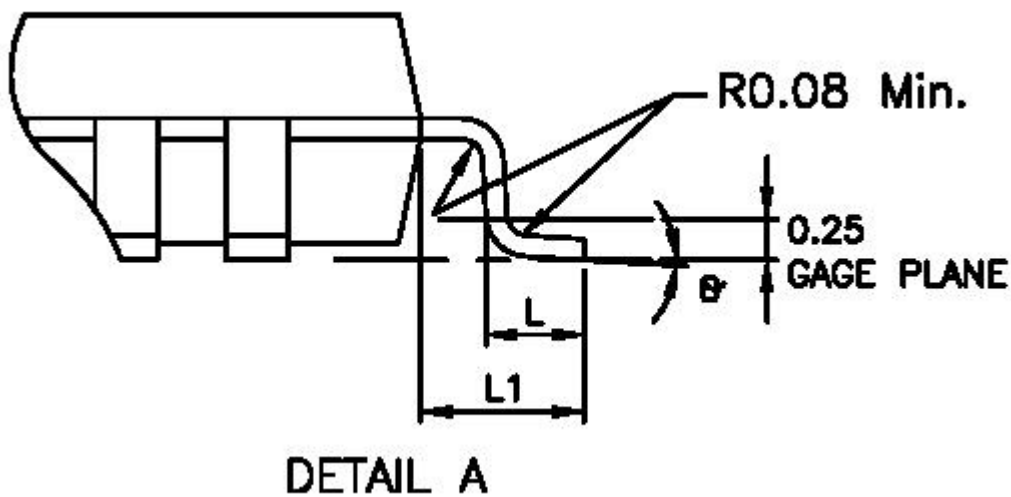
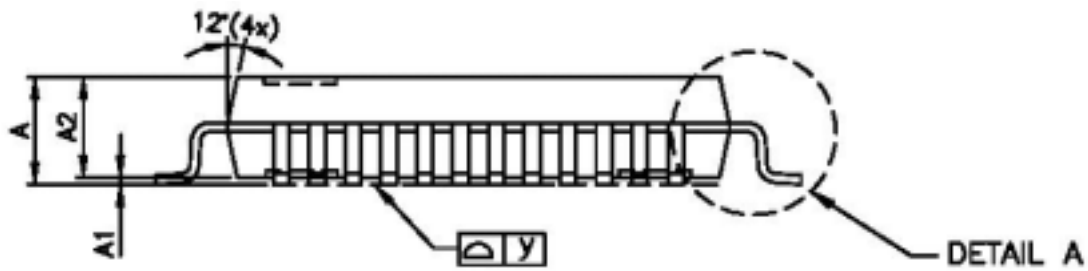
**BOTTOM VIEW**





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  |