



# AP2001

## MONOLITHIC DUAL CHANNEL PWM CONTROLLER

### Features

- Dual PWM control circuitry
- Operating voltage can be up to 40V
- Adjustable Dead Time Control (DTC)
- Under Voltage Lockout (UVLO) protection
- Short Circuit Protection (SCP)
- Variable oscillator frequency: 500KHz Max
- 2.5V voltage reference output
- SOP-16L package
- Lead Free Finish/RoHS Compliant for Lead Free products (Note 1)

### General Description

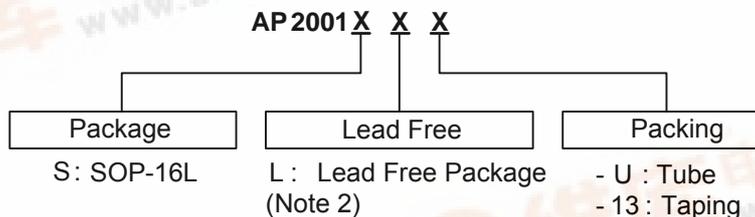
The AP2001 integrates Pulse-width-Modulation (PWM) control circuit into a single chip, mainly designed for power-supply regulator. All the functions included are an on-chip 2.5V reference output, two error amplifiers, an adjustable oscillator, two dead-time comparators, UVLO, SCP, DTC circuitry, and dual common-emitter (CE) output transistor circuit.

Recommend the output CE transistors as pre-driver for Driving externally. The DTC can provide from 0% to 100%. Switching frequency can be adjustable by trimming RT and CT. During low  $V_{CC}$  situation, the UVLO makes sure that the outputs are off until the internal circuit is operating normally.

### Applications

- Backlight inverter
- DC/DC converts in computers, etc.

### Ordering Information



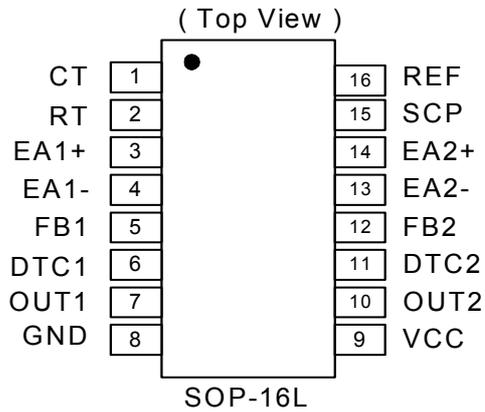
Note: 1. RoHS revision 13.2.2003. Glass and High Temperature Solder Exemptions Applied, see *EU Directive Annex Notes 5 and 7*.

| Device  | Package Code | Packaging (Note 2) | Tube     |                    | 13" Tape and Reel |                    |
|---------|--------------|--------------------|----------|--------------------|-------------------|--------------------|
|         |              |                    | Quantity | Part Number Suffix | Quantity          | Part Number Suffix |
| AP2001S | S            | SOP-16L            | 50       | -U                 | 2500/Tape & Reel  | -13                |

Note: 2. Pad layout as shown on Diodes Inc. suggested pad layout document AP02001, which can be found on our website at <http://www.diodes.com/datasheets/ap02001.pdf>.



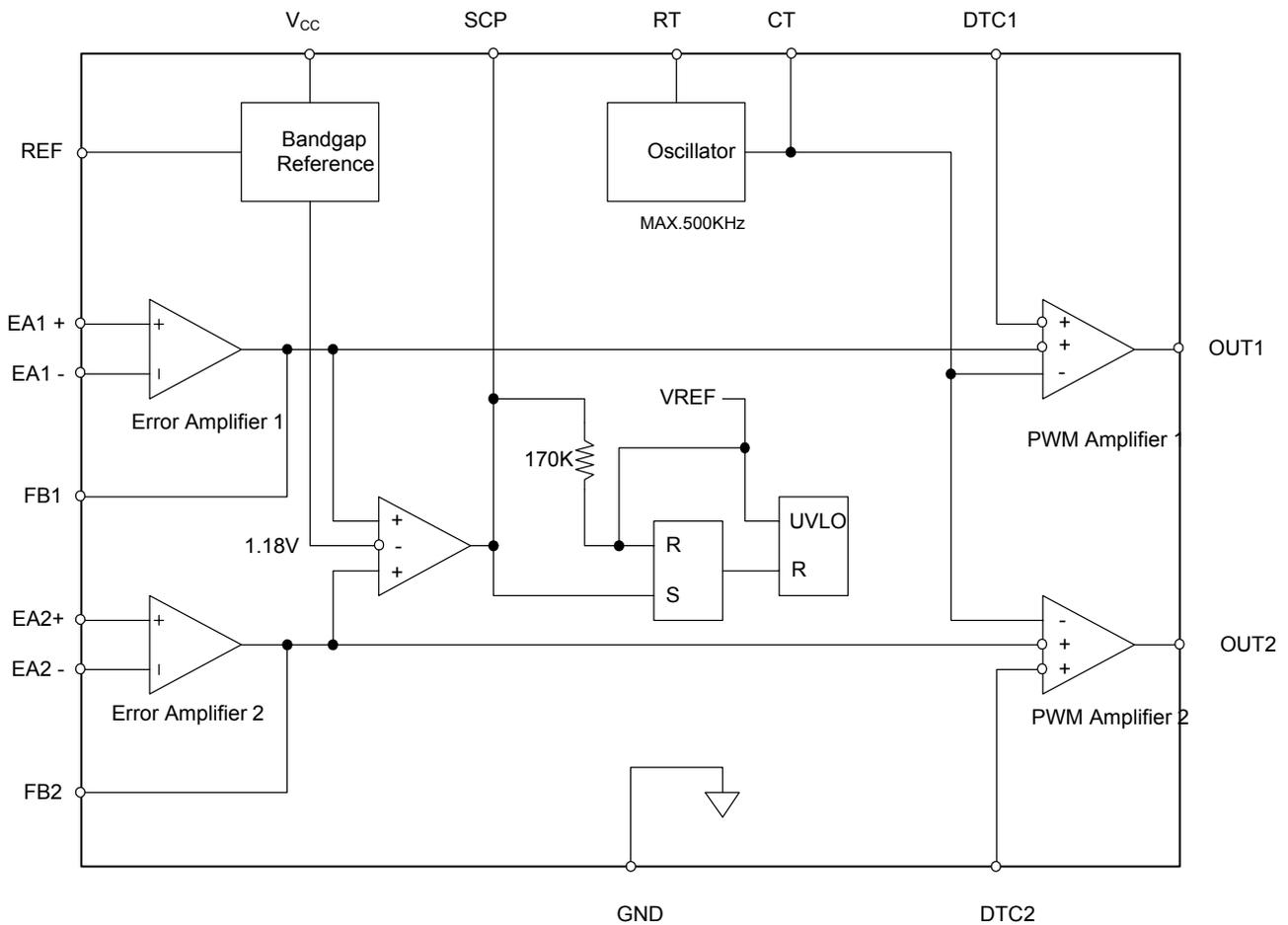
**Pin Assignments**



**Pin Descriptions**

| Name | Description                |
|------|----------------------------|
| CT   | Timing Capacitor           |
| RT   | Timing Resistor            |
| EA+  | Error Amplifier Input(+)   |
| EA - | Error Amplifier Input(-)   |
| FB   | Feedback Loop Compensation |
| DTC  | Dead Time Control          |
| OUT  | Pre-driver Output          |
| GND  | Ground                     |
| VCC  | Supply Voltage             |
| SCP  | Short Circuit Protection   |
| REF  | Voltage Reference          |

**Block Diagram**



**Absolute Maximum Ratings**

| Symbol            | Parameter   | Rating      | Unit |
|-------------------|---|-------------|------|
| V <sub>CC</sub>   | Supply Voltage  | 40          | V    |
| V <sub>I</sub>    | Amplifier Input Voltage                                     | 20          | V    |
| V <sub>O</sub>    | Collector Output Voltage                                    | 40          | V    |
| I <sub>O</sub>    | Collector Output Current                                    | 21          | mA   |
| T <sub>OP</sub>   | Operating Temperature Range                                 | -20 to +85  | °C   |
| T <sub>ST</sub>   | Storage Temperature Range                                   | -65 to +150 | °C   |
| T <sub>LEAD</sub> | Lead Temperature 1.6 mm (1/16 inch) from Case for 5 Seconds | 245         | °C   |

**Recommended Operating Conditions**

| Symbol    | Parameter                      | Min. | Max.  | Unit         |
|-----------|--------------------------------|------|-------|--------------|
| $V_{CC}$  | Supply Voltage                 | 3.6  | 40    | V            |
| $V_I$     | Amplifier Input Voltage        | 1.05 | 1.45  | V            |
| $V_O$     | Collector Output Voltage       |      | 40    | V            |
| $I_O$     | Collector Output Current       |      | 20    | mA           |
| $I_{FB}$  | Current into Feedback Terminal |      | 45    | $\mu$ A      |
| $R_F$     | Feedback Resistor              | 100  |       | k $\Omega$   |
| $C_T$     | Timing Capacitor               | 150  | 15000 | pF           |
| $R_T$     | Timing Resistor                | 5.1  | 100   | k $\Omega$   |
| $F_{OSC}$ | Oscillator Frequency           | 1    | 500   | KHz          |
| $T_{OP}$  | Operating Free-air Temperature | -20  | 85    | $^{\circ}$ C |

**Electrical Characteristics** ( $T_A = 25^{\circ}$ C,  $V_{CC} = 6V$ ,  $f = 200$  KHz)

**Reference (REF)**

| Symbol    | Parameter                              | Conditions                             | Min. | Typ. | Max.    | Unit    |
|-----------|--|--|------|------|---------|---------|
| $V_O$     | Output Voltage (pin 16)                | $I_O = 1$ mA                           | 2.4  | 2.5  | 2.6     | V       |
|           | Output Voltage Change with Temperature | $T_A = -20^{\circ}$ C ~ $25^{\circ}$ C |      | -0.1 | $\pm 1$ | %       |
|           |  | $T_A = 25^{\circ}$ C ~ $85^{\circ}$ C  |      |      | -0.2    | $\pm 1$ |
| $V_{DLI}$ | Input Stability                        | $V_{CC} = 3.6V \sim 40V$               |      | 2    | 12.5    | mV      |
| $V_{DLO}$ | Output Stability                       | $I_O = 0.1$ mA ~ 1mA                   |      | 1    | 7.5     | mV      |
| $I_O$     | Short-circuit Output Current           | $V_O = 0$                              | 3    | 10   | 30      | mA      |

**Under voltage lockout (UVLO)**

| Symbol    | Parameter                            | Conditions                                    | Min. | Typ. | Max. | Unit |
|-----------|--------------------------------------|---|------|------|------|------|
| $V_{UT}$  | Upper Threshold Voltage ( $V_{CC}$ ) | $I_{O(REF)} = 0.1$ mA<br>$T_A = 25^{\circ}$ C |      | 2.65 |      | V    |
| $V_{LWT}$ | Lower Threshold Voltage ( $V_{CC}$ ) |   |      | 2.45 |      | V    |
| $V_{HT}$  | Hysteresis ( $V_{CC}$ )              |   | 80   | 200  |      | mV   |

### Electrical Characteristics ( Continued )

#### Short-circuit protection (SCP) control

| Symbol    | Parameter                         | Conditions                                  | Min. | Typ. | Max. | Unit          |
|-----------|-----------------------------------|---|------|------|------|---------------|
| $V_{IT}$  | Input Threshold Voltage           | $T_A = 25^\circ\text{C}$                    | 0.65 | 0.7  | 0.75 | V             |
| $V_{STB}$ | Standby Voltage                   | No pull up                                  | 140  | 185  | 230  | mV            |
| $V_{LT}$  | Latched Input Voltage             | No pull up                                  |      | 60   | 120  | mV            |
| $I_{SCP}$ | Input (Source) Current            | $V_I = 0.7\text{V}, T_A = 25^\circ\text{C}$ | -10  | -15  | -20  | $\mu\text{A}$ |
| $V_{CT}$  | Comparator Threshold Voltage (FB) |   |      | 1.18 |      | V             |

#### Oscillator (OSC)

| Symbol           | Parameter                         | Conditions                                      | Min. | Typ. | Max.    | Unit |
|------------------|-----------------------------------|---|------|------|---------|------|
| $F_{OSC}$        | Frequency                         | $C_T = 330\text{ pF}, R_T = 10\text{ K}\Omega$  |      | 200  |         | KHz  |
| $\Delta F_{OSC}$ | Standard Deviation of Frequency   | $C_T = 330\text{ pF}, R_T = 10\text{ K}\Omega$  |      | 10   |         | %    |
|                  | Frequency Change with Voltage     | $V_{CC} = 3.6\text{V} \sim 40\text{V}$          |      | 1    |         |      |
|                  | Frequency Change with Temperature | $T_A = -20^\circ\text{C} \sim 25^\circ\text{C}$ |      | -0.4 | $\pm 2$ |      |
|                  |                                   | $T_A = 25^\circ\text{C} \sim 85^\circ\text{C}$  |      | -0.2 | $\pm 2$ |      |

#### Dead-time control (DTC)

| Symbol     | Parameter                                      | Conditions               | Min. | Typ. | Max. | Unit          |
|------------|--|--------------------------|------|------|------|---------------|
| $I_{BDT}$  | Input Bias Current                             |                          |      |      | 1    | $\mu\text{A}$ |
| $I_{DT}$   | Latch Mode (Source) Current                    | $T_A = 25^\circ\text{C}$ | -80  | -145 |      |               |
| $V_{DT}$   | Latched Input Voltage                          | $I_O = 40\mu\text{A}$    | 2.3  |      |      | V             |
| $V_{T0}$   | Input Threshold Voltage at $f = 10\text{ KHz}$ | Zero duty cycle          |      | 2.05 | 2.25 |               |
| $V_{T100}$ |  | Maximum duty cycle       | 1.2  | 1.45 |      |               |

#### Error-amplifier

| Symbol   | Parameter                       | Conditions                                  | Min.               | Typ. | Max.      | Unit          |
|----------|---------------------------------|---|--------------------|------|-----------|---------------|
| $V_{IO}$ | Input Offset Voltage            | $V_O (\text{FB}) = 1.25\text{V}$            |                    |      | $\pm 6$   | mV            |
| $I_{IO}$ | Input Offset Current            | $V_O (\text{FB}) = 1.25\text{V}$            |                    |      | $\pm 100$ | nA            |
| $I_{IB}$ | Input Bias Current              | $V_O (\text{FB}) = 1.25\text{V}$            |                    | 160  | 500       | nA            |
| $V_{CM}$ | Common-mode Input Voltage Range | $V_{CC} = 3.6\text{V} \sim 40\text{V}$      | 1.05<br>to<br>1.45 |      |           | V             |
| $A_V$    | Open-loop Voltage Amplification | $R_F = 200\text{ K}\Omega$                  | 70                 | 80   |           | dB            |
| GBW      | Unity-gain Bandwidth            |   |                    | 1.5  |           | MHz           |
| CMRR     | Common-mode Rejection Ratio     |   | 60                 | 80   |           | dB            |
| $V_{OH}$ | Max. Output Voltage             |   | $V_{ref}-0.1$      |      |           | V             |
| $V_{OL}$ | Min. Output Voltage             |   |                    |      | 1         | V             |
| $I_{OI}$ | Output (Sink) Current (FB)      | $V_{ID} = -0.1\text{V}, V_O = 1.25\text{V}$ | 0.5                | 1.6  |           | mA            |
| $I_{OO}$ | Output (Source) Current (FB)    | $V_{ID} = 0.1\text{V}, V_O = 1.25\text{V}$  | -45                | -70  |           | $\mu\text{A}$ |

**Electrical Characteristics ( Continued )**

**Output section**

| Symbol     | Parameter                    | Conditions           | Min. | Typ. | Max. | Unit    |
|------------|------------------------------|----------------------|------|------|------|---------|
| $I_{LEAK}$ | Leakage Current              | $V_O = 40V$          |      |      | 10   | $\mu A$ |
| $V_{SAT}$  | Output Saturation Voltage    | $I_O = 10\text{ mA}$ |      | 1.2  | 2    | V       |
| $I_{SC}$   | Short-circuit Output Current | $V_O = 6V$           |      | 90   |      | mA      |

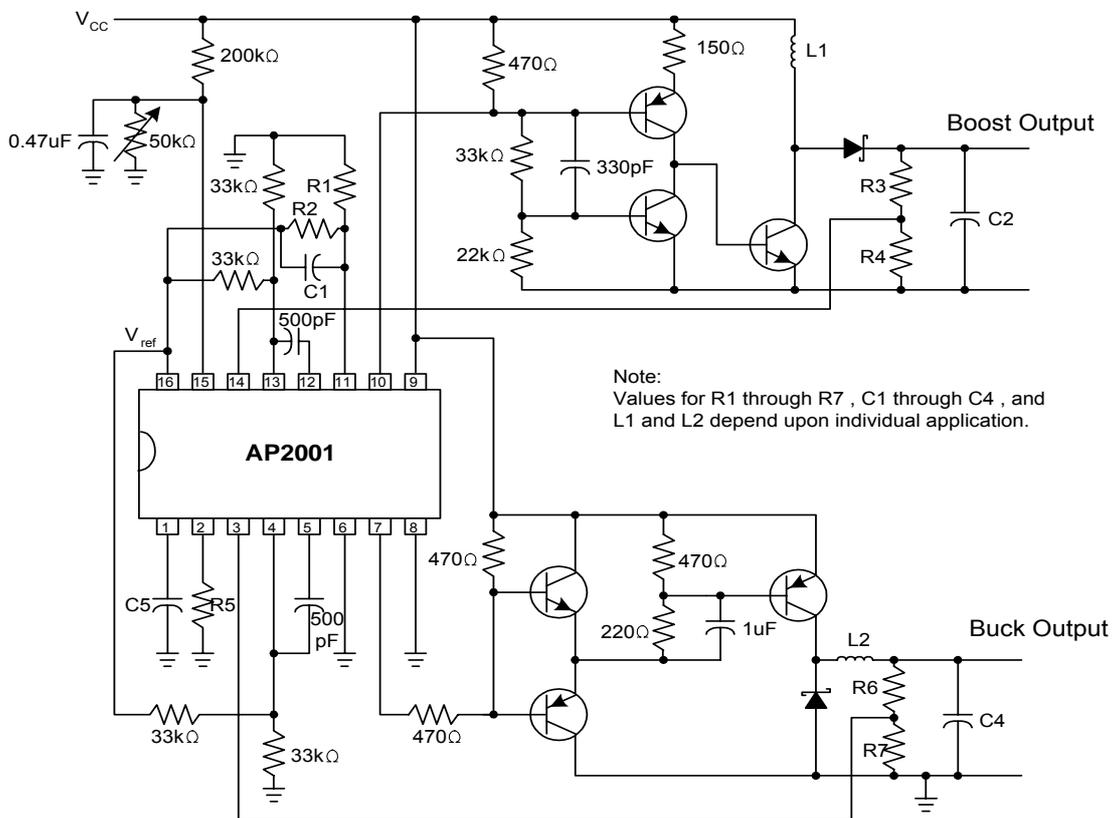
**PWM comparator**

| Symbol     | Parameter   | Conditions         | Min. | Typ. | Max. | Unit |
|------------|---|--------------------|------|------|------|------|
| $V_{T0}$   | Input Threshold Voltage at $f = 10\text{ KHz (FB)}$ | Zero duty cycle    |      | 2.05 | 2.25 | V    |
| $V_{T100}$ |   | Maximum duty cycle | 1.2  | 1.45 |      | V    |

**Total device**

| Symbol    | Parameter              | Conditions                | Min. | Typ. | Max. | Unit |
|-----------|------------------------|---------------------------|------|------|------|------|
| $I_{CCS}$ | Standby Supply Current | Off-state                 |      | 2.5  | 3.0  | mA   |
| $I_{CCA}$ | Average Supply Current | $R_T = 10\text{ K}\Omega$ |      | 2.8  | 3.5  | mA   |

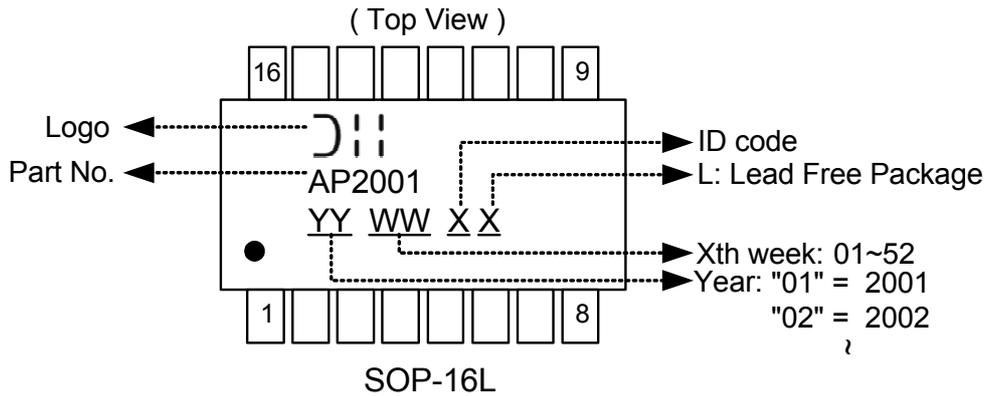
**Typical Application Circuit**



**Dual output DC/DC converter**

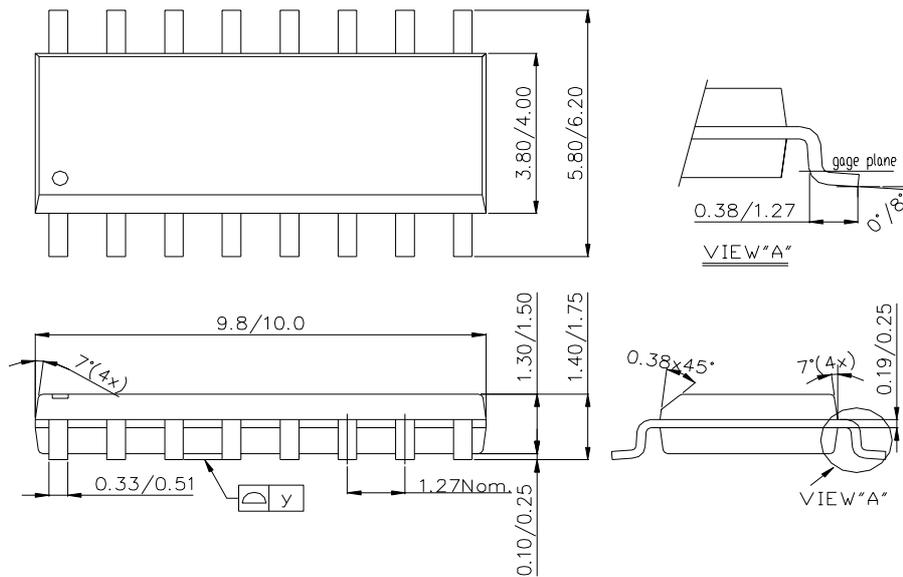
**Marking Information**

(1) SOP-16L



**Package Information**

**(1) Package Type: SOP-16L**



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