

Description

The AP3983B/C/D are series of high frequency power switcher for power supplies with better conversion efficiency, better voltage & current accuracy, and improved protection functions. Typical applications include charger, adapter for ADSL, home appliance power supply, LED lighting power supply and PC auxiliary power supplies. The AP3983B/C/D with built in MOSFET, regulates the output voltage and current in the primary side by piece-wise Pulse Frequency Modulation (p-PFM) in discontinuous conduction mode (DCM). The system operating frequency reduces linearly from heavy load to light load in each interval of the p-PFM, and enters constant current mode when the load current equals to the maximum system output current.

The AP3983B/C/D has good transient characteristics. Typically, minimal voltage of 4.3V at PCB side can be achieved for dynamic test of 5V application system.

The AP3983B/C/D provides operating frequency dithering function to improve EMC performance of power supply. The AP3983B/C/D also has built-in fixed cable voltage drop compensation and adjustable line voltage compensation.

The AP3983B/C/D solution has fewer component number, smaller size, and lower total cost.

The AP3983B/C is packaged in SO-7. The AP3983C/D is packaged in PDIP-7.

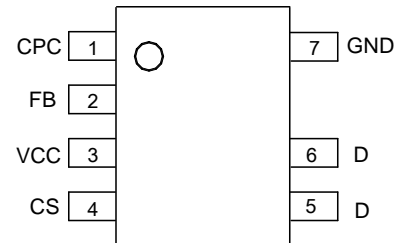
Features

- Primary Side Control for Eliminating Opto-coupler
- Better Transient Characteristics
- Built-in N Channel MOSFET with 650 BV_{DSS}
- Low Start-up Current: 0.2μA (Typ.)
- Internal Output Cable Voltage Drop Compensation
- Hiccup Function to Improve Short Circuit Protection
- Better Over Voltage Protection
- Better Over Temperature Protection
- Low Total Cost Solution
- Output Power Range (Note 1):
 - AP3983B for 6W Adapter
 - AP3983C (SO-7) for 7.5W
 - AP3983C (PDIP-7) for 10W Adapter
 - AP3983D for 18W Adapter
- **Totally Lead-Free & Fully RoHS Compliant (Notes 2 & 3)**
- **Halogen and Antimony Free. "Green" Device (Note 4)**

- Notes:
1. Typical continuous power in a non-ventilated enclosed adapter measured at +50°C ambient.
 2. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
 3. See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
 4. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

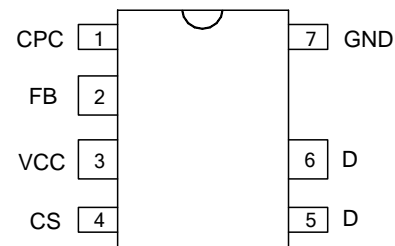
Pin Assignments

(Top View)



SO-7 For AP3983B/C

(Top View)

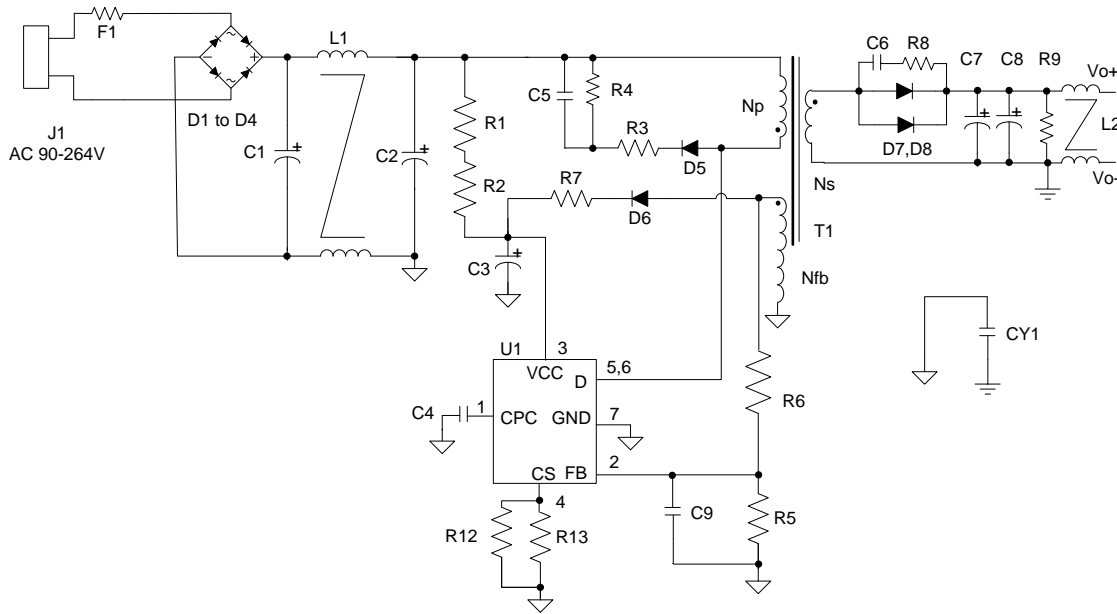


PDIP-7 For AP3983C/D

Applications

- Adapters
- Set Top Boxes
- Auxiliary Supplies
- Appliances
- LED Driver

Typical Applications Circuit



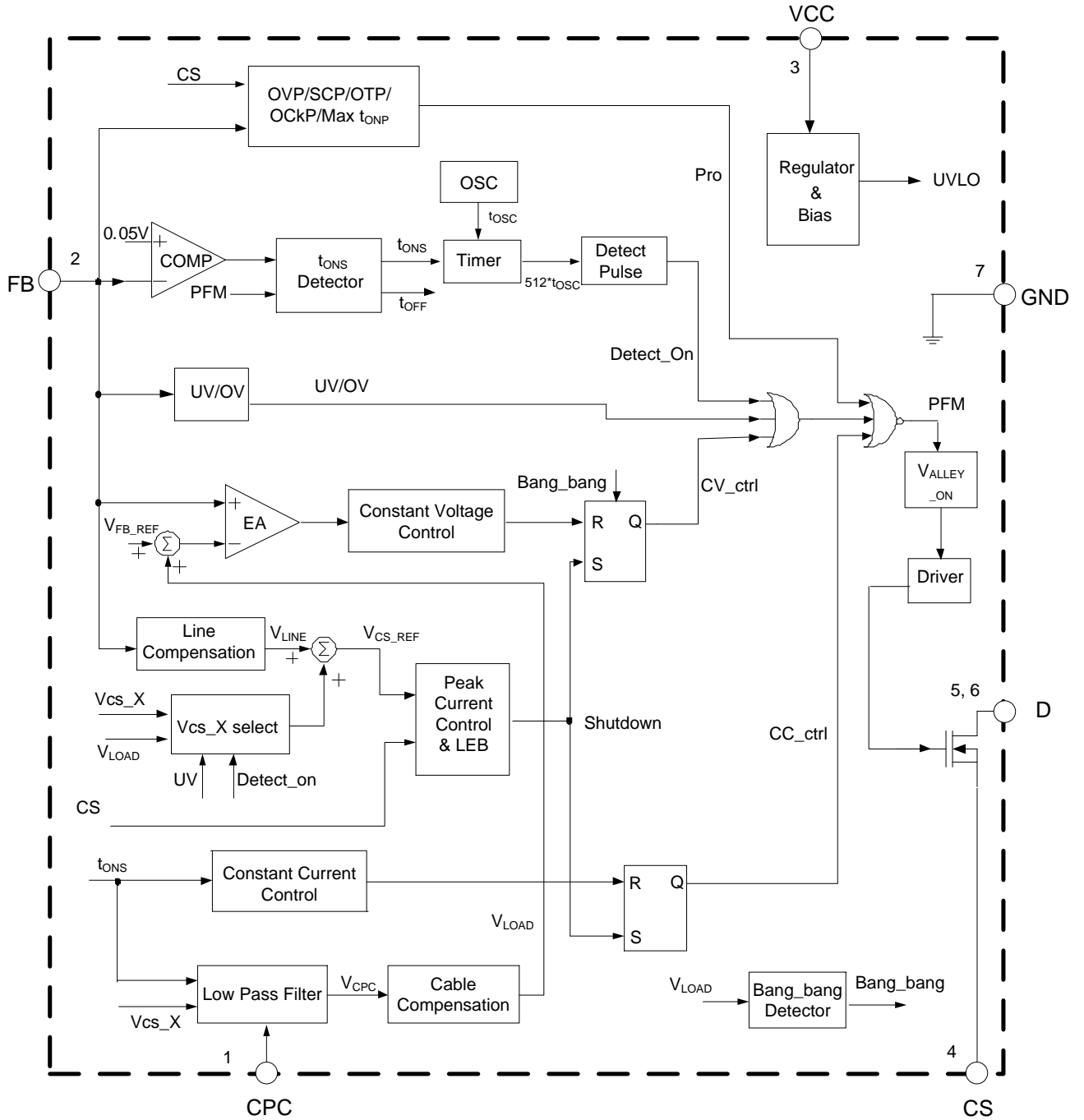
For AP3983B/C/D (12V/1.5A)

| Item | Function | QTY | Item | Function | QTY |
|----------|---------------------------------------|-----|--------|------------------------------|-----|
| C1, C2 | 15μF/400V, electrolytic | 2 | U1 | AP3983D, PDIP-7 | 1 |
| C3 | 4.7μF/50V, electrolytic | 1 | R1, R2 | 2MΩ, 1206 | 2 |
| C4 | 10nF, ceramic, 0805 | 1 | R3 | 200Ω, 1206 | 1 |
| C5 | 1nF/250V, ceramic | 1 | R4 | 150kΩ, 1206 | 1 |
| C6 | 1nF/100V, 0805 | 1 | R5 | 22kΩ, 1%, 0805 | 1 |
| C7, C8 | 1000μF/16V, electrolytic | 2 | R6 | 47kΩ, 1%, 0805 | 1 |
| C9 | 10pF/16V, 0805 | 1 | R7 | 2Ω, 1206 | 1 |
| CY1 | 1nF/250V _{AC} , Y1 capacitor | 1 | R8 | 30Ω, 1206 | 1 |
| D1 to D6 | 1N4007, rectifier diode | 6 | R9 | 5.1kΩ, 1206 | 1 |
| D7, D8 | MBR3100, Schottky diode | 2 | R12 | 1.2Ω, 1%, 1206 | 1 |
| F1 | 2A/250V, fuse | 1 | R13 | 1.8Ω, 1%, 1206 | 1 |
| L1 | 30mH, Common inductor, EE9.8 | 1 | T1 | EE20 core, PC40, transformer | 1 |
| L2 | 250μH/2A, Common inductor | 1 | - | - | - |

Pin Descriptions

| Pin Number | Pin Name | Function |
|------------|----------|---|
| 1 | CPC | This pin connects a capacitor to GND for output cable compensation |
| 2 | FB | The voltage feedback from auxiliary winding |
| 3 | VCC | This pin receives rectified voltage from the auxiliary winding of the transformer |
| 4 | CS | Current sense for primary side of transformer |
| 5, 6 | D | This pin is connected with an internal power MOSFET's drain |
| 7 | GND | This pin is the signal reference ground |

Functional Block Diagram



Absolute Maximum Ratings (Note 5)

| Symbol | Parameter | Rating | | Unit |
|------------------------------------|---|------------------|------|------|
| V _{CC} | Supply Voltage | -0.3 to 30 | | V |
| V _{CS} , V _{CPC} | Voltage on CS, CPC Pin | -0.3 to 7 | | V |
| V _{FB} | FB Input Voltage | -0.3 to 8 | | V |
| BV _{DSS} | Drain Voltage (T _J = +25°C) | 700 | | V |
| I _D | Drain Continuous Current (T _J = +25°C) | AP3983B | 1 | A |
| | | AP3983C | 2 | |
| | | AP3983D | 4 | |
| T _J | Operating Junction Temperature | -40 to +150 | | °C |
| T _{STG} | Storage Temperature | -65 to +150 | | °C |
| T _{LEAD} | Lead Temperature (Soldering, 10 sec) | +300 | | °C |
| – | ESD (Machine Model) | 200 | | V |
| – | ESD (Human Body Model) | 2000 | | V |
| P _D | Total Power Dissipation | AP3983B | 0.7 | W |
| | | AP3983C (SO-7) | 0.85 | |
| | | AP3983C (PDIP-7) | 1.0 | |
| | | AP3983D | 1.8 | |

Note 5: Stresses greater than those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “Recommended Operating Conditions” is not implied. Exposure to “Absolute Maximum Ratings” for extended periods may affect device reliability.

Recommended Operating Conditions

| Symbol | Parameter | Min | Max | Unit |
|---------------------|-----------------------------|-----|------|------|
| V _{CC} | Supply Voltage | – | 25 | V |
| T _{OP} | Operating Temperature Range | -40 | +105 | °C |
| f _{S(MAX)} | Maximum Operating Frequency | – | 80 | kHz |

Thermal Impedance (Note 6)

| Symbol | Parameter | Value | | Unit |
|-----------------|---------------------|------------------|----|------|
| θ _{JA} | Junction to Ambient | AP3983B | 95 | °C/W |
| | | AP3983C (SO-7) | 85 | |
| | | AP3983C (PDIP-7) | 70 | |
| | | AP3983D | 40 | |
| θ _{JC} | Junction to Case | AP3983B | 48 | |
| | | AP3983C (SO-7) | 43 | |
| | | AP3983C (PDIP-7) | 35 | |
| | | AP3983D | 20 | |

Note 6: When mounted a standard single-sided FR-4 board with 300mm² Cu (at least 35µm thick) connected to all collectors and CS pins.

Electrical Characteristics (@V_{CC} = 15V, T_J = +25°C, unless otherwise specified.)

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|--|--|--|------|------|------|------|
| STARTUP AND UVLO SECTION | | | | | | |
| V _{TH_ST} | Turn-on Voltage | – | 13 | 15.5 | 18 | V |
| V _{OPR(MIN)} | Turn-off Voltage | – | 6 | 6.8 | 7.6 | V |
| STANDBY CURRENT SECTION | | | | | | |
| I _{ST} | Turn-on Current | V _{CC} = V _{TH_ST} -1V before startup | 0 | 0.2 | 0.6 | μA |
| I _{CC_OPR} | Operating Current | Static current @ no load | 350 | 500 | 650 | |
| OPERATING FREQUENCY SECTION (5% LOAD TO FULL LOAD) | | | | | | |
| f _{S(MAX)} | Operating Frequency in Full Load Condition | – | – | 65 | 80 | kHz |
| Δf/f | Frequency Dithering | 5% to 100% of full load range | 4 | 7 | 10 | % |
| OPERATING FREQUENCY SECTION (NO LOAD TO 5% OF I_{OUT(MAX)}) | | | | | | |
| f _{S(MIN)} | Output Voltage Detection Frequency | – | 1.8 | 2 | 2.2 | kHz |
| CURRENT SENSE SECTION | | | | | | |
| V _{CS_H} | Peak Current Sense Voltage in Heavy Load | 30% to 100% of full load | 828 | 900 | 972 | mV |
| ΔV _{CS} /V _{CS} | V _{CS} Modulation for Frequency Dithering | – | – | 2.5 | – | % |
| t _{MOD} | V _{CS} Modulation Period | – | – | 250 | – | μs |
| R _{LINE} | Built-in Line Compensation Resistor | – | – | 230 | – | Ω |
| t _{LEB} | Leading Edge Blanking | @ V _{CS_H} and V _{CS_M} | 410 | 500 | 575 | ns |
| | | @ V _{CS_EL} | 220 | 250 | 288 | ns |
| CONSTANT VOLTAGE SECTION | | | | | | |
| V _{FB} | Equivalent Feedback Voltage @ Light Load | Closed loop test of V _{OUT} | 3.89 | 3.95 | 4.01 | V |
| R _{FB} | FB Pin Input Resistance | – | 560 | 700 | 840 | kΩ |
| V _{CABLE} /V _{OUT} | Cable Compensation Ratio | (V _{FB@FULLLOAD} -V _{FB})/V _{FB} | 5.65 | 6.00 | 6.40 | % |
| CONSTANT CURRENT SECTION | | | | | | |
| t _{ONS} /t _{SW} | Secondary Winding Conduction Duty | V _{FB} = 2V | – | 4/8 | – | – |
| POWER MOSFET SECTION | | | | | | |
| BV _{DSS} | Drain-Source Breakdown Voltage | – | 650 | – | – | V |
| R _{DS(ON)} | On State Resistor | AP3983B | – | 9 | 12 | Ω |
| | | AP3983C | – | 5 | 6 | |
| | | AP3983D | – | 2.4 | 3 | |
| PROTECTION FUNCTION SECTION | | | | | | |
| V _{FB(OVP)} | Over Voltage Protection | – | – | 7.5 | – | V |
| V _{FB(SCP)} | Short Circuit Protection | V _{FB} @ Hiccup | 1.4 | 1.5 | 1.6 | V |
| T _{OTP} | Shutdown Temperature | – | +125 | +160 | – | °C |
| T _{HYS} | Temperature Hysteresis | – | – | +40 | – | °C |

Operation Description

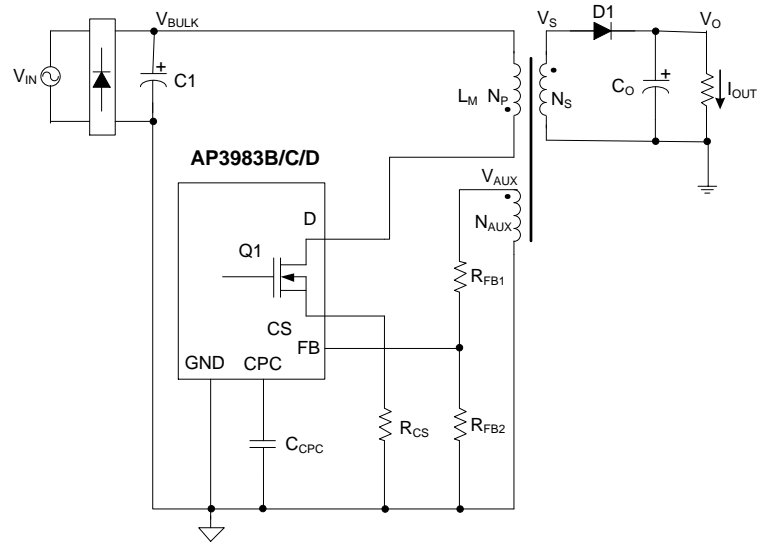


Figure 1. Simplified Flyback Converter Controlled by AP3983B/C/D

Constant Primary Peak Current

The primary $i_P(t)$ current is sensed by a current sense resistor R_{CS} as shown in Figure 1.

The current rises up linearly at a rate of:

$$\frac{di_P(t)}{dt} = \frac{V_{BULK}(t)}{L_M} \dots\dots\dots (1)$$

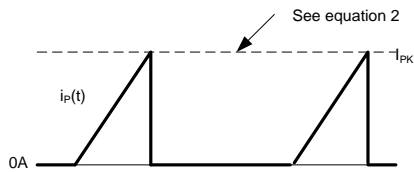


Figure 2. Primary Current Waveform

As illustrated in Figure 2, when the current $i_P(t)$ rises up to I_{PK} , the switch Q1 turns off. The constant peak current is given by:

$$I_{PK} = \frac{V_{CS}}{R_{CS}} \dots\dots\dots (2)$$

The energy stored in the magnetizing inductance L_M each cycle is therefore:

$$E_G = \frac{1}{2} \cdot L_M \cdot I_{PK}^2 \dots\dots\dots (3)$$

So the power transferring from input to output is given by:

$$P = \frac{1}{2} \cdot L_M \cdot I_{PK}^2 \cdot f_{SW} \dots\dots\dots (4)$$

Where f_{SW} is the switching frequency. When the peak current I_{PK} is constant, the output power depends on the switching frequency f_{SW} .

Constant Voltage Operation

The AP3983B/C/D captures the auxiliary winding feedback voltage at FB pin and operates in constant-voltage (CV) mode to regulate the output voltage. Assuming the secondary winding is master, the auxiliary winding is slave during the D1 on-time. The auxiliary voltage is given by:

Operation Description (Cont.)

$$V_{AUX} = \frac{N_{AUX}}{N_S} \cdot (V_0 + V_D) \dots\dots\dots(5)$$

Where V_D is the diode forward drop voltage, N_{AUX} is the turns of auxiliary winding, and N_S is the turns of secondary winding.

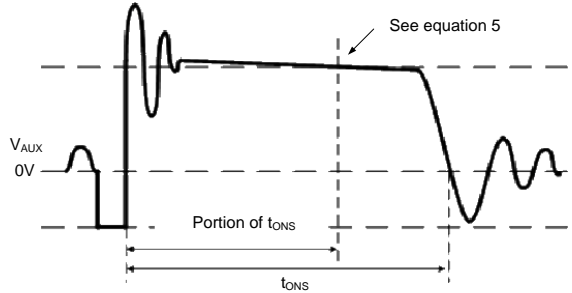


Figure 3. Auxiliary Voltage Waveform

The output voltage is different from the secondary voltage in a diode forward drop voltage V_D which depends on the current. If the secondary voltage is always detected at a constant secondary current, the difference between the output voltage and the secondary voltage will be a fixed V_D . The voltage detection point is portion of t_{ONS} after D1 is turned on. The CV loop control function of AP3983B/C/D then generates a D1 off-time to regulate the output voltage.

Constant Current Operation

The AP3983B/C/D is designed to work in constant current (CC) mode. Figure 4 shows the secondary current waveforms.

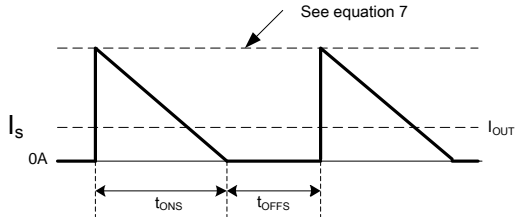


Figure 4. Secondary Current Waveform

In CC operation, the CC loop control function of AP3983B/C/D will keep a fixed proportion between D1 on-time t_{ONS} and D1 off-time t_{OFFS} by discharging or charging the built-in capacitance connected. This fixed proportion is

$$\frac{t_{ONS}}{t_{OFFS}} = \frac{4}{4} \dots\dots\dots(6)$$

The relation between the output constant-current and secondary peak current I_{PKS} is given by:

$$I_{OUT} = \frac{1}{2} \cdot I_{PKS} \cdot \frac{t_{ONS}}{t_{ONS} + t_{OFFS}} \dots\dots\dots(7)$$

At the instant of D1 turn-on, the primary current transfers to the secondary at an amplitude of:

$$I_{PKS} = \frac{N_P}{N_S} \cdot I_{PK} \dots\dots\dots(8)$$

Thus the output constant current is given by:

$$I_{OUT} = \frac{1}{4} \cdot \frac{N_P}{N_S} \cdot I_{PK} \dots\dots\dots(9)$$

Operation Description (Cont.)

Leading Edge Blanking (LEB)

When the power switch is turned on, a turn-on spike on the output pulse rising edge will occur on the sense-resistor. To avoid false termination of the switching pulse, a typical 500ns leading edge blanking is built in. During this blanking period, the current sense comparator is disabled and the gate driver cannot be switched off.

The built-in LEB in AP3983B/C/D has shorter delay time from current sense terminal to output pulse than those IC solutions adopting external RC filter as LEB.

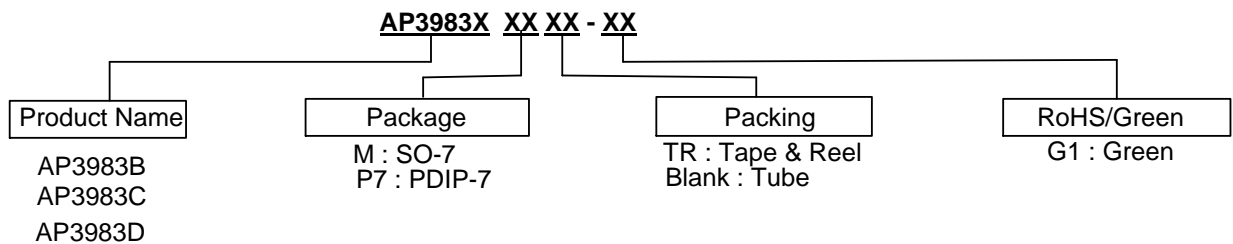
Built-in Cable Compensation

The AP3983B/C/D has built-in fixed voltage of 0.3V typical to compensate the drop of output cable when the load is changed from zero to full load. A typical 10nF external capacitor connected to the CPC pin is used to smooth voltage signal for cable compensation.

Over Temperature Protection

The AP3983B/C/D has internal thermal sensing circuit to shut down the PFM driver output when the die temperature reaches +160°C typical. When the die temperature drops about +40°C, the IC will recover automatically to normal operation.

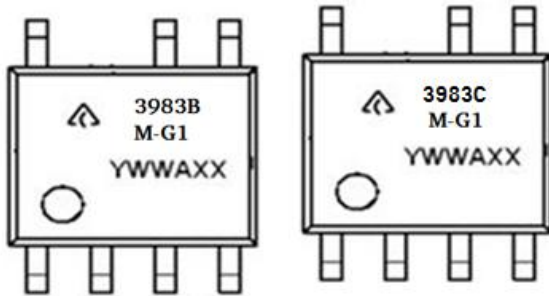
Ordering Information



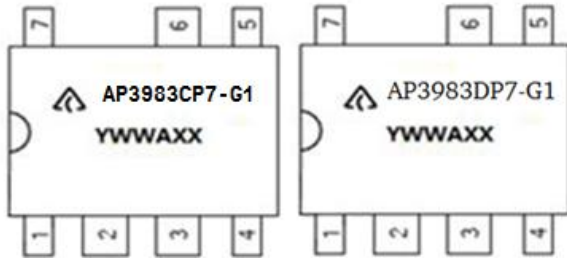
| Package | Temperature Range | Part Number | Marking ID | Packing |
|---------|-------------------|---------------|--------------|------------------|
| SO-7 | -40°C to +105°C | AP3983BMTR-G1 | 3983BM-G1 | 4000/Tape & Reel |
| SO-7 | | AP3983CMTR-G1 | 3983CM-G1 | 4000/Tape & Reel |
| PDIP-7 | | AP3983CP7-G1 | AP3983CP7-G1 | 50/Tube |
| PDIP-7 | | AP3983DP7-G1 | AP3983DP7-G1 | 50/Tube |

Marking Information

(Top View)



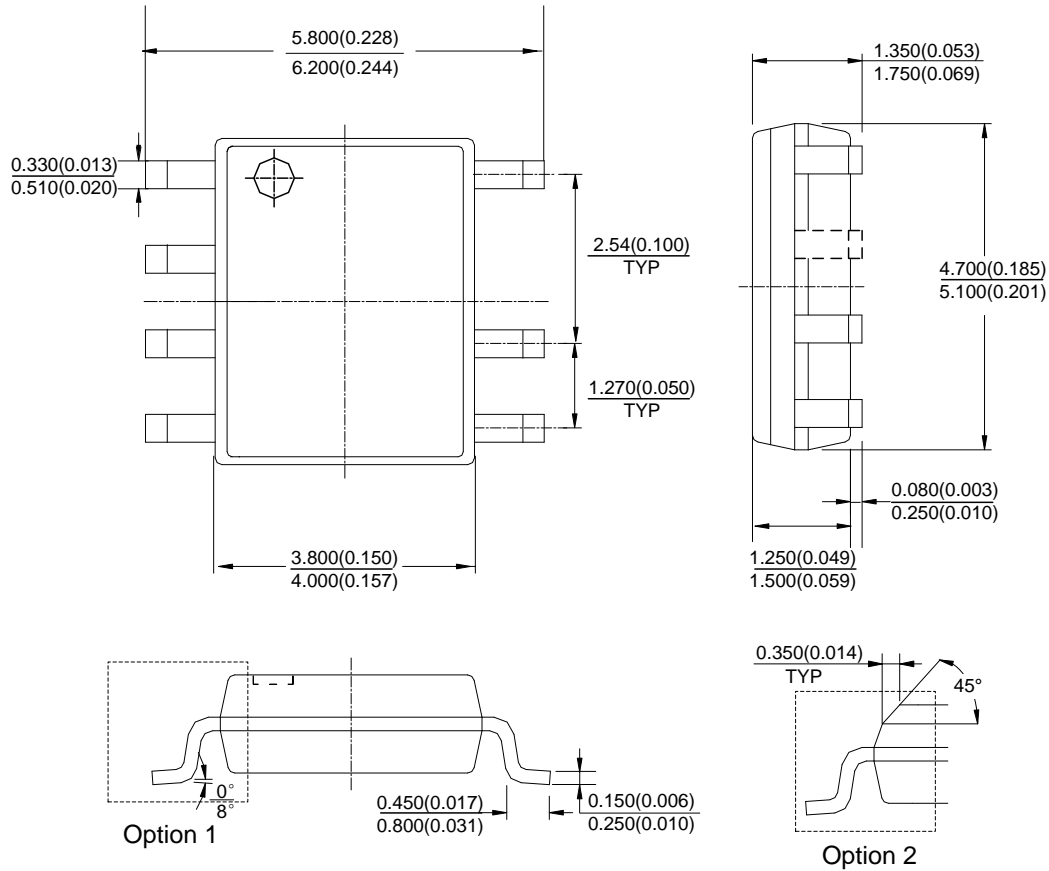
First and Second Lines: Logo and Marking ID
 Third Line: Date Code
 Y: Year
 WW: Work Week of Molding
 A: Assembly House Code
 XX: 7th and 8th Digits of Batch No.



First Line: Logo and Marking ID
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Package Outline Dimensions (All dimensions in mm (inch).)

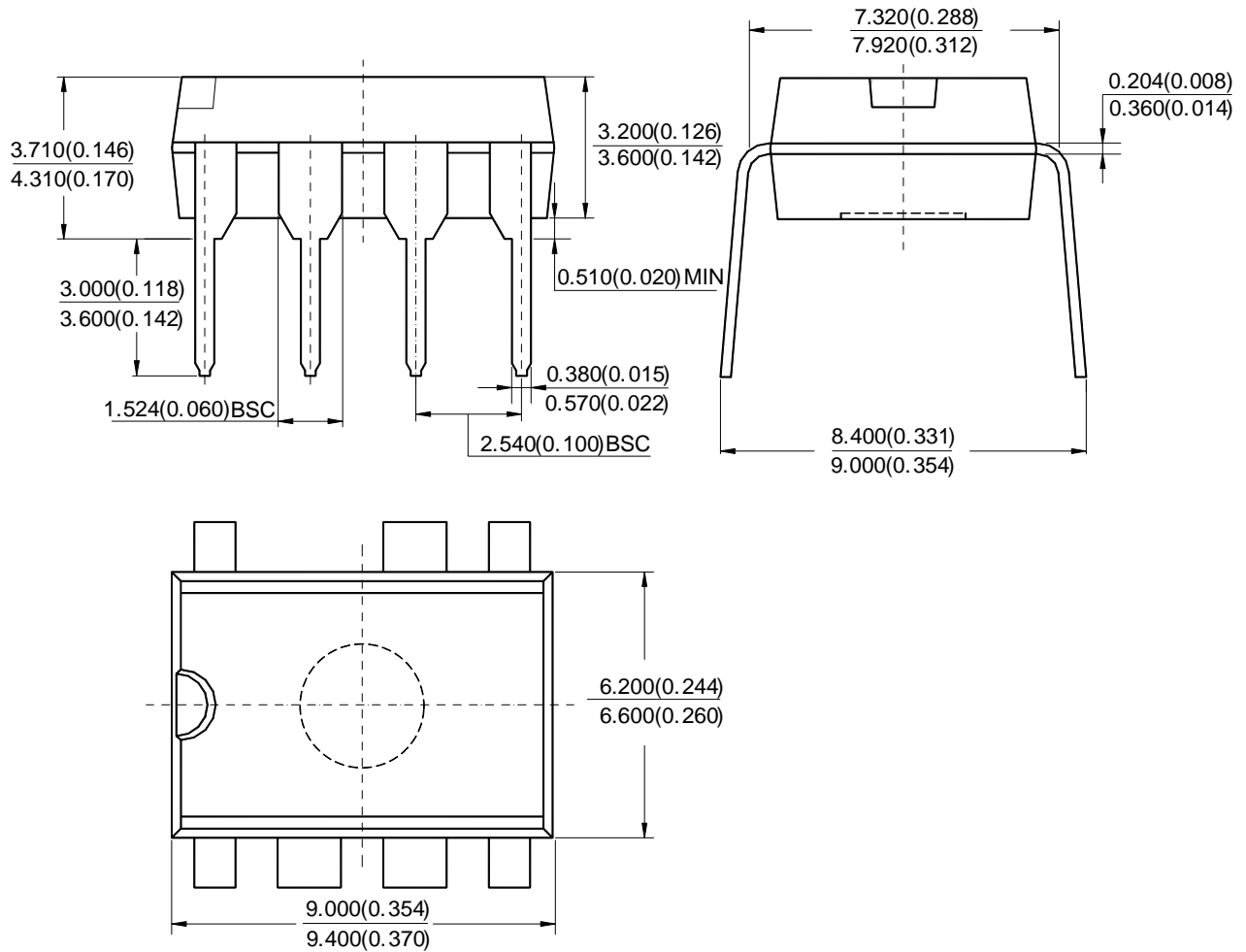
(1) Package Type: SO-7



Note: Eject hole, oriented hole and mold mark is optional.

Package Outline Dimensions (Cont.) (All dimensions in mm (inch).)

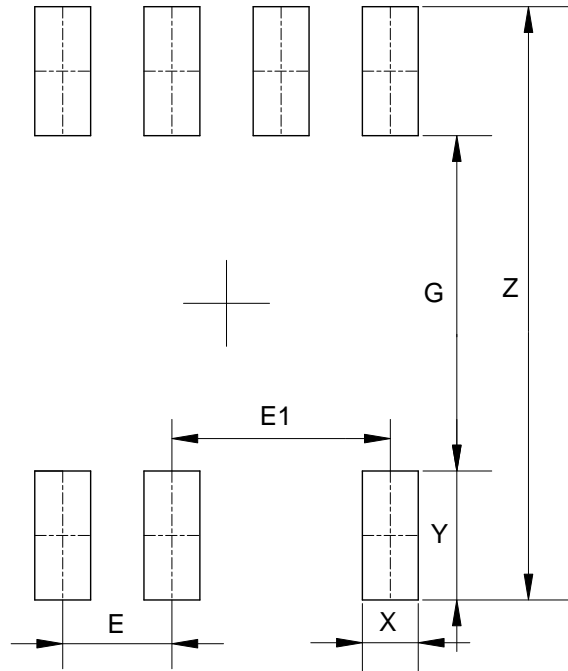
(2) Package Type: PDIP-7



Note: Eject hole, oriented hole and mold mark is optional

Suggested Pad Layout

(1) Package Type: SO-7



| Dimensions | Z (mm)/(inch) | G (mm)/(inch) | X (mm)/(inch) | Y (mm)/(inch) | E (mm)/(inch) | E1 (mm)/(inch) |
|------------|------------------|------------------|------------------|------------------|------------------|-------------------|
| Value | 6.900/0.272 | 3.900/0.154 | 0.650/0.026 | 1.500/0.059 | 1.270/0.050 | 2.540/0.100 |

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