

ActiveQR™ Quasi-Resonant PWM Power Switch

FEATURES

- Integrated Power MOSFET
- CCM and Quasi-Resonant Operation
- Adjustable up to 75kHz Switching Frequency
- Integrated Patented Frequency Foldback Technique
- Integrated Patented Line Compensation
- Built-in Soft-Start Circuit
- OCP/OLP Protection
- Line Under-Voltage, Thermal, Output Over-voltage, Output Short Protections
- Current Sense Resistor Short Protection
- Transformer Short Winding Protection
- 100mW Standby Power
- Complies with Global Energy Efficiency and CEC Average Efficiency Standards
- SOP-8 and DIP-7 Packages

APPLICATIONS

- Power Supplies for Portable Media Player, DSCs, Set-top boxes, DVD players, records
- Adaptors for Small home appliances
- Auxiliary Power Supply for PC, LCD TV and PDP TV

GENERAL DESCRIPTION

ACT518 is a high performance peak current mode PWM power switch. It applies ActiveQR™ and frequency foldback technique to reduce EMI and improve efficiency. Its maximum design switching frequency is set at 75kHz. Very low standby power, good dynamic response and accurate voltage regulation is achieved with an opto-coupler and the secondary side control circuit.

The Idle mode operation enables low standby power of 100mW with small output voltage ripple. By applying frequency foldback and ActiveQR™ technology, The integrated power switch increases the average system efficiency compared to

conventional solutions and exceeds the latest ES2.0 efficiency standard with good margin.

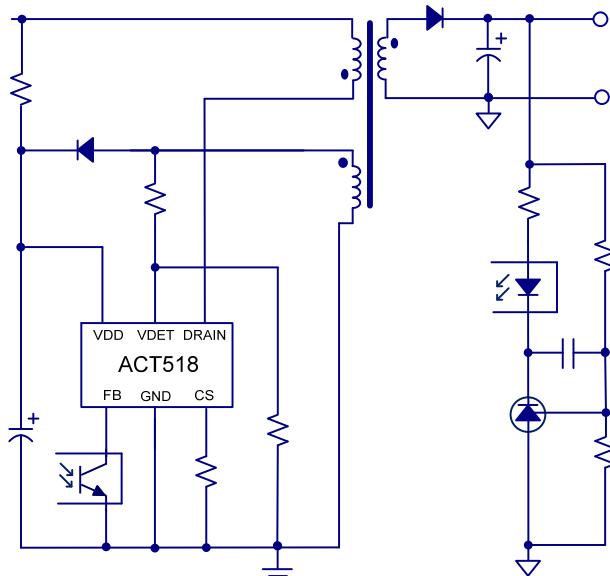
ACT518 integrates comprehensive protection. In case of over temperature, over voltage, short winding, short current sense resistor, open loop and overload conditions, it would enter into auto restart mode including Cycle-by-Cycle current limiting.

ACT518 is to achieve no overshoot and very short rise time even with big capacitive load with the built-in fast and soft start process.

In full load condition, ACT518 is able to be designed to work in both CCM mode and DCM mode to meet different types of applications. Quasi-Resonant (QR) operation mode can effectively improve efficiency during DCM operation, and reduce the EMI noise and further reduce the components in input filter.

ACT518SH is for application up to 10 Watt and ACT518DF is for application up to 18 Watt.

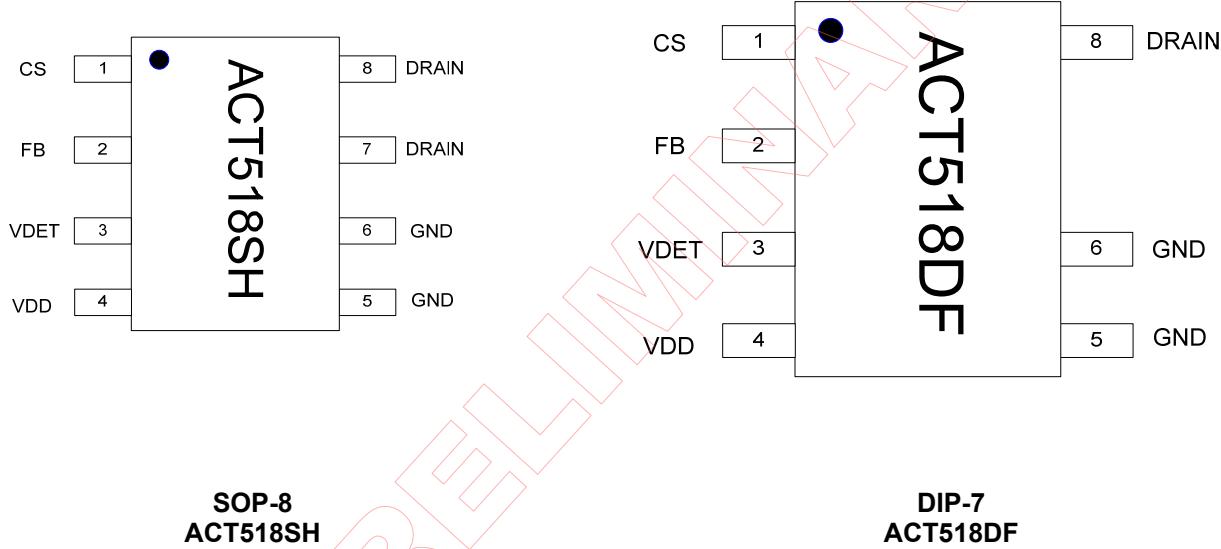
Figure 1:
Simplified Application Circuit



ORDERING INFORMATION

| PART NUMBER | TEMPERATURE RANGE | PACKAGE | PINS | PACKING METHOD | TOP MARK |
|-------------|-------------------|---------|------|----------------|----------|
| ACT518SH-T | -40°C to 85°C | SOP-8 | 8 | TUBE & REEL | ACT518SH |
| ACT518DF | -40°C to 85°C | DIP-7 | 7 | TUBE | ACT518DF |

PIN CONFIGURATION



PIN DESCRIPTIONS

| PIN | NAME | DESCRIPTION |
|-----|-------|---|
| 1 | CS | Current Sense Pin. Connect an external resistor (R_{CS}) between this pin and ground to set peak current limit for the primary switch. |
| 2 | FB | Feedback Pin. Connect this pin to optocouplers's collector for output regulation. |
| 3 | VDET | Valley Detector Pin. Connect this pin to a resistor divider network from the auxiliary winding to detect zero-crossing points for valley turn on operation. |
| 4 | VDD | Power Supply. This pin provides bias power for the IC during startup and steady state operation. |
| 5,6 | GND | Ground. |
| 7,8 | DRAIN | MOSFET Drain Pin. |

ABSOLUTE MAXIMUM RATINGS^①

| PARAMETER | VALUE | UNIT |
|--|---------------|------|
| DRAIN to GND | -0.3 to + 650 | V |
| FB, CS, VDET to GND | -0.3 to + 6 | V |
| VDD to GND | -0.3 to + 28 | V |
| Continuous Drain Current, $T_C=25^\circ\text{C}$ | SOP-8 | 2 |
| | DIP-7 | 4 |
| Continuous Drain Current, $T_C=100^\circ\text{C}$ | SOP-8 | 1.1 |
| | DIP-7 | 2.9 |
| Maximum Power Dissipation | SOP-8 | 0.95 |
| | DIP-7 | 1.5 |
| Junction to Ambient Thermal Resistance (θ_{JA}) | SOP-8 | 105 |
| | DIP-7 | 80 |
| Operating Junction Temperature | -40 to 125 | °C |
| Storage Temperature | -55 to 150 | °C |
| Lead Temperature (Soldering, 10 sec) | 300 | °C |

①: Do not exceed these limits to prevent damage to the device. Exposure to absolute maximum rating conditions for long periods.

ELECTRICAL CHARACTERISTICS

($V_{DD} = 14\text{V}$, $L_M = 1.3\text{mH}$, $R_{CS} = 1.65\Omega$, $V_{OUT} = 5\text{V}$, $N_P = 114$, $N_S = 9$, $N_A = 23$, $T_A = 25^\circ\text{C}$, unless otherwise specified.)

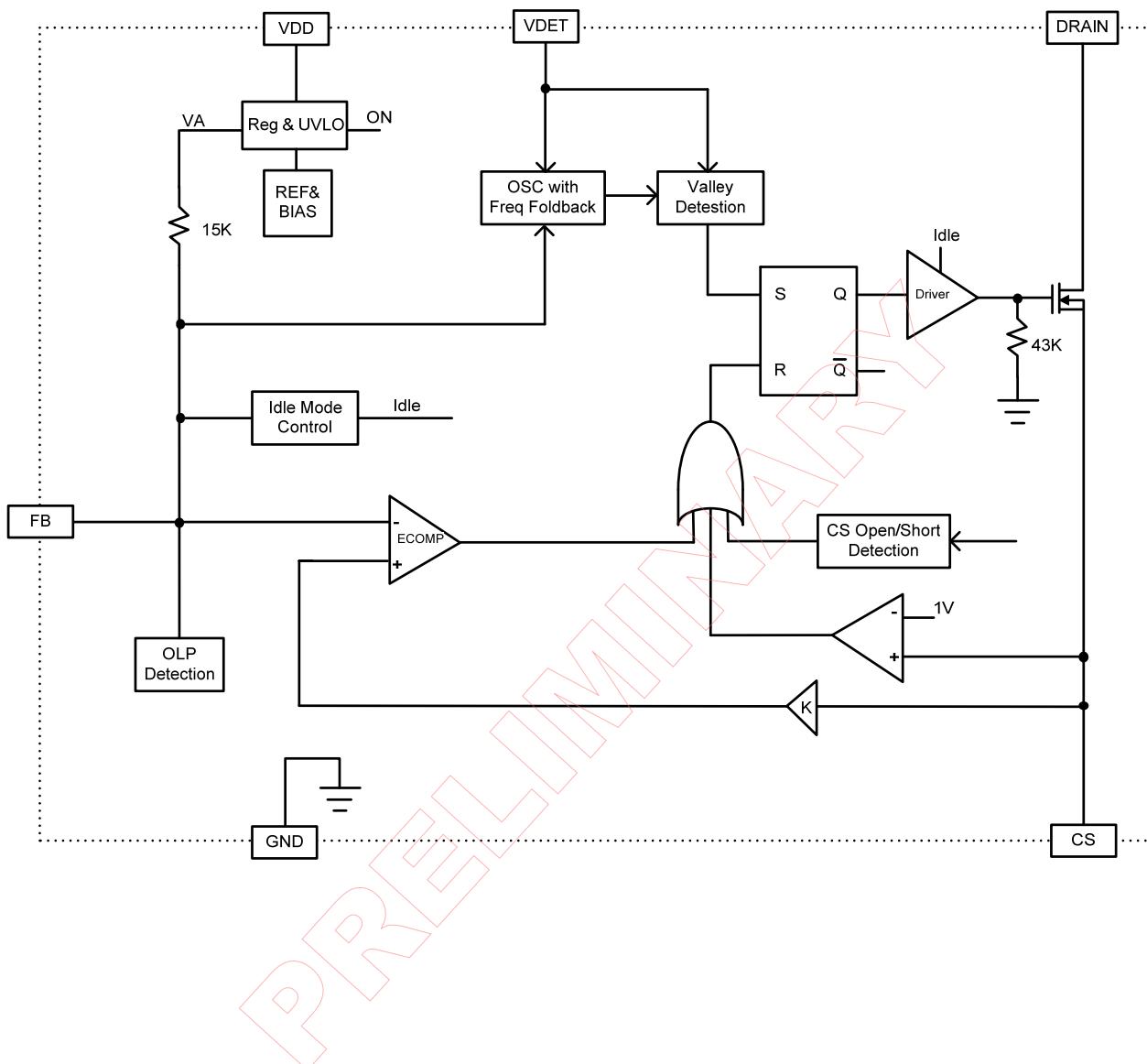
| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|-------------------------------------|---------------|--|------|--------------|------|------------------|
| Supply | | | | | | |
| VDD Turn-On Voltage | V_{DDON} | V_{DD} Rising from 0V | 11.3 | 12.3 | 13.3 | V |
| VDD Turn-Off Voltage | V_{DDOFF} | V_{DD} Falling after Turn-on | 6.7 | 7.4 | 8.1 | V |
| VDD Over Voltage Protection | V_{DDOVP} | V_{DD} Rising from 0V | | 25 | | V |
| Start Up Supply Current | I_{DDST} | $V_{DD} = 10\text{V}$, before VDD Turn-on | | 8 | 15 | μA |
| IDD Supply Current | I_{DD} | $V_{DD} = 15\text{V}$, after VDD Turn-on, FB floating | | 0.6 | | mA |
| IDD Supply Current at Standby | I_{DDSTBY} | FB = 1.3V | | 0.4 | | mA |
| IDD Supply Current at Fault | $I_{DDFAULT}$ | Fault mode, FB Floating | | 250 | | μA |
| Feedback | | | | | | |
| FB Pull up Resistor | R_{FB} | | 15 | | | $\text{k}\Omega$ |
| CS to FB Gain | A_{CS} | | 3 | | | V/V |
| VFB at Max Peak Current | | | | 3 + V_{BE} | | V |
| FB Threshold to Stop Switching | V_{FBM1} | | 1.32 | | | V |
| FB Threshold to Start Switching | V_{FBM2} | | 1.41 | | | V |
| Output Overload Threshold | | | 4.2 | | | V |
| OverLoad/Over Voltage Blanking Time | $T_{OVBLANK}$ | | 320 | | | ms |

ELECTRICAL CHARACTERISTICS CONT'D

($V_{DD} = 14V$, $L_M = 1.3mH$, $R_{CS} = 1.65\Omega$, $V_{OUT} = 5V$, $N_P = 114$, $N_S = 9$, $N_A = 23$, $T_A = 25^\circ C$, unless otherwise specified.)

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--------------------------------|------------------|---|-------|-------------|-------|------------|
| Power Mosfet | | | | | | |
| Drain Source Breakdown Voltage | BV_{DSS} | $V_{GS}=0V, I_D=250\mu A$ | 650 | | | V |
| Drain On Resistor | R_{DSON} | $V_{GS}=10V, I_D=1A, SOP-8$ | | 5.1 | | Ω |
| | | $V_{GS}=10V, I_D=2A, DIP-7$ | | | 3.6 | Ω |
| Current Limit | | | | | | |
| CS Current Limit Threshold | V_{CSLIM} | | 0.91 | 0.96 | 1.01 | V |
| Leading Edge Blanking Time | $T_{CSBLANK}$ | | 240 | 300 | 360 | ns |
| Oscillator | | | | | | |
| Maximum Switching Frequency | f_{MAX} | | | 75 | | kHz |
| Switching Frequency Foldback | f_{MIN} | $FB = 2.3V + V_{BE}$ | | $f_{MAX}/3$ | | kHz |
| Maximum Duty Cycle | D_{MAX} | | 65 | 75 | | % |
| Valley Detection | | | | | | |
| ZCD Threshold Voltage | $V_{DET_{TH}}$ | | 100 | | | mV |
| Valley Detection Time Window | | After valley detection time window, if no valley detected, forcedly turn-on main switch | | 3.5 | | μs |
| VDET Leakage Current | | | 1 | | | μA |
| Protection | | | | | | |
| CS Short Waiting Time | | | 2 | | | μs |
| CS Short Detection Threshold | | | 0.115 | | | V |
| CS Open Threshold Voltage | | | 1.73 | | | V |
| Abnormal OCP Blanking Time | | | 150 | | | ns |
| Thermal Shutdown Temperature | | | 135 | | | $^\circ C$ |
| Line UVLO | $I_{VDETUVLO}$ | | 0.1 | | | mA |
| Line OVP | $I_{VDETOVP}$ | | 2 | | | mA |
| VDET Over Voltage Protection | $V_{DETVOVP}$ | | 2.448 | 2.72 | 2.992 | V |
| VDET Vo Short Threshold | $V_{DETVOshort}$ | | 0.406 | 0.58 | 0.754 | V |

FUNCTIONAL BLOCK DIAGRAM



FUNCTIONAL DESCRIPTION

ACT518 is a high performance peak current mode PWM integrated power IC. It includes the most advance features that are required in the adaptor applications up to 12 Watt. Unique fast startup, frequency foldback, QR switching technique, accurate peak current line compensation, Idle mode, short winding protection, OCP, OTP, OVP and UVLO are included in the controller.

Startup

Startup current of ACT518 is designed to be very low so that VDD could be charged to V_{DDON} threshold level and device starts up quickly. A large value startup resistor can therefore be used to minimize the power loss yet reliable startup in application. For a typical AC/DC adaptor with universal input range design, two $1\text{M}\Omega$, $1/8\text{ W}$ startup resistors could be used together with a VDD capacitor(4.7uF) to provide a fast startup and yet low power dissipation design solution.

During startup period, the IC begins to operate with minimum I_{ppk} to minimize the switching stresses for the main switch, output diode and transformers. And then, the IC operates at maximum power output to achieve fast rise time. After this, V_{OUT} reaches about 90% V_{OUT} , the IC operates with a 'soft-landing' mode(decrease I_{ppk}) to avoid output overshoot.

Constant Voltage (CV) Mode Operation

In constant voltage operation, the ACT518 regulates its output voltage through secondary side control circuit . The output voltage information is sensed at FB pin through OPTO coupling. The error signal at FB pin is amplified through TL431 and OPTO circuit. When the secondary output voltage is above regulation, the error amplifier output voltage decreases to reduce the switch current. When the secondary output voltage is below regulation, the error amplifier output voltage increases to ramp up the switch current to bring the secondary output back to regulation. The output regulation voltage is determined by the following relationship:

$$V_{OUTCV} = V_{REF_TL431} \times \left(1 + \frac{R_{F1}}{R_{F2}}\right) \quad (1)$$

where R_{F1} (R_{13}) and R_{F2} (R_{14}) are top and bottom feedback resistor of the TL431.

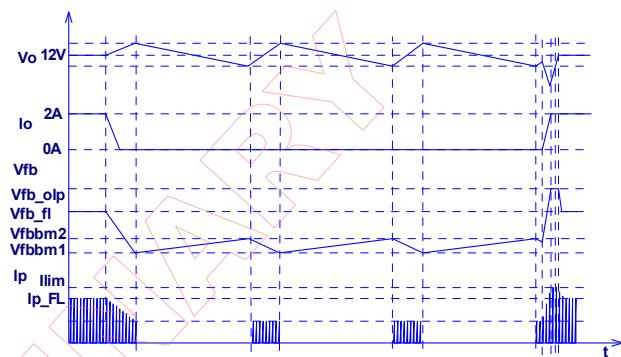
No Load Idle Mode

In no load standby mode, the feedback voltage falls below V_{FBM2} and reaches V_{FBM1} , ACT518 stop switching. After it stops, as a result of a feedback

reaction, the feedback voltage increases. When the feedback voltage reaches V_{FBM2} , ACT518 start switching again. Feedback voltage drops again and output voltage starts to bounds back and forward with very small output ripple. ACT518 leaves Idle mode when load is added strong enough to pull feedback voltage exceed V_{FBM2} .

Figure 2:

Idle Mode



Primary Inductor Current Limit Compensation

The ACT518 integrates a primary inductor peak current limit compensation circuit to achieve constant OLP over wide line and wide inductance.

Frequency Foldback

When the load drops to 75% of full load level, ACT518 starts to reduce the switching frequency, which is proportional to the load current ,to improve the efficiency of the converter.

ACT518's load adaptive switching frequency enables applications to meet all latest green energy standards. The actual minimum average switching frequency is programmable with output capacitance, feedback circuit and dummy load (while still meeting standby power).

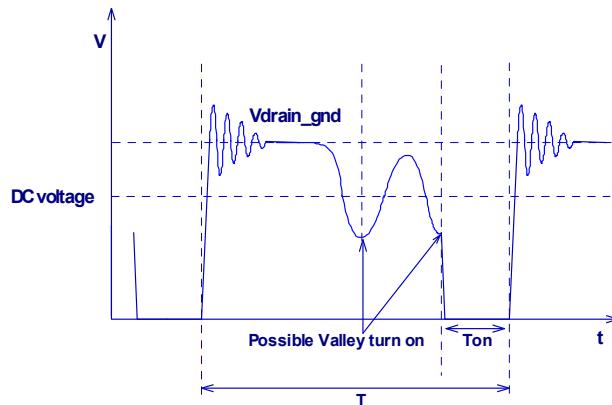
Valley Switching

ACT518 employed valley switching from no load to heavy load to reduce switching loss and EMI. In discontinuous mode operation, the resonant voltage between inductance and parasitic capacitance on MOSFET source pin is coupled by auxiliary winding and reflected on VDET pin through feedback network R6, R7. Internally, the VDET pin is connected to an zero-crossing detector to generate the switch turn on signal when the conditions are met.

FUNCTIONAL DESCRIPTION CONT'D

Figure 3:

Valley Switching



Protection Features

The ACT518 provides full protection functions. The following table summarizes all protection functions.

Auto-Restart Operation

ACT518 will enter into auto-restart mode when a fault is identified. There is a startup phase in the auto-restart mode. After this startup phase the conditions are checked whether the failure is still present. Normal operation proceeds once the failure mode is removed. Otherwise, new startup phase will be initiated again.

To reduce the power loss during fault mode, the startup delay control is implemented. The startup delay time increases over lines.

| PROTECTION FUNCTIONS | FAILURE CONDITION | PROTECTION MODE |
|---|--|-----------------|
| V _{DD} Over Voltage | V _{DD} > 25V (4 duty cycle) | Auto Restart |
| V _{VDET} Over Voltage/No Voltage | V _{VD} > 2.72V or No switching for 4 cycles | Auto Restart |
| Over Temperature | T > 135°C | Auto Restart |
| Short Winding/Short Diode | V _{CS} > 1.72V | Auto Restart |
| Over Load/Open Loop | IPK = I _{LIMIT} or V _{FB} = 3.5V + V _{BE} for 320ms | Auto Restart |
| Output Short Circuit | V _{DET} < 0.58V | Auto Restart |
| V _{DD} Under Voltage | V _{DD} < 7.4V | Auto Restart |

Figure 4:
Universal VAC Input, 5V/2A Output Adaptor

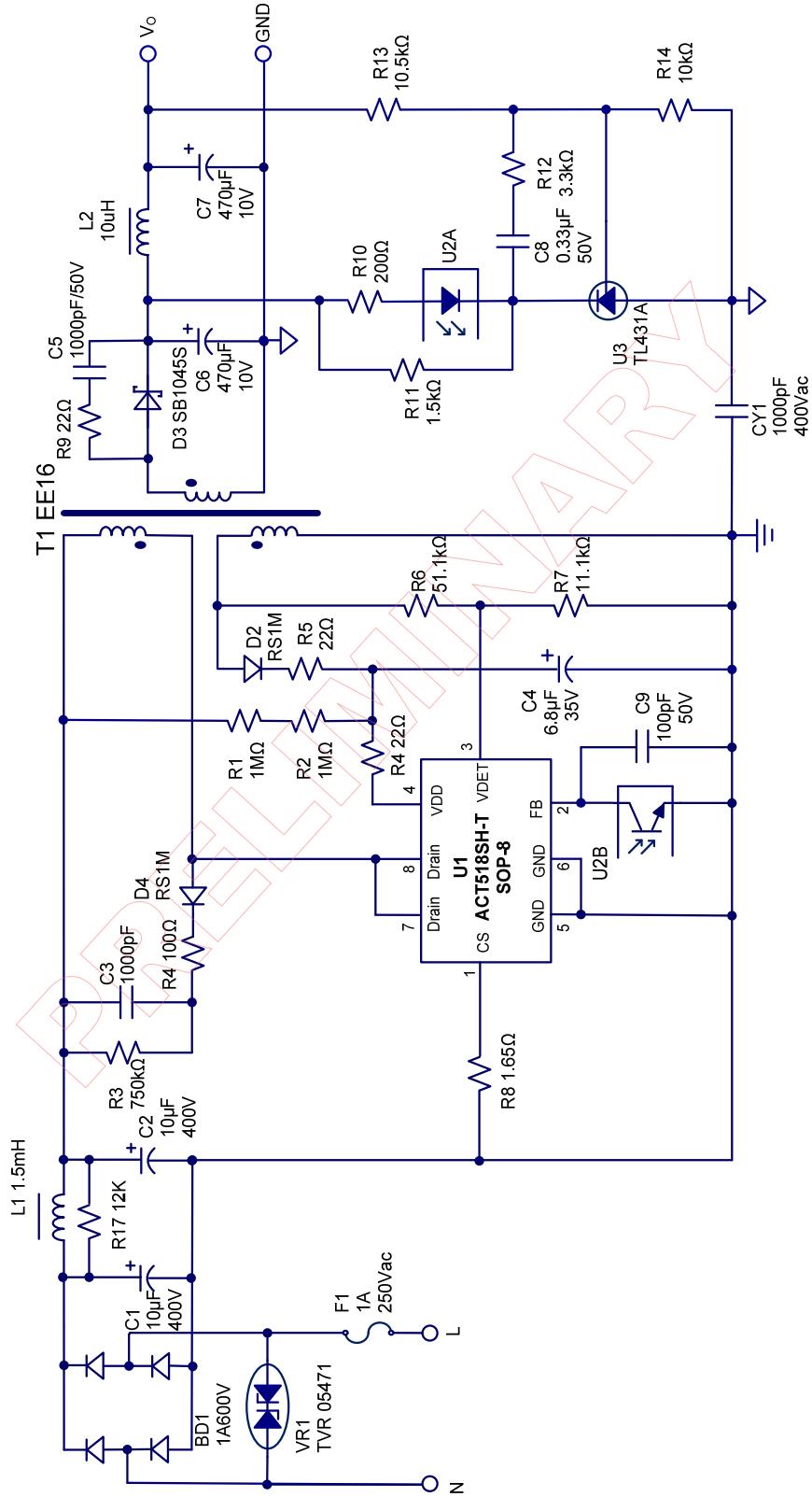
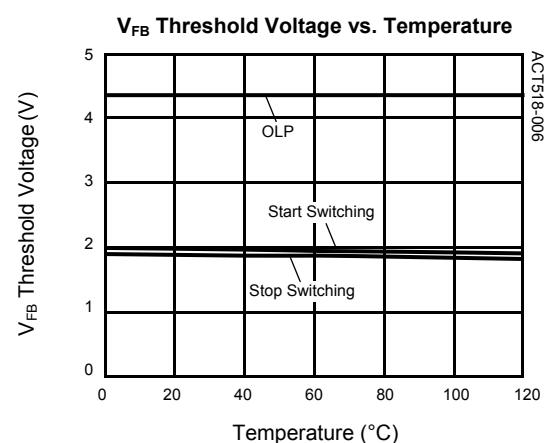
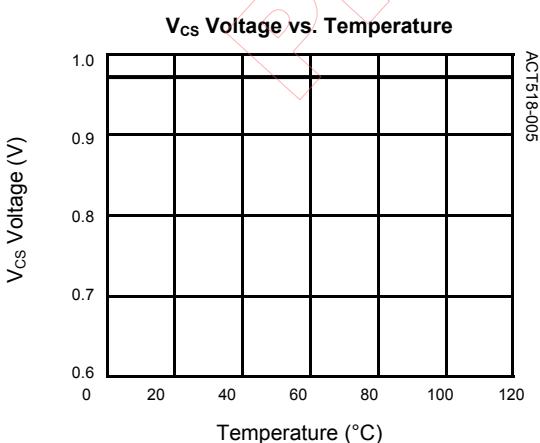
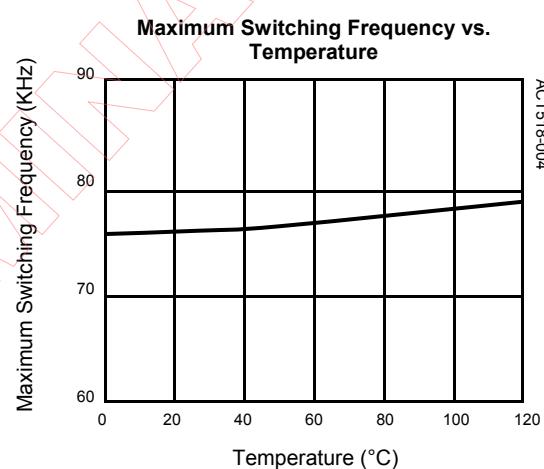
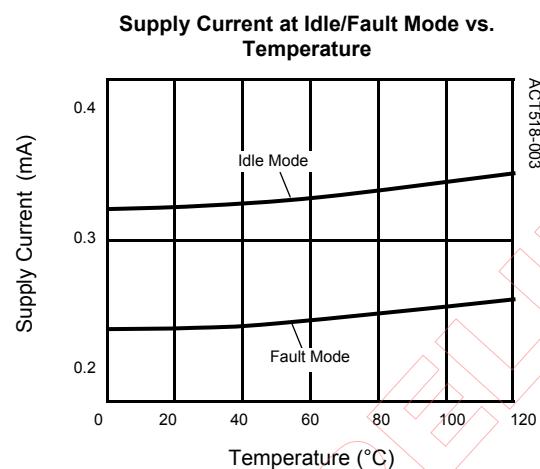
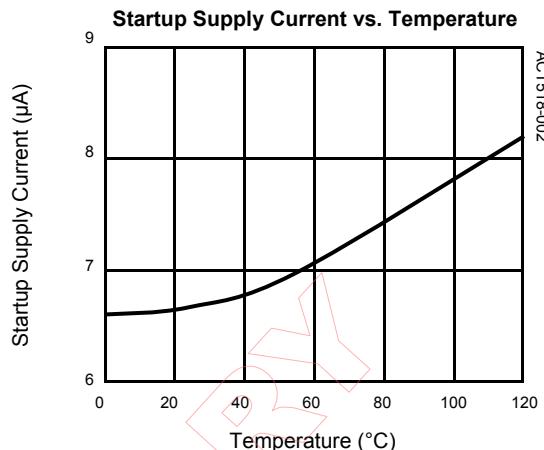
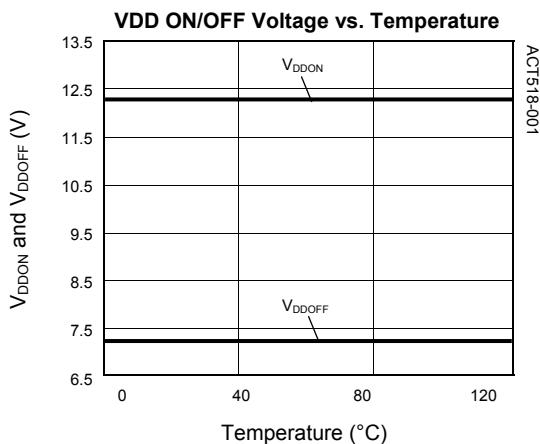


Table 1:
ACT518 5V10W Bill of Materials

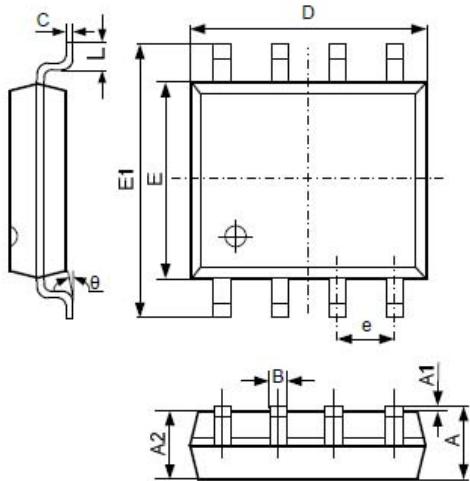
| ITEM | REFERENCE | DESCRIPTION | QTY | MANUFACTURER |
|------|-----------|--|-----|--------------|
| 1 | U1 | IC, ACT518, SOP-8 | 1 | Active-Semi |
| 2 | C1,C2 | Capacitor, Electrolytic, 10µF/400V, 10 × 14mm | 1 | KSC |
| 3 | C3 | Capacitor, Ceramic, 1000pF/500V, 0805, SMD | 1 | POE |
| 4 | C4 | Capacitor, Electrolytic, 6.8µF/35V, 5 × 11mm | 1 | KSC |
| 5 | C7,C6 | Capacitor, Electrolytic, 470µF/10V, 10 × 11.5mm | 2 | KSC |
| 6 | C8 | Capacitor, Ceramic, 0.33µF/50V, 0805, SMD | 1 | POE |
| 7 | C9 | Capacitor, Ceramic, 100pF/100V, 0805, SMD | 1 | POE |
| 8 | C5 | Capacitor, Ceramic, 1000pF/50V, 0805, SMD | 1 | POE |
| 9 | BD1 | Diode, Rectifier, 1000V1A, MB6S, DO-4 | 1 | Good-Ark |
| 10 | D2,D4 | Diode, Ultra Fast, RS1M, 1000V/1.0A, SMD | 2 | Good-Ark |
| 11 | D3 | Diode, Schottky, 45V/10A, SB1045S, DO-201 | 1 | Good-Ark |
| 12 | L1 | DM Inductor, 1.5mH, DR5 | 1 | SoKa |
| 13 | Bead1,2 | T6*2*3, R5 | 2 | SoKa |
| 14 | L2 | DM Inductor, 10µH, DR5 | 1 | SoKa |
| 15 | PCB1 | PCB, L*W*T = 48.5x29x1.6mm, Cem-1, Rev:A | 1 | Jintong |
| 16 | F1 | Fusible, 1A/250V | 1 | TY-OHM |
| 17 | R1,2 | Chip Resistor, 1MΩ, 0805, 5% | 2 | TY-OHM |
| 18 | R3 | Carbon Resistor, 750kΩ, 1206, 5% | 1 | TY-OHM |
| 19 | R11 | Chip Resistor, 1.5kΩ, 0805, 5% | 1 | TY-OHM |
| 20 | R4,5,9 | Chip Resistor, 22Ω, 0805, 5% | 3 | TY-OHM |
| 21 | R6 | Chip Resistor, 51.1kΩ, 0805, 1% | 1 | TY-OHM |
| 22 | R7 | Chip Resistor, 11.1kΩ, 0805, 1% | 1 | TY-OHM |
| 23 | R8 | Chip Resistor, 1.65Ω, 1206, 1% | 1 | TY-OHM |
| 24 | R9 | Chip Resistor, 0.87Ω, 1W, 1% | 1 | TY-OHM |
| 25 | R10 | Chip Resistor, 200Ω, 0805, 5% | 1 | TY-OHM |
| 26 | R12 | Chip Resistor, 3.3kΩ, 0805, 5% | 1 | TY-OHM |
| 27 | R13 | Chip Resistor, 10.5Ω, 0805, 1% | 1 | TY-OHM |
| 28 | R14 | Chip Resistor, 10kΩ, 0805, 1% | 1 | TY-OHM |
| 29 | R17 | Chip Resistor, 12kΩ, 0805, 5% | 1 | TY-OHM |
| 30 | T1 | Transformer, L _P = 1.3mH, EE16 | 1 | |
| 31 | NTC | Thermistor, SC053 | 1 | TY-OHM |
| 32 | TVS | Varistor, 10471 | 1 | TY-OHM |
| 33 | CY1 | Y capacitance, 2200pF/400V, Y1 | 1 | SEC |
| 34 | U2 | Opto-coupler, PC817C CTR = 200% | 1 | Sharp |
| 35 | U3 | Voltage Regulator, TL431A, V _{REF} = 2.5V | 1 | ST |

TYPICAL PERFORMANCE CHARACTERISTICS



PACKAGE OUTLINE

SOP-8 PACKAGE OUTLINE AND DIMENSIONS

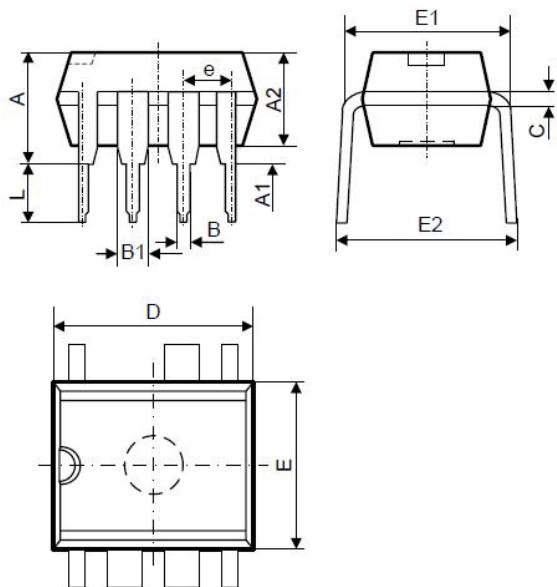


| SYMBOL | DIMENSION IN MILLIMETERS | | DIMENSION IN INCHES | |
|--------|--------------------------|-------|---------------------|-------|
| | MIN | MAX | MIN | MAX |
| A | 1.350 | 1.750 | 0.053 | 0.069 |
| A1 | 0.100 | 0.250 | 0.004 | 0.010 |
| A2 | 1.350 | 1.550 | 0.053 | 0.061 |
| B | 0.330 | 0.510 | 0.013 | 0.020 |
| C | 0.190 | 0.250 | 0.007 | 0.010 |
| D | 4.700 | 5.100 | 0.185 | 0.201 |
| E | 3.800 | 4.000 | 0.150 | 0.157 |
| E1 | 5.800 | 6.300 | 0.228 | 0.248 |
| e | 1.270 TYP | | 0.050 TYP | |
| L | 0.400 | 1.270 | 0.016 | 0.050 |
| θ | 0° | 8° | 0° | 8° |

PRELIMINARY

PACKAGE OUTLINE

DIP-7 PACKAGE OUTLINE AND DIMENSIONS



| SYMBOL | DIMENSION IN MILLIMETERS | | DIMENSION IN INCHES | |
|--------|--------------------------|-------|---------------------|-------|
| | MIN | MAX | MIN | MAX |
| A | 3.710 | 4.310 | 0.146 | 0.170 |
| A1 | 0.510 | | 0.020 | |
| A2 | 3.200 | 3.600 | 0.126 | 0.142 |
| B | 0.360 | 0.560 | 0.014 | 0.022 |
| B1 | 1.524 TYP | | 0.060 TYP | |
| C | 0.204 | 0.360 | 0.008 | 0.014 |
| D | 9.000 | 9.400 | 0.354 | 0.370 |
| E | 6.200 | 6.600 | 0.244 | 0.260 |
| E1 | 7.620 TYP | | 0.300 TYP | |
| e | 2.540 TYP | | 0.100 TYP | |
| L | 3.000 | 3.600 | 0.118 | 0.142 |
| E2 | 8.200 | 9.400 | 0.323 | 0.370 |

PRELIMINARY

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