LOW DROPOUT VOLTAGE REGULATOR

FEATURES

- Available in ± 2.0 % or ± 1.0 % Output Tolerance
- Active High On/Off Control
- Very Low Quiescent Current
- Very Low Dropout Voltage
- Reverse Bias Protection
- Miniature Package (SOT-23-5)
- Short Circuit Switch
- High Ripple Rejection
- Very High Output Impedance (Output Off)
- Very Low Noise

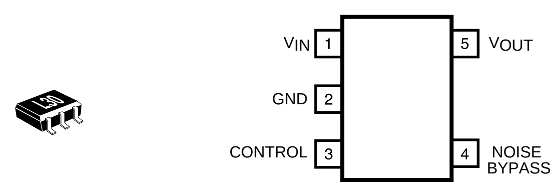
APPLICATIONS

- Battery Powered Systems
- Cellular Telephones
- Pagers
- Personal Communications Equipment
- Portable Instrumentation
- Portable Consumer Equipment
- Radio Control Systems
- Toys
- Low Voltage Systems

DESCRIPTION

The TK716xx is a low dropout linear regulator housed in a small SOT-23-5 package, rated at 500 mW. The device is in the "on" state when the control pin is pulled to a logic high level. An internal PNP pass transistor is used to achieve a low dropout voltage of 90 mV (typ.) at 50 mA load current. This device offers high precision output voltage of ± 2.0 % or ± 1.0 %. The low quiescent current and dropout voltage make this part ideal for battery powered applications. This part incorporates an output disconnect feature to reduce the reverse bias current in the "off" state to less than 50 nA. The internal reverse bias protection eliminates the requirement for a reverse voltage protection diode, saving cost and board space. The high 60 dB ripple rejection (400 Hz) and low noise provide enhanced performance for critical applications. An external capacitor can be connected to the noise bypass pin to lower the output noise level to 30 μVrms.

TK716xx



ORDERING INFORMATION

TK716 □□SCL
TK716 □□SIL
TK716 □□SCL H

Voltage Code
Package Code
Tolerance Code
Tape/Reel Code
Temp. Code

VOLTAGE CODE

20 = 2.0 V *	31 = 3.1 V	42 = 4.2 V
21 = 2.1 V *	32 = 3.2 V	43 = 4.3 V
22 = 2.2 V *	33 = 3.3 V	44 = 4.4 V
23 = 2.3 V *	34 = 3.4 V	45 = 4.5 V
24 = 2.4 V	35 = 3.5 V	46 = 4.6 V
25 = 2.5 V	36 = 3.6 V	47 = 4.7 V
26 = 2.6 V	37 = 3.7 V	48 = 4.8 V
27 = 2.7 V	38 = 3.8 V	49 = 4.9 V
28 = 2.8 V	39 = 3.9 V	50 = 5.0 V
29 = 2.9 V	40 = 4.0 V	
30 = 3.0 V	41 = 4.1 V	

* Not available in I Temp. Code

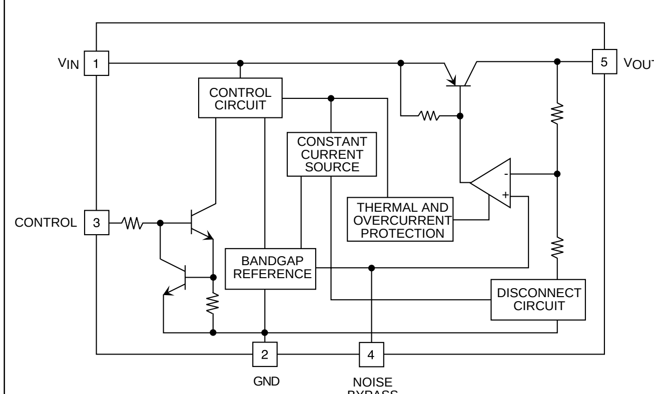
TAPE/REEL CODE
L: Tape Left

TEMPERATURE CODE
C: Standard Temp. Range
I: Extended Temp. Range

PACKAGE CODE
S: SOT-23-5

TOLERANCE CODE
H: 1 % Output Voltage Tolerance

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Supply Voltage .... 16 V
Power Dissipation (Note 1) .... 500 mW
Reverse Bias Voltage .... 6 V
Control Terminal Voltage .... 12 V
Noise Bypass Terminal Voltage .... 5 V
Operating Voltage Range .... 1.8 to 12 V
Storage Temperature Range .... -55 to +150 °C
Operating Temperature (Ambient) Range
TK716xxSCL, TK716xxSCLH ....-30 to +80 °C
TK716xxSIL... -40 to +85 °C
Junction Temperature (Operating) .... 125 °C
Junction Temperature (Shutdown) .... 150 °C
Lead Soldering Temperature (10 s) .... 235 °C

TK716xxSCL AND TK716SCLH ELECTRICAL CHARACTERISTICS

Test conditions: $V_{IN} = V_{OUT(TYP)} + 1$ V, $T_A = 25$ °C, unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
I_Q	Quiescent Current	$I_{OUT} = 0$ mA, Excluding I_{CONT}		70	100	µA
I_{STBY}	Standby Current	$V_{IN} = 8$ V, Output OFF			0.1	µA
I_{REV}	Reverse Bias Current	$V_{IN} = 0$ V, $V_{REV} = 5$ V, Output OFF		1	50	nA
I_{GND}	GND Pin Current	$I_{OUT} = 50$ mA		1	1.8	mA
I_{OUT}	Continuous Output Current				150	mA
$I_{OUT(PULSE)}$	Pulse Output Current	10 ms pulse, Duty Cycle = 40 %			200	mA
V_{OUT}	Output Voltage	$V_{IN} = V_{OUT(TYP)} + 1$ V, $I_{OUT} = 5$ mA	See Table 1 and 2			V
$\Delta V_{OUT}/\Delta T$	Temperature Coefficient			20		ppm/° C
Line Reg	Line Regulation	$V_{IN} = V_{OUT(TYP)} + 1$ V to $V_{OUT(TYP)} + 6$ V		2	15	mV
Load Reg	Load Regulation	1 mA < I_{OUT} < 50 mA		4	18	mV
		1 mA < I_{OUT} < 100 mA		7	28	mV
		1 mA < I_{OUT} < 150 mA		12	50	mV
V_{DROP}	Dropout Voltage	$I_{OUT} = 50$ mA		90	160	mV
		$I_{OUT} = 100$ mA		140	230	mV
		$I_{OUT} = 150$ mA, $V_{OUT} \geq 2.4$ V		200	300	mV
		$I_{OUT} = 150$ mA, $V_{OUT} < 2.4$ V		200	350	mV
V_{ref}	Noise Bypass Terminal Voltage			1.26		V
CONTROL TERMINAL SPECIFICATIONS						
I_{CONT}	Control Current	$V_{OUT} = 1.6$ V, Output ON			10	µA
$V_{CONT(ON)}$	Control Voltage ON	Output ON	1.6			V
$V_{CONT(OFF)}$	Control Voltage OFF	Output OFF			0.6	V

Note 1: Power dissipation is 500 mW when mounted as recommended. Derate at 4.0 mW/°C for operation above 25 °C.
Gen Note: Exceeding the “Absolute Maximum Ratings” may damage the device.
Gen Note: Parameters with min. or max. values are 100% tested at $T_A = 25$ °C.
Gen Note: Ripple rejection is @ 60 dB when f = 400 Hz, $C_L = 10$ µF, $C_N = 0.1$ µF, input noise = 100 mVrms, $V_{IN} = V_{OUT(TYP)} + 1.5$ V and $I_{OUT} = 30$ mA.
Gen Note: Output noise is 0.13 ~ 0.23 $\mu V/\sqrt{Hz}$ at 1 kHz when $C_N = 0.1$ µF.
Gen Note: Parameters with min. or max. values are 100% tested at $T_A = 25$ °C.

TK716SCL ELECTRICAL CHARACTERISTICS TABLE 1

Test Conditions: $V_{IN} = V_{OUT(TYP)} + 1$ V, $I_{OUT} = 5$ mA, $T_A = 25$ °C, unless otherwise specified.

Output Voltage	Voltage Code	$V_{OUT(MIN)}$	$V_{OUT(MAX)}$
2.0 V	20	1.940 V	2.060 V
2.1 V	21	2.040 V	2.160 V
2.2 V	22	2.140 V	2.260 V
2.3 V	23	2.240 V	2.360 V
2.4 V	24	2.340 V	2.460 V
2.5 V	25	2.440 V	2.560 V
2.6 V	26	2.540 V	2.660 V
2.7 V	27	2.640 V	2.760 V
2.8 V	28	2.740 V	2.860 V
2.9 V	29	2.840 V	2.960 V
3.0 V	30	2.940 V	3.060 V
3.1 V	31	3.038 V	3.162 V
3.2 V	32	3.136 V	3.264 V
3.3 V	33	3.234 V	3.366 V
3.4 V	34	3.332 V	3.468 V
3.5 V	35	3.430 V	3.570 V

Output Voltage	Voltage Code	$V_{OUT(MIN)}$	$V_{OUT(MAX)}$
3.6 V	36	3.528 V	3.672 V
3.7 V	37	3.626 V	3.774 V
3.8 V	38	3.724 V	3.876 V
3.9 V	39	3.822 V	3.978 V
4.0 V	40	3.920 V	4.080 V
4.1 V	41	4.018 V	4.182 V
4.2 V	42	4.116 V	4.284 V
4.3 V	43	4.214 V	4.386 V
4.4 V	44	4.312 V	4.488 V
4.5 V	45	4.410 V	4.590 V
4.6 V	46	4.508 V	4.692 V
4.7 V	47	4.606 V	4.794 V
4.8 V	48	4.704 V	4.896 V
4.9 V	49	4.802 V	5.008 V
5.0 V	50	4.900 V	5.100 V

TK716SCLH ELECTRICAL CHARACTERISTICS TABLE 2

Test Conditions: $V_{IN} = V_{OUT(TYP)} + 1$ V, $I_{OUT} = 5$ mA, $T_A = 25$ °C, unless otherwise specified.

Output Voltage	Voltage Code	$V_{OUT(MIN)}$	$V_{OUT(MAX)}$
2.0 V	20	1.960 V	2.040 V
2.1 V	21	2.060 V	2.140 V
2.2 V	22	2.160 V	2.240 V
2.3 V	23	2.260 V	2.340 V
2.4 V	24	2.360 V	2.440 V
2.5 V	25	2.460 V	2.540 V
2.6 V	26	2.560 V	2.640 V
2.7 V	27	2.660 V	2.740 V
2.8 V	28	2.760 V	2.840 V
2.9 V	29	2.860 V	2.940 V
3.0 V	30	2.960 V	3.040 V
3.1 V	31	3.060 V	3.140 V
3.2 V	32	3.160 V	3.240 V
3.3 V	33	3.260 V	3.340 V
3.4 V	34	3.360 V	3.440 V
3.5 V	35	3.460 V	3.540 V

Output Voltage	Voltage Code	$V_{OUT(MIN)}$	$V_{OUT(MAX)}$
3.6 V	36	3.560 V	3.640 V
3.7 V	37	3.660 V	3.740 V
3.8 V	38	3.760 V	3.840 V
3.9 V	39	3.860 V	3.940 V
4.0 V	40	3.960 V	4.040 V
4.1 V	41	4.059 V	4.141 V
4.2 V	42	4.158 V	4.242 V
4.3 V	43	4.247 V	4.343 V
4.4 V	44	4.356 V	4.444 V
4.5 V	45	4.455 V	4.545 V
4.6 V	46	4.554 V	4.646 V
4.7 V	47	4.653 V	4.747 V
4.8 V	48	4.752 V	4.848 V
4.9 V	49	4.851 V	4.949 V
5.0 V	50	4.950 V	5.050 V

TK716xxSIL ELECTRICAL CHARACTERISTICS

Test conditions: $V_{IN} = V_{OUT(TYP)} + 1$ V, $T_A = 25$ °C, unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
I_Q	Quiescent Current	$I_{OUT} = 0$ mA, Excluding I_{CONT}		70	100	µA
I_{STBY}	Standby Current	$V_{IN} = 8$ V, Output OFF			0.2	µA
I_{REV}	Reverse Bias Current	$V_{IN} = 0$ V, $V_{REV} = 5$ V, Output OFF		1	70	nA
I_{GND}	GND Pin Current	$I_{OUT} = 50$ mA		1	2.0	mA
I_{OUT}	Continuous Output Current				150	mA
$I_{OUT(PULSE)}$	Pulse Output Current	10 ms pulse, Duty Cycle = 40 %			200	mA
V_{OUT}	Output Voltage	$V_{IN} = V_{OUT(TYP)} + 1$ V, $I_{OUT} = 5$ mA	See Table 3			V
$\Delta V_{OUT}/\Delta T$	Temperature Coefficient			20		ppm/° C
Line Reg	Line Regulation	$V_{IN} = V_{OUT(TYP)} + 1$ V to $V_{OUT(TYP)} + 6$ V		2	17	mV
Load Reg	Load Regulation	1 mA < I_{OUT} < 50 mA		4	20	mV
		1 mA < I_{OUT} < 100 mA		7	30	mV
V_{DROP}	Dropout Voltage	$I_{OUT} = 50$ mA		90	160	mV
		$I_{OUT} = 100$ mA		150	240	mV
		$I_{OUT} = 150$ mA		200	310	mV
V_{ref}	Noise Bypass Terminal Voltage			1.26		V
CONTROL TERMINAL SPECIFICATIONS						
I_{CONT}	Control Current	$V_{OUT} = 1.6$ V, Output ON			10	µA
$V_{CONT(ON)}$	Control Voltage ON	Output ON	1.8			V
$V_{CONT(OFF)}$	Control Voltage OFF	Output OFF			0.4	V

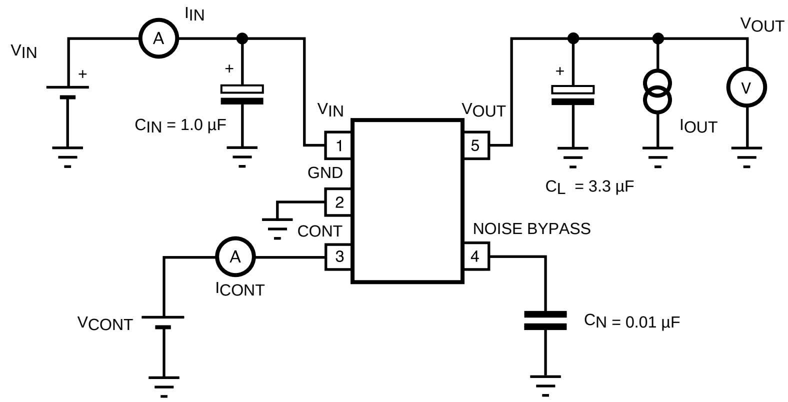
Gen Note: Exceeding the “Absolute Maximum Ratings” may damage the device.
Gen Note: Parameters with min. or max. values are 100% tested at $T_A = 25$ °C.
Gen Note: Ripple rejection is @ 60 dB when f = 400 Hz, $C_L = 10$ µF, $C_N = 0.1$ µF, input noise = 100 mVrms, $V_{IN} = V_{OUT(TYP)} + 1.5$ V and $I_{OUT} = 30$ mA.
Gen Note: Output noise is 0.13 ~ 0.23 $\mu V/\sqrt{Hz}$ at 1 kHz when $C_N = 0.1$ µF.
Gen Note: Parameters with min. or max. values are 100% tested at $T_A = 25$ °C.

TK716SIL ELECTRICAL CHARACTERISTICS TABLE 3

Test Conditions: $V_{IN} = V_{OUT(TYP)} + 1$ V, $I_{OUT} = 5$ mA, $T_A = 25$ °C, unless otherwise specified.

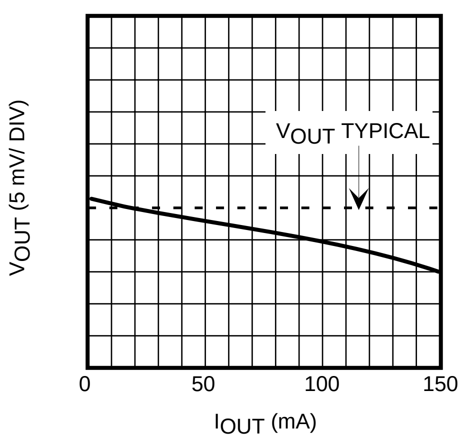
Output Voltage	Voltage Code	Room Temp. Range (T_A = 25 °C)		Full Temp. Range (T_A = -40 to +85 °C)	
		$V_{OUT(MIN)}$	$V_{OUT(MAX)}$	$V_{OUT(MIN)}$	$V_{OUT(MAX)}$
2.4 V	24	2.360 V	2.440 V	2.320 V	2.480 V
2.5 V	25	2.460 V	2.540 V	2.420 V	2.580 V
2.6 V	26	2.560 V	2.640 V	2.520 V	2.680 V
2.7 V	27	2.660 V	2.740 V	2.620 V	2.780 V
2.8 V	28	2.760 V	2.840 V	2.720 V	2.880 V
2.9 V	29	2.860 V	2.940 V	2.820 V	2.980 V
3.0 V	30	2.960 V	3.040 V	3.920 V	3.080 V
3.1 V	31	3.060 V	3.140 V	3.020 V	3.180 V
3.2 V	32	3.160 V	3.240 V	3.120 V	3.280 V
3.3 V	33	3.260 V	3.340 V	3.220 V	3.380 V
3.4 V	34	3.360 V	3.440 V	3.320 V	3.480 V
3.5 V	35	3.460 V	3.540 V	3.420 V	3.580 V
3.6 V	36	3.560 V	3.640 V	3.520 V	3.680 V
3.7 V	37	3.660 V	3.740 V	3.620 V	3.780 V
3.8 V	38	3.760 V	3.840 V	3.720 V	3.880 V
3.9 V	39	3.860 V	3.940 V	3.820 V	3.980 V
4.0 V	40	3.960 V	4.040 V	3.920 V	4.090 V
4.1 V	41	4.059 V	4.141 V	4.009 V	4.191 V
4.2 V	42	4.158 V	4.242 V	4.108 V	4.292 V
4.3 V	43	4.257 V	4.343 V	4.197 V	4.893 V
4.4 V	44	4.356 V	4.444 V	4.306 V	4.494 V
4.5 V	45	4.455 V	4.545 V	4.405 V	4.595 V
4.6 V	46	4.554 V	4.646 V	4.504 V	4.496 V
4.7 V	47	4.653 V	4.747 V	4.603 V	4.497 V
4.8 V	48	4.752 V	4.848 V	4.702 V	4.898 V
4.9 V	49	4.851 V	5.049 V	4.801 V	5.099 V
5.0 V	50	4.950 V	5.050 V	4.900 V	5.100 V

TEST CIRCUIT

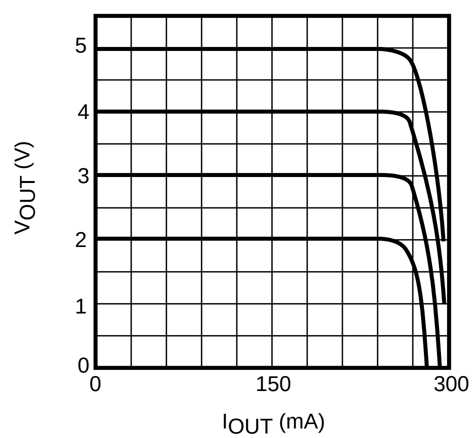


TYPICAL PERFORMANCE CHARACTERISTICS

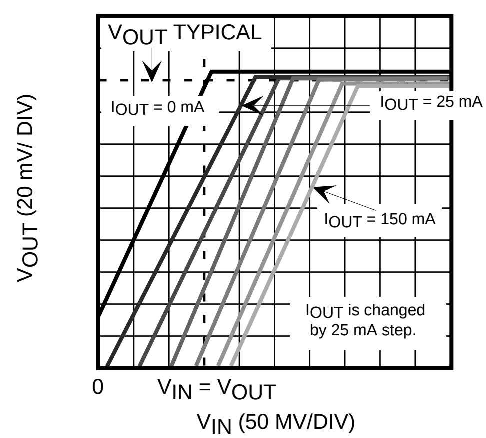
LOAD REGULATION



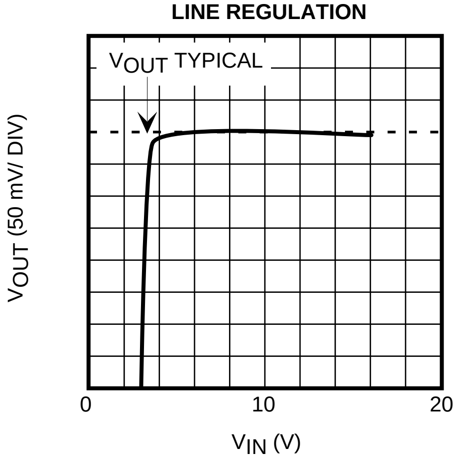
SHORT CIRCUIT PROTECTION



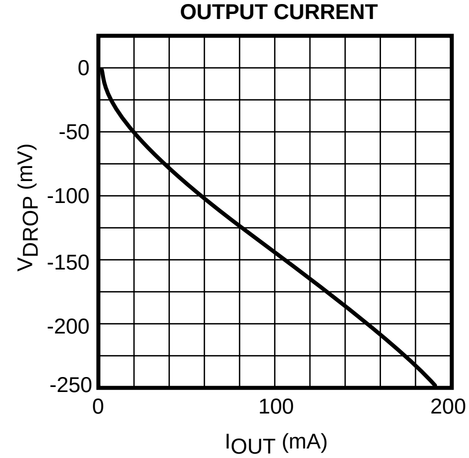
OUTPUT VOLTAGE vs. INPUT VOLTAGE



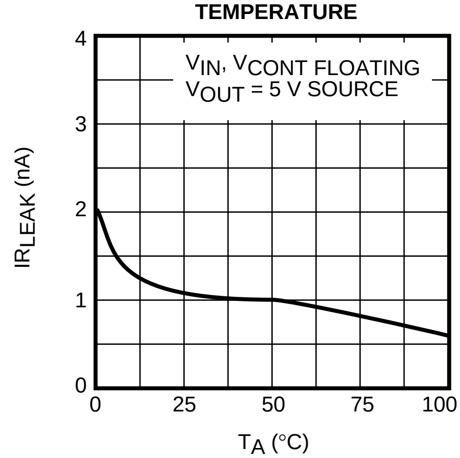
LINE REGULATION



DROPOUT VOLTAGE vs. OUTPUT CURRENT

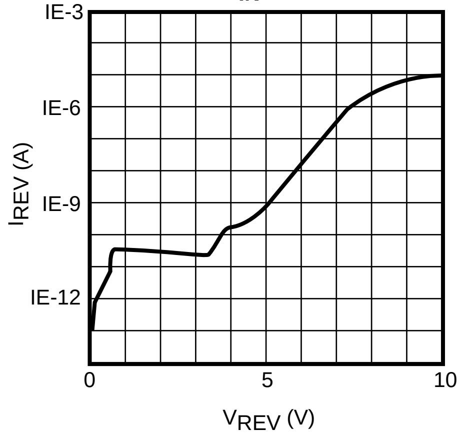


REVERSE LEAKAGE CURRENT vs. TEMPERATURE

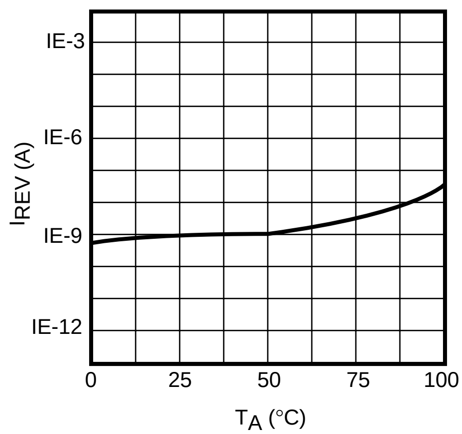


TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

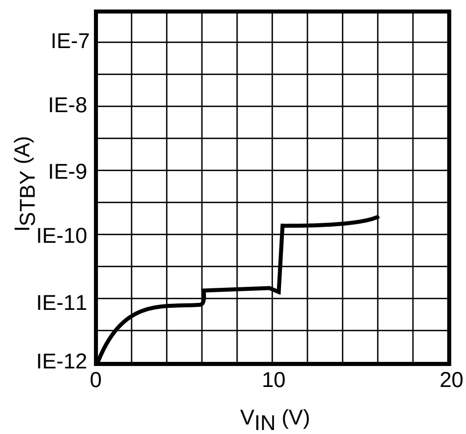
REVERSE BIAS CURRENT (V_{IN} = 0 V)



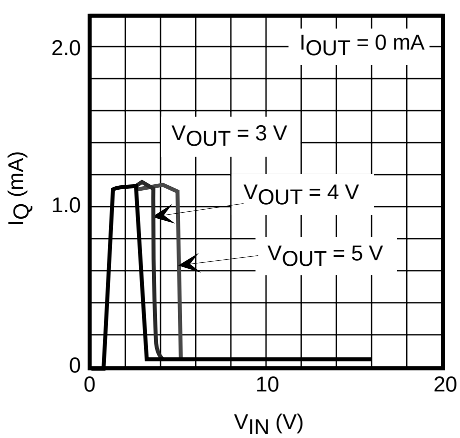
REVERSE BIAS CURRENT vs. TEMPERATURE (V_{IN} = 0 V)



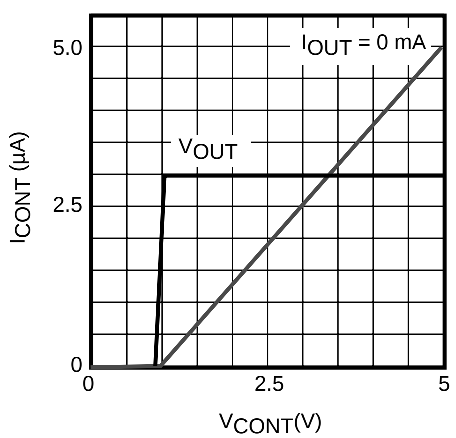
STANDBY CURRENT vs. INPUT VOLTAGE



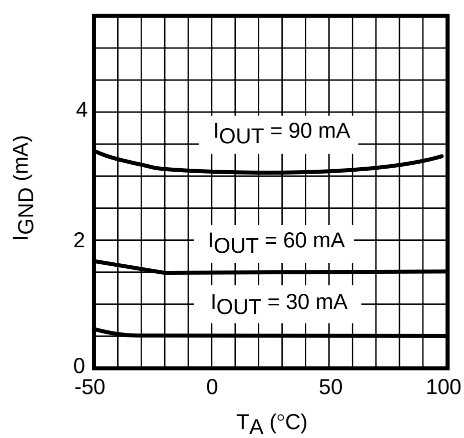
QUIESCENT CURRENT (ON MODE) vs. INPUT VOLTAGE



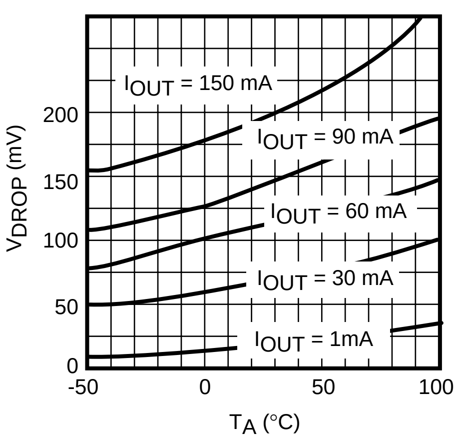
CONTROL CURRENT (ON MODE) vs. CONTROL PIN VOLTAGE



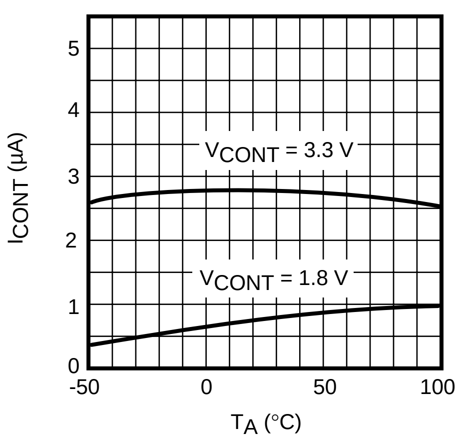
GROUND CURRENT



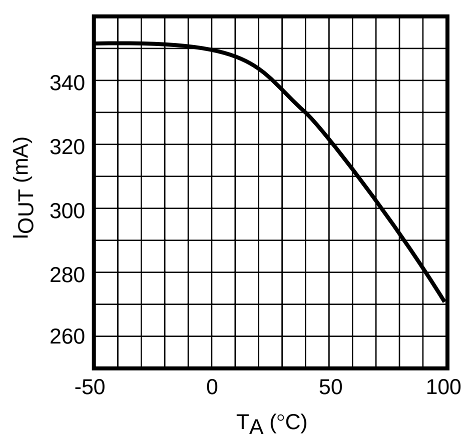
DROPOUT VOLTAGE



CONTROL CURRENT

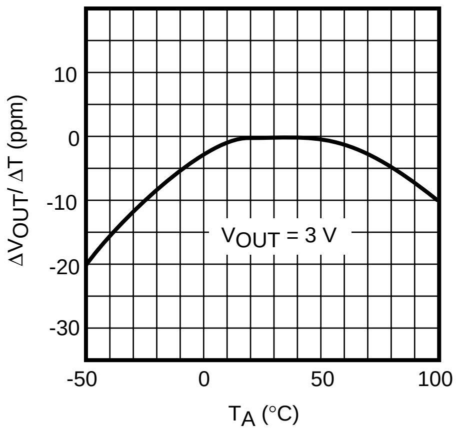


MAXIMUM OUTPUT CURRENT

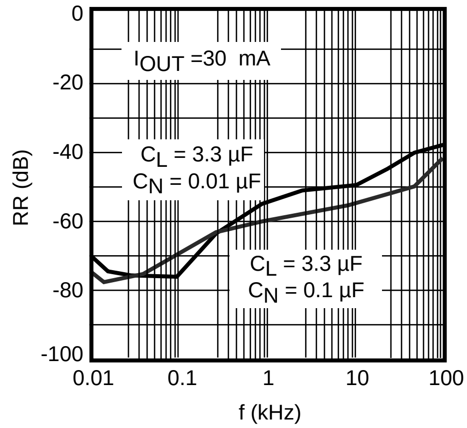


TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

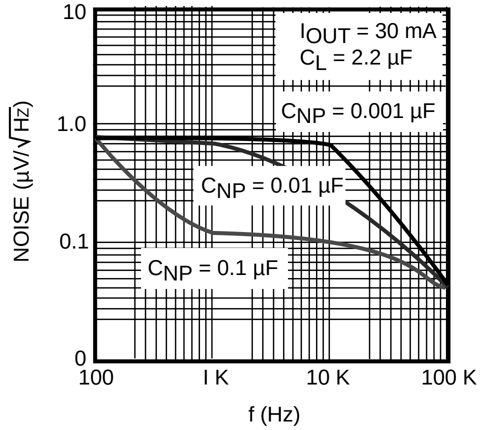
OUTPUT VOLTAGE TEMPERATURE COEFFICIENT



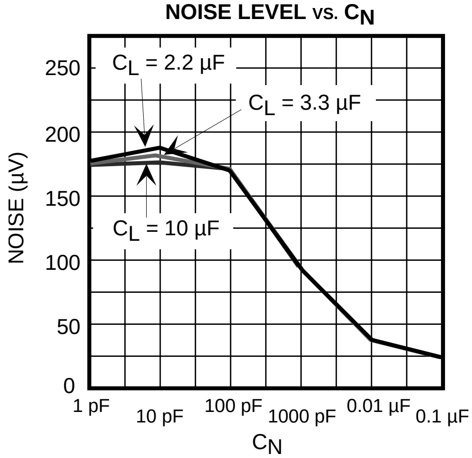
RIPPLE REJECTION



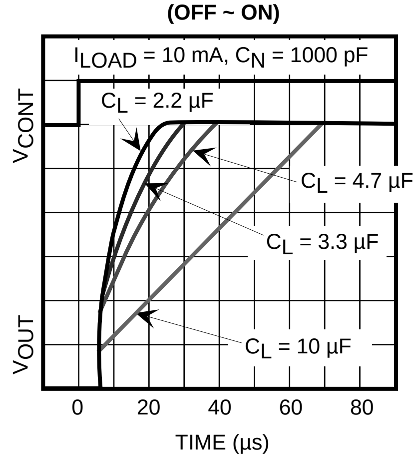
OUTPUT NOISE DENSITY



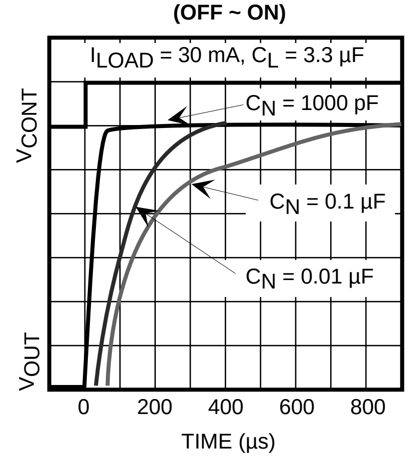
NOISE LEVEL vs. CN



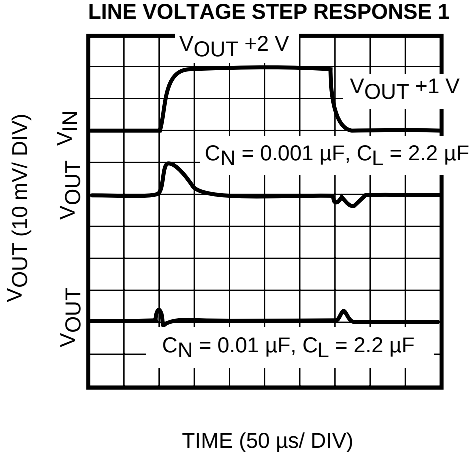
OUTPUT VOLTAGE RESPONSE 1 (OFF ~ ON)



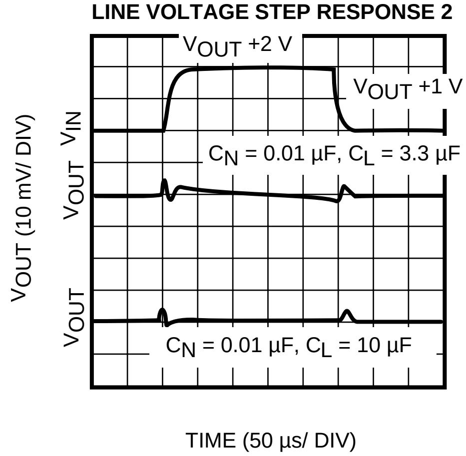
OUTPUT VOLTAGE RESPONSE 2 (OFF ~ ON)



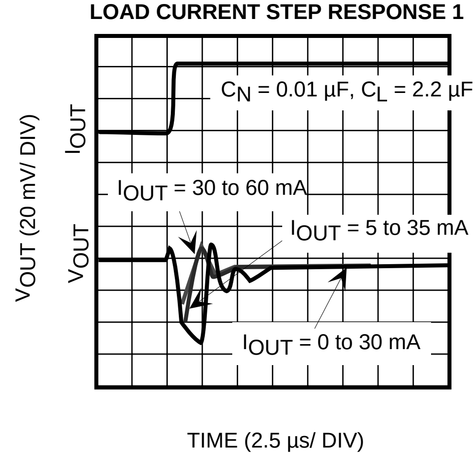
LINE VOLTAGE STEP RESPONSE 1



LINE VOLTAGE STEP RESPONSE 2

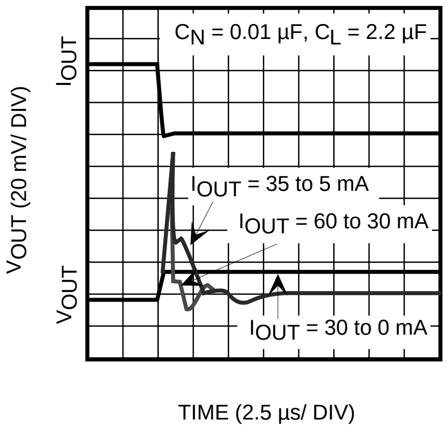


LOAD CURRENT STEP RESPONSE 1

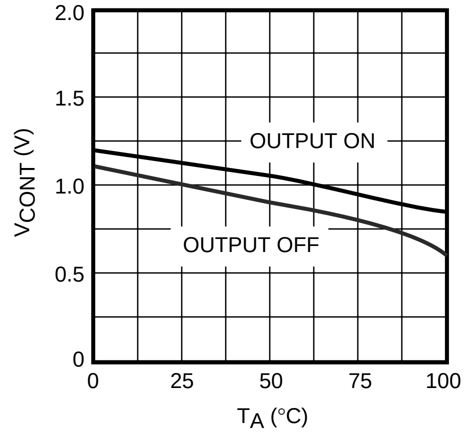


TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

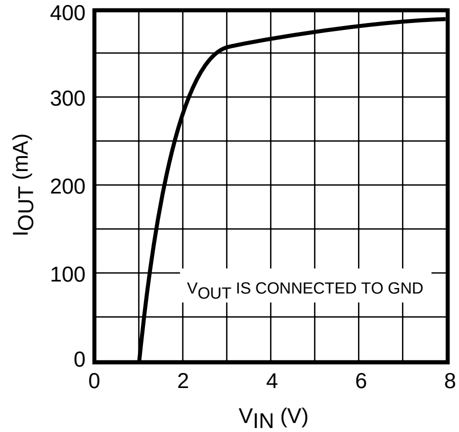
LOAD CURRENT STEP RESPONSE 2



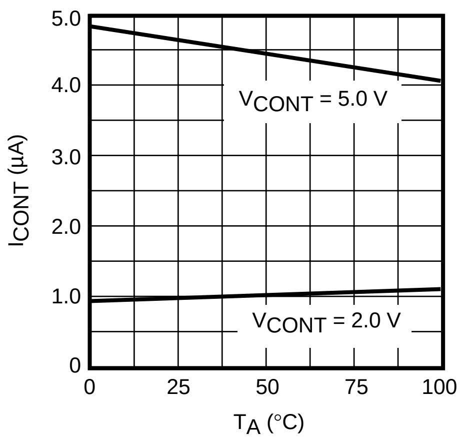
CONTROL VOLTAGE vs. TEMPERATURE



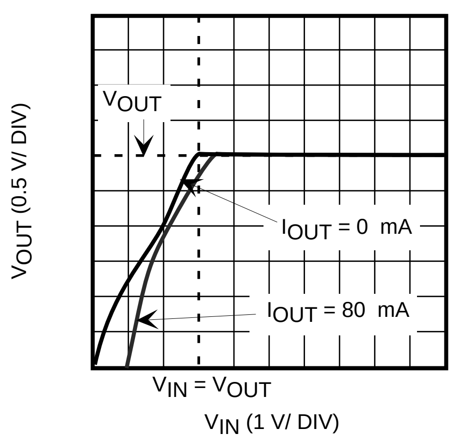
SHORT CIRCUIT CURRENT vs. INPUT VOLTAGE



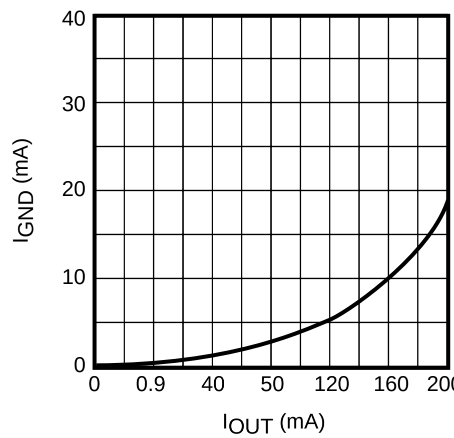
CONTROL CURRENT vs. TEMPERATURE



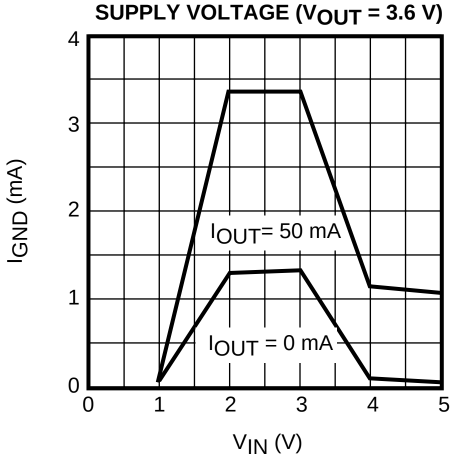
DROPOUT CHARACTERISTICS



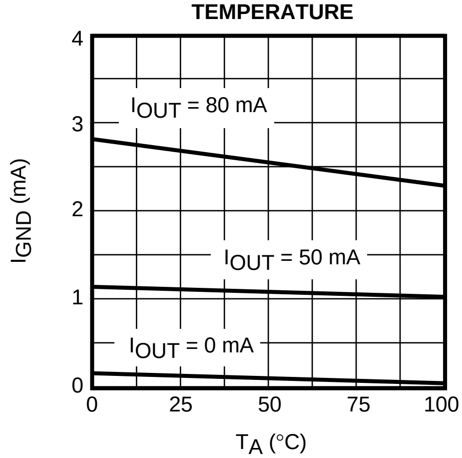
GROUND CURRENT vs. OUTPUT CURRENT



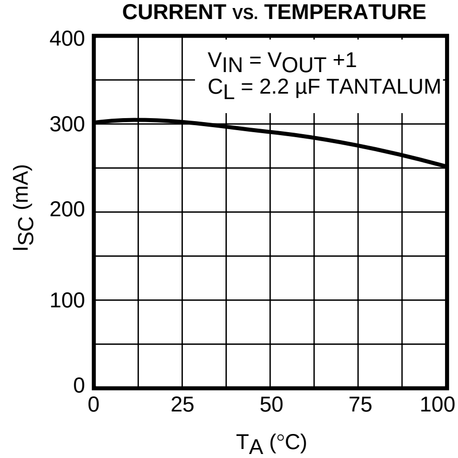
GROUND CURRENT vs. INPUT SUPPLY VOLTAGE (V_{OUT} = 3.6 V)



GROUND CURRENT vs. TEMPERATURE



INSTANTANEOUS SHORT CIRCUIT CURRENT vs. TEMPERATURE



DEFINITION AND EXPLANATION OF TECHNICAL TERMS

OUTPUT VOLTAGE (V_{OUT})

The output voltage is specified with V_{IN} = ($V_{OUT(TYP)}$ + 1 V) and I_{OUT} = 5 mA.

DROPOUT VOLTAGE (V_{DROP})

The dropout voltage is the difference between the input voltage and the output voltage at which point the regulator starts to fall out of regulation. Below this value, the output voltage will fall as the input voltage is reduced. It is dependent upon the load current and the junction temperature.

CONTINUOUS OUTPUT CURRENT (I_{OUT})

Normal operating output current. This is limited by package power dissipation.

PULSE OUTPUT CURRENT ($I_{OUT\ (PULSE)}$)

Maximum pulse width 10 ms; duty cycle is 40%: pulse load only.

LINE REGULATION (Line Reg)

Line regulation is the ability of the regulator to maintain a constant output voltage as the input voltage changes. The line regulation is specified as the input voltage is changed from V_{IN} = V_{OUT} + 1 V to V_{IN} = V_{OUT} + 6 V.

LOAD REGULATION (Load Reg)

Load regulation is the ability of the regulator to maintain a constant output voltage as the load current changes. It is a pulsed measurement to minimize temperature effects with the input voltage set to V_{IN} = V_{OUT} +1 V. The load regulation is specified under three output current step conditions of 1 mA to 50 mA, 1 mA to 100 mA and 1 mA to 150 mA.

QUIESCENT CURRENT (I_Q)

The quiescent current is the current which flows through the ground terminal under no load conditions (I_{OUT} = 0 mA).

GROUND CURRENT (I_{GND})

Ground Current is the current which flows through the ground pin(s). It is defined as I_{IN} - I_{OUT}, excluding control current.

RIPPLE REJECTION RATIO (RR)

Ripple rejection is the ability of the regulator to attenuate the ripple content of the input voltage at the output. It is specified with 100 mVrms, 400 Hz superimposed on the input voltage, where V_{IN} = V_{OUT} + 1.5 V. The output decoupling capacitor is set to 10 µF, the noise bypass capacitor is set to 0.1 µF, and the load current is set to 30 mA. Ripple rejection is the ratio of the ripple content of the output vs. the input and is expressed in dB.

STANDBY CURRENT (I_{STBY})

Standby current is the current which flows into the regulator when the output is turned off by the control function (V_{CONT} = 0 V). It is measured with V_{IN} = 8 V.

SENSOR CIRCUITS

Overcurrent Sensor

The overcurrent sensor protects the device if the output is shorted to ground.

Thermal Sensor

The thermal sensor protects the device if the junction temperature exceeds the safe value (T_j = 150 °C). This temperature rise can be caused by extreme heat, excessive power dissipation caused by large output voltage drops, or excessive output current. The regulator will shut off when the temperature exceeds the safe value. As the junction temperature decreases, the regulator will begin to operate again. Under sustained fault conditions, the regulator output will oscillate as the device turns off then resets. Damage may occur to the device under extreme fault conditions.

Reverse Voltage Protection

Reverse voltage protection prevents damage due to the output voltage being higher than the input voltage. This fault condition can occur when the output capacitor remains charged and the input is reduced to zero, or when an external voltage higher than the input voltage is applied to the output side.

DEFINITION AND EXPLANATION OF TECHNICAL TERMS (CONT.)

PACKAGE POWER DISSIPATION (P_D)

This is the power dissipation level at which the thermal sensor is activated. The IC contains an internal thermal sensor which monitors the junction temperature. When the junction temperature exceeds the monitor threshold of 150 °C, the IC is shut down. The junction temperature rises as the difference between the input power (V_{IN} x I_{IN}) and the output power (V_{OUT} x I_{OUT}) increases. The rate of temperature rise is greatly affected by the mounting pad configuration on the PCB, the board material, and the ambient temperature. When the IC mounting has good thermal conductivity, the junction temperature will be low even if the power dissipation is great. When mounted on the recommended mounting pad, the power dissipation of the SOT-23-5 is increased to 500 mW. For operation at ambient temperatures over 25 °C, the power dissipation of the SOT-23-5 device should be derated at 4.0 mW/ °C. To determine the power dissipation for shutdown when mounted, attach the device on the actual PCB and deliberately increase the output current (or raise the input voltage) until the thermal protection circuit is activated. Calculate the power dissipation of the device by subtracting the output power from the input power. These measurements should allow for the ambient temperature of the PCB. The value obtained from P_D/(150 °C - T_A) is the derating factor. The PCB mounting pad should provide maximum thermal conductivity in order to maintain low device temperatures. As a general rule, the lower the temperature, the better the reliability of the device. The thermal resistance when mounted is expressed as follows:

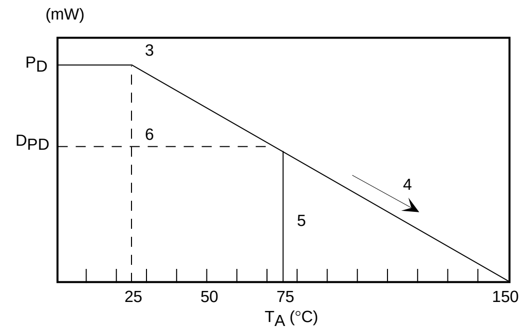
$$T_j = \theta_{jA} \times P_D + T_A$$

For Toko ICs, the internal limit for junction temperature is 150 °C. If the ambient temperature (T_A) is 25 °C, then:

$$150\ °C = \theta_{jA} \times P_D + 25\ °C$$
$$\theta_{jA} = 125\ °C / P_D$$

P_D is the value when the thermal protection circuit is activated. A simple way to determine P_D is to calculate V_{IN} x I_{IN} when the output side is shorted. Input current gradually falls as temperature rises. You should use the value when thermal equilibrium is reached.

The range of usable currents can also be found from the graph below.

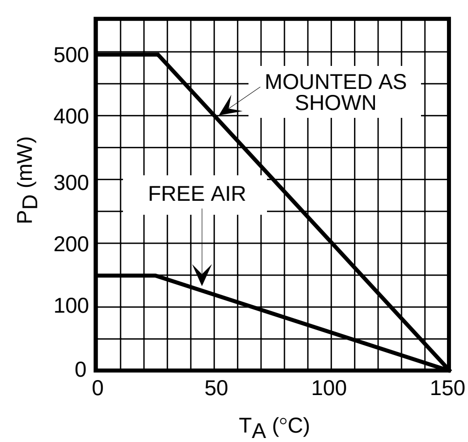


Procedure:

1) Find P_D
2) P_{D1} is taken to be P_D x (~0.8 - 0.9)
3) Plot P_{D1} against 25 °C
4) Connect P_{D1} to the point corresponding to the 150 °C with a straight line.
5) In design, take a vertical line from the maximum operating temperature (e.g., 75 °C) to the derating curve.
6) Read off the value of P_D against the point at which the vertical line intersects the derating curve. This is taken as the maximum power dissipation, D_{PD}.

The maximum operating current is:

$$I_{OUT} = (D_{PD} / (V_{IN(MAX)} - V_{OUT})$$



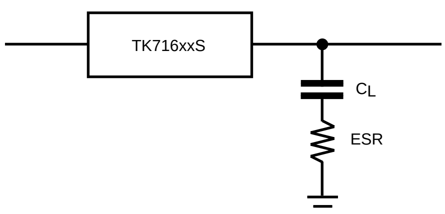
SOT-23-5 POWER DISSIPATION CURVE

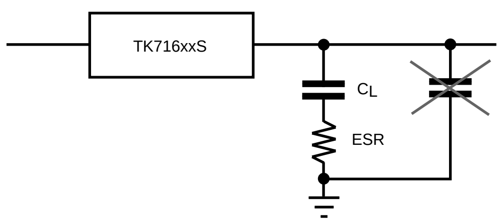
APPLICATION INFORMATION

INPUT-OUTPUT CAPACITORS

Linear regulators require input and output capacitors in order to maintain regulator loop stability. The recommended minimum value of the input capacitor is 0.22 µF. The output capacitor should be selected within the Equivalent Series Resistance (ESR) range as shown in the graphs below for stable operation. When a ceramic capacitor is connected in parallel with the output capacitor, a maximum of 1000 pF is recommended. This is because the ceramic capacitor's electrical characteristics (capacitance and ESR) vary widely over temperature. If a large ceramic capacitor is used, a resistor should be connected in series with it to bring it into the stable operating area shown in the graphs below. Minimum resistance should be added to maintain load and line transient response.

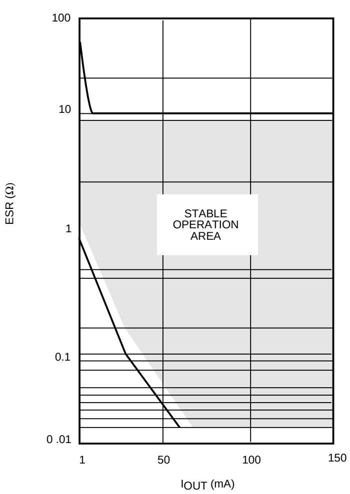
Note: It is very important to check the selected manufacturers electrical characteristics (capacitance and ESR) over temperature.



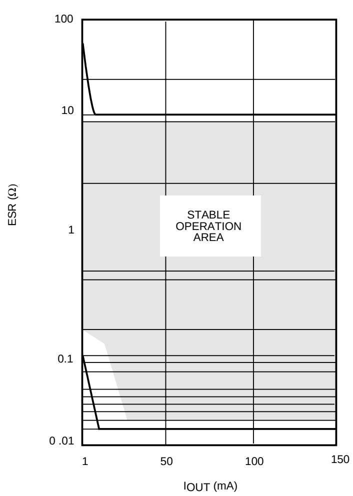


Note: It is not necessary to connect a ceramic capacitor in parallel with an aluminum or tantalum output capacitor.

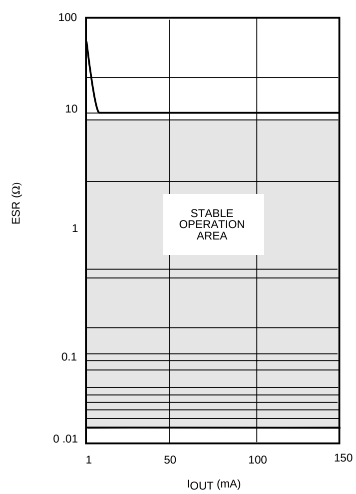
C_L = 1 µF



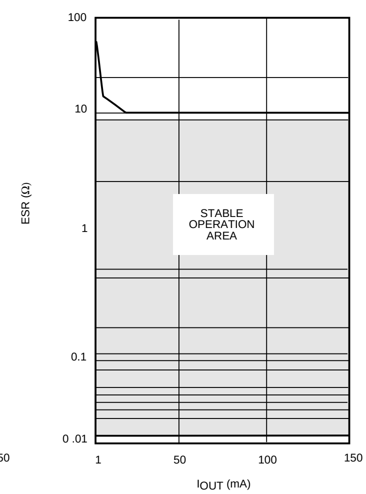
C_L = 2.2 µF



C_L = 3.3 µF



C_L = 10 µF



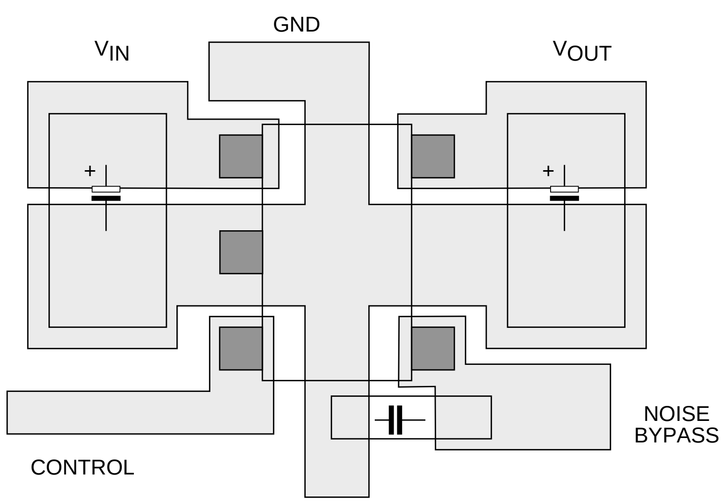
APPLICATION INFORMATION (CONT.)

In general, the capacitor should be at least 1 μF (aluminum electrolytic) and be rated for the actual ambient operating temperature range. The table below shows typical characteristics for several types and values of capacitance. Please note that the ESR varies widely depending upon manufacturer, type, size, and material.

ESR / Capacitance	Aluminum Capacitor	Tantalum Capacitor	Ceramic Capacitor
1.0 μF	2.4 Ω	2.3 Ω	0.140 Ω
2.2 μF	2.0 Ω	1.9 Ω	0.059 Ω
3.3 μF	4.6 Ω	1.0 Ω	0.049 Ω
10 μF	1.4 Ω	0.5 Ω	0.025 Ω

Note: ESR is measured at 10 kHz.

BOARD LAYOUT

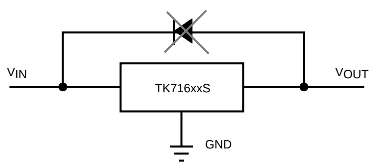


SOT-23-5 BOARD LAYOUT

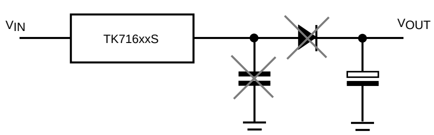
APPLICATION INFORMATION (CONT.)

REVERSE BIAS PROTECTION

The internal reverse bias protection eliminates the requirement for a reverse voltage protection diode. This saves both cost and board space.

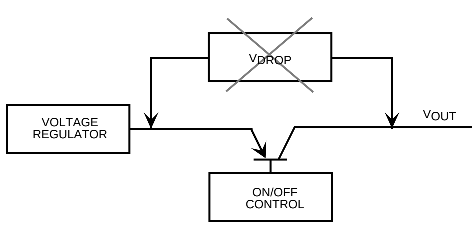


Another reverse bias protection technique is illustrated below. The extra diode and extra capacitor are not necessary with the TK716xx. The high output voltage accuracy is maintained because the diode forward voltage variations over temperature and load current have been eliminated.

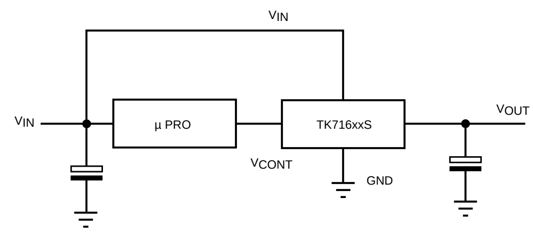


HIGH-SIDE SWITCHING

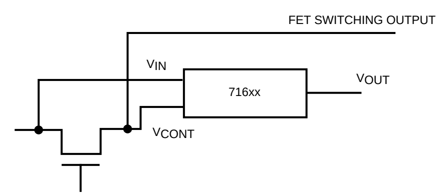
High-side switching should not be implemented by an external transistor as shown below. This results in additional voltage drop and loss of accuracy.



The high output voltage accuracy and low dropout voltage are maintained when the IC is turned ON/OFF by using the control pin as illustrated below.

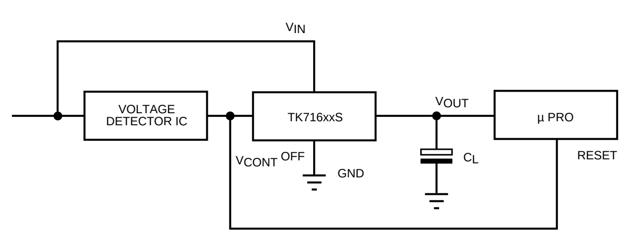


High-side switching with a FET is illustrated below. Battery life is extended by the dropout voltage of the FET when the input of the TK716xx is connected in front of the FET switch.



VOLTAGE BACKUP OPERATION (HOLDUP TIME)

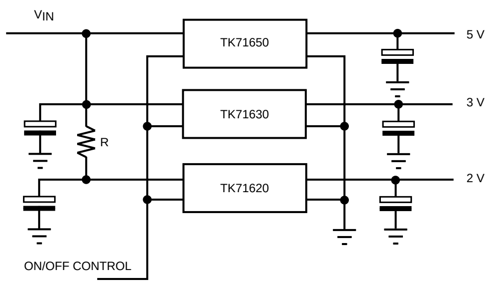
C_L becomes the backup power supply when the microprocessor is reset with the voltage detector IC simultaneously with the turning OFF the TK716xx. C_L provides the holdup time necessary to do an orderly shutdown of the microprocessor.



APPLICATION INFORMATION (CONT.)

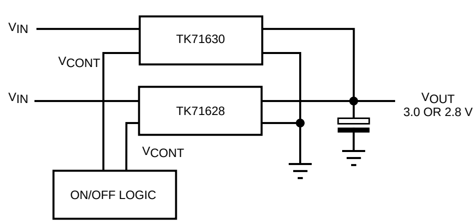
PARALLEL ON/OFF CONTROL

The figure below illustrates multiple regulators being controlled by a single ON/OFF control signal. The series resistor R is put in the input line of the low output voltage regulator in order to prevent overdissipation. The voltage dropped across the resistor reduces the large input-to-output voltage across the regulator, reducing the power dissipation in the device.

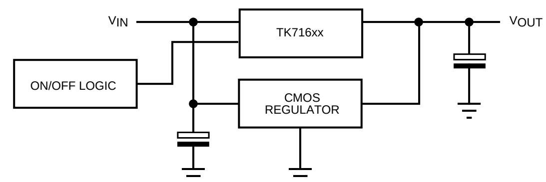


SWITCHING OPERATION

Even though the input voltages or the output voltages are different, the outputs of the TK716xx regulators can be connected together, and the output voltages switched. If two or more TK716xx regulators are turned ON simultaneously, the highest output voltage will be present.

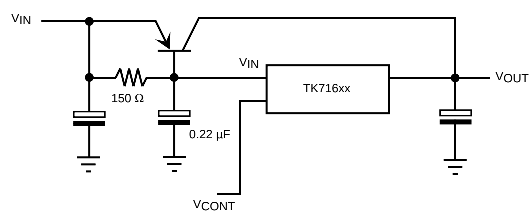


The outputs of the TK716xx regulator and a CMOS regulator can be connected together as long as the output voltage of the TK716xx is greater than the CMOS regulator. When the TK716xx is OFF, the CMOS regulator is turned ON. When the TK716xx is ON, the CMOS regulator is turned OFF.



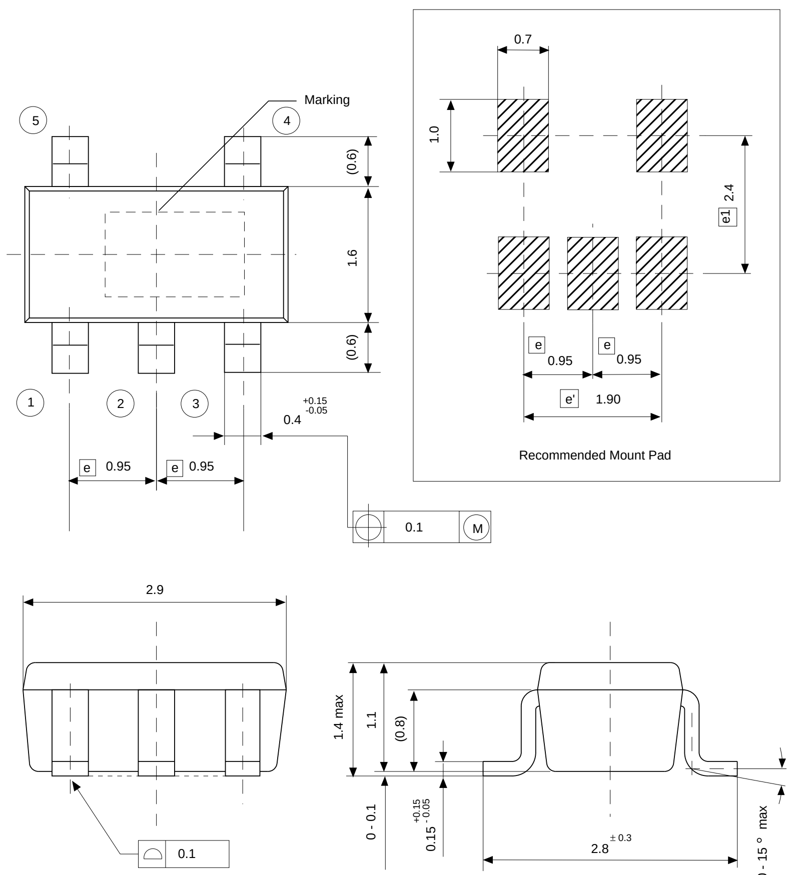
CURRENT BOOST OPERATION

The output current can be increased by connecting an external PNP transistor as shown below. The output current capability depends upon the H_{fe} of the external transistor. Note: The TK716xx internal short circuit protection and thermal sensor do not protect the external transistor.



PACKAGE OUTLINE

SOT-23-5



Dimensions are shown in millimeters
Tolerance: x.x = ± 0.2 mm (unless otherwise specified)

Marking Information

Part Number	Marking
TK71620	L20
TK71621	L21
TK71622	L22
TK71623	L23
TK71624	L24
TK71625	L25
TK71626	L26
TK71627	L27
TK71628	L28
TK71629	L29
TK71630	L30
TK71631	L31
TK71632	L32
TK71633	L33
TK71634	L34
TK71635	L35
TK71636	L36
TK71637	L37
TK71638	L38
TK71639	L39
TK71640	L40
TK71641	L41
TK71642	L42
TK71643	L43
TK71644	L44
TK71645	L45
TK71646	L46
TK71647	L47
TK71648	L48
TK71649	L49
TK71650	L50

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