VOLTAGE REGULATOR WITH ON/OFF SWITCH

FEATURES

- **High Precision Output Voltage (± 1.5% or ± 50 mV)**
- **Active High On/Off Control**
- **Very Low Dropout Voltage (V_{DROP} = 103 mV at 100 mA)**
- **Very Good Stability: CL = 0.1 μF is Stable For Any Type Capacitor with $V_{OUT} \geq$ 1.8 V (I_{OUT} > 0.5 mA)**
- **Excellent Ripple Rejection Ratio (80 dB @ 1 kHz)**
- **Very Low Quiescent Current (I_Q = 63 μA at I_{OUT} = 0 mA)**
- **Peak Output Current is 320 mA**
- **SOT23-5 Package**
- **Wide Operating Voltage Range (1.8 V ~ 14 V)**
- **Reverse Bias and Overcurrent Protection**
- **Built-in Thermal Shutdown**
- **Short Circuit Protection**

DESCRIPTION

The TK111xxC is a low dropout linear regulator with a built-in electronic switch. The internal switch can be controlled by TTL or CMOS logic levels. The device is in the "on" state when the control pin is pulled to a logic high level. An external capacitor can be connected to the noise bypass pin to lower the output noise level to 30 µV_{RMS}.

An internal PNP pass transistor is used to achieve a low dropout voltage of 80 mV (typ.) at 50 mA load current. The TK111xxC has a very low quiescent current of 63 µA (typ.) at no load . The internal thermal shut down circuitry limits the junction temperature to 150 °C. The load current is internally monitored and the device will shut down in the presence of a short circuit or overcurrent condition at the output.

ORDERING INFORMATION

TK111□□CS□L

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

VOLTAGE CODE:
Refer to Table 1

PACKAGE CODE:
S: SOT23-5

TAPE/REEL CODE:
L: Tape Left
Reel Size = 3000 pcs.

TEMP. CODE:
C: -30 ~ 80°C
I : -40 ~ 85°C

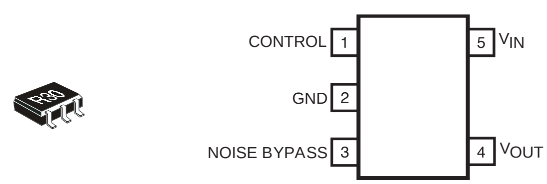
APPLICATIONS

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

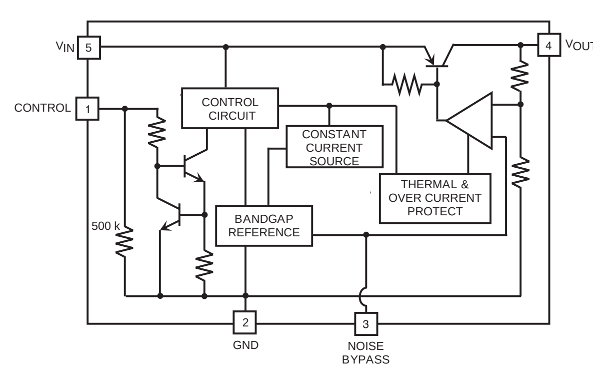
The TK111xxC circuit features very high stability. An output capacitor of 0.1 μF provides stable operation for $V_{OUT} \geq$ 2.0 V. Any type of capacitor can be used; however, the larger this capacitor is, the better the overall characteristics are. The ripple rejection ratio is 84 dB at 400 Hz, and 80 dB at 1 kHz.

The TK111xxC is available in a SOT23-5 surface mount package.

TK111xxC



BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS TK111xxC (C RANK)

Supply Voltage .... -0.4 to16 V
Noise Bypass Terminal Voltage .... -0.4 to 5 V
Power Dissipation (Note 1) .... 500 mW
Reverse Bias .... -0.4 to 6 V
Storage Temperature Range .... -55 to +150 °C
Operating Temperature Range .... -30 to +80 °C
Operating Voltage Range .... 1.8 to 14 V
Control Pin Voltage .... -0.4 to 16 V
Short Circuit Current .... 360 mA

TK111xxCSC ELECTRICAL CHARACTERISTICS (C RANK)

Test conditions: $V_{IN} = V_{OUT(TYP)} + 1$ V, $V_{CONT} \geq 1.8$ V, $T_A = 25$ °C, unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
V_{OUT}	Output Voltage	See Table 1				
Line Reg	Line Regulation	Δ V = 5 V ($V_{IN} = V_{OUT(TYP)}$ + 1 V to $V_{OUT(TYP)}$ + 6 V)		0.3	5	mV
Load Reg	Load Regulation	I_{OUT} = 5 mA to100 mA (Note 2)		11	28	mV
		I_{OUT} = 5 mA to 200 mA (Note 2)		27	64	mV
V_{DROP}	Dropout Voltage (Note 3)	I_{OUT} = 50 mA		80	140	mV
		I_{OUT} = 100 mA		120	210	mV
		I_{OUT} = 200 mA ($V_{OUT} \geq 2.4$ V)		200	350	mV
		I_{OUT} = 180 mA (2.1 V $\leq V_{OUT} <$ 2.4 V)		230	350	mV
I_{OUTMAX}	Maximum Output Current	$V_{OUT} = V_{OUT(TYP)}$ x 0.9	240	320		mA
		1.8 V $\leq V_{IN} \leq$ 2.1 V Reference Value		250		mA
I_Q	Quiescent Current	I_{OUT} = 0 mA Excluding I_{CONT}		63	100	µA
I_{STBY}	Standby Current	V_{IN} = 8 V, $V_{CONT} \leq$ 0.15 V (Note 4)		0.0	0.1	µA
I_{GND}	Ground Pin Current	I_{OUT} = 50 mA		1.0	1.8	mA
CONTROL TERMINAL SPECIFICATIONS (Note 4)						
I_{CONT}	Control Current	V_{CONT} = 1.8 V, Output ON		5	15	µA
V_{CONT}	Control Voltage On	ON State	1.6			V
		OFF State			0.6	V
V_{REF}	Noise Bypass Terminal Voltage			1.28		V
$\Delta V_{OUT} / \Delta T_A$	Temperature Coefficient			35		ppm / °C

TK111xxCSC ELECTRICAL CHARACTERISTICS - C RANK (CONT)

Test conditions: $V_{IN} = V_{OUT(TYP)} + 1$ V, $V_{CONT} \geq 1.8$ V, $T_A = 25$ °C, unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
V_{NO}	Output Noise	$V_{OUT} = 3$ V, f = 1 kHz		0.20		μV / √Hz
		$V_{OUT} = 3$ V, at BW 400 Hz to 80 kHz		45		μV_{RMS}
RR	Ripple Rejection	f = 400 Hz, CL = 1.0 μF, $C_N = 0.01$ μF, $V_{NOISE} = 200$ mV_{RMS}, $V_{IN} = V_{OUT(TYP)} + 1.5$ V, $I_{OUT} = 10$ mA		84		dB
		f = 1 kHz, CL = 1.0 μF, $C_N = 0.01$ μF, $V_{NOISE} = 200$ mV_{RMS}, $V_{IN} = V_{OUT(TYP)} + 1.5$ V, $I_{OUT} = 10$ mA		80		dB

Note 1: Power dissipation is 150 mW in free air. Power dissipation is 500 mW when mounted as recommended. Derate at 4.0 mW / °C for operation above 25 °C.

Note 2: This value depends on the output voltage. (This is a value for a $V_{OUT} = 3$ V device.)

Note 3: The minimum operating Voltage for V_{IN} can be 2.1 V. Also, the minimum voltage required for V_{IN} is $V_{IN} = V_{DROP} + V_{OUT}$. As a result, operating at $V_{OUT} \leq 2.0$ V at the minimum operating voltage is not preferred.

Note 4: The input current decreases to the pA level by connecting the control terminal to GND (Off State). The internal pull-down resistor is 500 KΩ.

General Note: Parameters with only typical values are just reference. (Not guaranteed)

General Note: Limits are guaranteed by production testing or correction techniques using Statistical Quality Control (SQC) methods. Unless otherwise noted, $V_{IN} = V_{OUT(TYP)} + 1$ V, $I_{OUT} = 5$ mA (Tj = 25 °C). The operation of -30 °C to + 80 °C is guaranteed in the design by a usual inspection.

General Note: Exceeding the “Absolute Maximum Rating” may damage the device.

General Note: Connecting a capacitor to the noise bypass pin can decrease the output noise voltage.

ABSOLUTE MAXIMUM RATINGS TK111xxC

Supply Voltage .... -0.4 to16 V
Noise Bypass Terminal Voltage .... -0.4 to 5 V
Power Dissipation (Note 1) .... 500 mW
Reverse Bias .... -0.4 to 6 V
Storage Temperature Range .... -55 to +150 °C
Operating Temperature Range .... -40 to +85 °C
Operating Voltage Range .... 2.1 to 14 V
Control Pin Voltage .... -0.4 to 16 V
Short Circuit Current .... 360 mA

TK111xxCSI ELECTRICAL CHARACTERISTICS (I RANK)

Test conditions: $V_{IN} = V_{OUT(TYP)} + 1$ V, $I_{OUT} = 5$ mA, $T_A = 25$ °C, Boldfaced type specifications apply over the full operating temperature Rang (-40 to +85 °C).

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
V_{OUT}	Output Voltage	See Table 1				
Line Reg	Line Regulation	Δ V = 5 V, ($V_{VIN} = V_{OUT(TYP)}$ + 1 V to $V_{OUT(TYP)}$ + 6 V)		0.3	5	mV
					8	
Load Reg	Load Regulation	I_{OUT} = 5 mA to100 mA (Note 2)		11	28	mV
					34	
		I_{OUT} = 5 mA to 200 mA (Note 2)		27	64	mV
					90	
V_{DROP}	Dropout Voltage (Note 3)	I_{OUT} = 50 mA		80	140	mV
					180	
		I_{OUT} = 100 mA		120	210	mV
					270	
		I_{OUT} = 200 mA ($V_{OUT} \geq 2.4$ V)		200	350	mV
					390	
		I_{OUT} = 180 mA (2.1 V $\leq V_{OUT} <$ 2.4 V)		230	350	mV
					390	
$I_{OUT(MAX)}$	Maximum Output Current	$V_{OUT} = V_{OUT(TYP)}$ x 0.9	240	320		mA
			220			
I_Q	Quiescent Current	I_{OUT} = 0 mA Excluding I_{CONT}		63	100	μA
					120	
I_{STBY}	Standby Current	V_{CC} = 8 V, $V_{CONT} \leq 0.15$ V (OFF State) (Note 4)		0.0	0.1	μA
					0.5	
I_{GND}	Ground Pin Current	I_{OUT} = 50 mA		1.0	**1.8**	mA

TK111xxCSI ELECTRICAL CHARACTERISTICS - I RANK (CONT)

Test conditions: $V_{IN} = V_{OUT(TYP)} + 1$ V, $I_{OUT} = 5$ mA, $T_A = 25$ °C, Boldfaced type specifications apply over the full operating temperature Rang (-40 to +85 °C).

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
CONTROL TERMINAL SPECIFICATIONS (Note 4)						
I_{CONT}	Control Current	V_{CONT} = 1.8 V, Output ON		5	15	µA
V_{CONT}	Control Voltage	ON State	1.6			V
			1.9			
		OFF State			0.6	V
					0.35	
V_{REF}	Noise Bypass Terminal Voltage			1.28		V
$\Delta V_{OUT} / \Delta T_A$	Temperature Coefficient			25		ppm / °C
V_{NO}	Output Noise Voltage	V_{OUT} = 3 V, f = 1kHz		0.20		μV / √Hz
		V_{OUT} = 3 V, at BW 400 Hz to 80 kHz		45		μV_{RMS}
RR	Ripple Rejection	f = 400 Hz, CL = 1.0 μF, C_N = 0.01 μF, V_{NOISE} = 200 mV_{RMS}, $V_{IN} = V_{OUT(TYP)}$ + 1.5 V, I_{OUT} = 10 mA		84		dB
		f = 1 kHz, CL = 1.0 μF, C_N = 0.01 μF, V_{NOISE} = 200 mV_{RMS}, $V_{IN} = V_{OUT(TYP)}$ + 1.5 V, I_{OUT} = 10 mA		80		dB

Note 1: Power dissipation is 150 mW in free air. Power dissipation is 500 mW when mounted as recommended. Derate at 4.0 mW / °C for operation above 25 °C.
Note 2: This value depends on the output voltage. (This is a value for a V_{OUT} = 3 V device.)
Note 3: The minimum operating Voltage for V_{IN} can be 2.1 V. Also, the minimum voltage required for V_{IN} is $V_{IN} = V_{DROP} + V_{OUT}$. As a result, operating at $V_{OUT} \leq 2.0$ V at the minimum operating voltage is not preferred.
Note 4: The input current decreases to the pA level by connecting the control terminal to GND (Off State). The internal pull-down resistor is 500 KΩ.

General Note: Parameters with only typical values are just reference. (Not guaranteed)

General Note: Limits are guaranteed by production testing or correction techniques using Statistical Quality Control (SQC) methods. Unless otherwise noted, $V_{IN} = V_{OUT(TYP)} + 1$ V, I_{OUT} = 5 mA (Tj = 25 °C). The operation of -40 °C to + 85 °C is guaranteed in the design by a usual inspection.
General Note: Exceeding the “Absolute Maximum Rating” may damage the device.
General Note: Connecting a capacitor to the noise bypass pin can decrease the output noise voltage.

TK111xxCSC ELECTRICAL CHARACTERISTICS TABLE 1

T_A = 25 °C, I_{OUT} = 5 mA, V_{IN} = $V_{OUT(TYP)}$ + 1 V

			Standard Temp. Range Spec. Room Temp (T_A = 25°C)		Extended Temp. Range. Spec. Full Temp (T_A = -40 to 85°C)	
Availability	**Output Voltage**	**Voltage Code**	**V_{OUT} Min**	**V_{OUT} Max**	**V_{OUT} Min**	**V_{OUT} Max**
*	1.5 V	15	1.450 V	1.550 V	1.420 V	1.580 V
	1.6 V	16	1.550 V	1.650 V	1.520 V	1.680 V
	1.7 V	17	1.650 V	1.750 V	1.620 V	1.780 V
*	1.8 V	18	1.750 V	1.850 V	1.720 V	1.880 V
*	1.9 V	19	1.850 V	1.950 V	1.820 V	1.980 V
*	2.0 V	20	1.950 V	2.050 V	1.920 V	2.080 V
	2.1 V	21	2.050 V	2.150 V	2.020 V	2.180 V
*	2.2 V	22	2.150 V	2.250 V	2.120 V	2.280 V
	2.3 V	23	2.250 V	2.350 V	2.220 V	2.380 V
	2.4 V	24	2.350 V	2.450 V	2.320 V	2.480 V
*	2.5 V	25	2.450 V	2.550 V	2.420 V	2.580 V
	2.6 V	26	2.550 V	2.650 V	2.520 V	2.680 V
*	2.7 V	27	2.650 V	2.750 V	2.620 V	2.780 V
*	2.8 V	28	2.750 V	2.850 V	2.720 V	2.880 V
*	2.9 V	29	2.850 V	2.950 V	2.820 V	2.980 V
*	3.0 V	30	2.950 V	3.050 V	2.920 V	3.080 V
*	3.1 V	31	3.050 V	3.150 V	3.020 V	3.180 V
*	3.2 V	32	3.150 V	3.250 V	3.120 V	3.280 V
*	3.3 V	33	3.250 V	3.350 V	3.217 V	3.383 V
	3.4 V	34	3.349 V	3.451 V	3.315 V	3.485 V
*	3.5 V	35	3.447 V	3.553 V	3.412 V	3.588 V

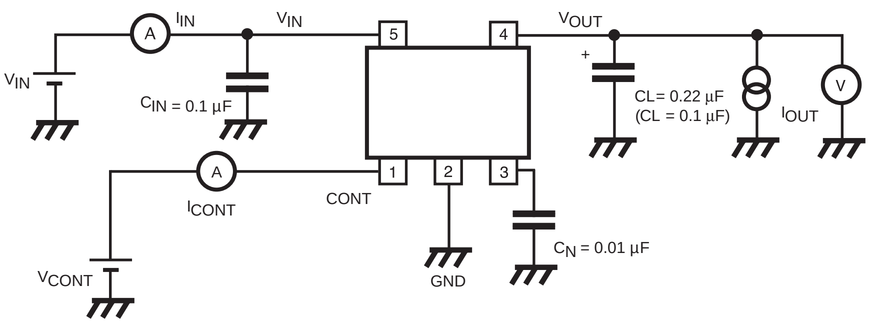
TK111xxCSC ELECTRICAL CHARACTERISTICS TABLE 1 (CONT)

T_A = 25 °C, I_{OUT} = 5 mA, V_{IN} = $V_{OUT(TYP)}$ + 1 V

			Standard Temp. Range Spec. Room Temp (T_A = 25°C)		Extended Temp. Range. Spec. Full Temp (T_A = -40 to 85°C)	
Availability	**Output Voltage**	**Voltage Code**	**V_{OUT} Min**	**V_{OUT} Max**	**V_{OUT} Min**	**V_{OUT} Max**
*	3.6 V	36	3.546 V	3.654 V	3.510 V	3.690 V
	3.7 V	37	3.644 V	3.756 V	3.607 V	3.793 V
*	3.8 V	38	3.743 V	3.857 V	3.705 V	3.895 V
	3.9 V	39	3.841 V	3.959 V	3.802 V	3.998 V
*	4.0 V	40	3.940 V	4.060 V	3.900 V	4.100 V
	4.1 V	41	4.038 V	4.162 V	3.997 V	4.203 V
	4.2 V	42	4.137 V	4.263 V	4.095 V	4.305 V
	4.3 V	43	4.235 V	4.365 V	4.192 V	4.408 V
	4.4 V	44	4.334 V	4.466 V	4.290 V	4.510 V
*	4.5 V	45	4.432 V	4.568 V	4.387 V	4.613 V
	4.6 V	46	4.531 V	4.669 V	4.485 V	4.715 V
*	4.7 V	47	4.629 V	4.771 V	4.582 V	4.818 V
	4.8 V	48	4.728 V	4.872 V	4.680 V	4.920 V
	4.9 V	49	4.826 V	4.974 V	4.777 V	5.023 V
*	5.0 V	50	4.925 V	5.075 V	4.875 V	5.125 V

Note: * Denotes voltage presently available.
Consult factory for availability of other voltages.

TEST CIRCUIT

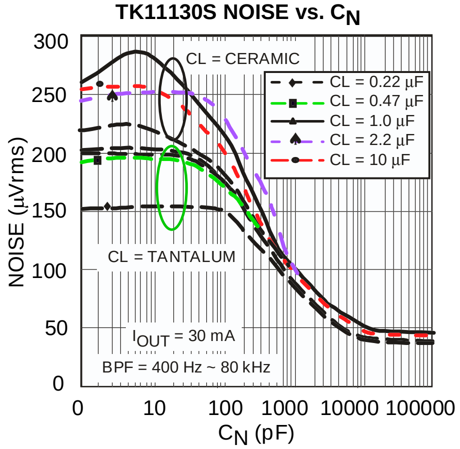


TYPICAL PERFORMANCE CHARACTERISTICS

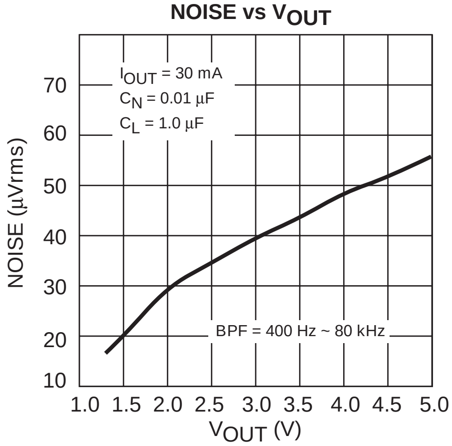
T_A = 25 °C, unless otherwise specified.

Output Noise

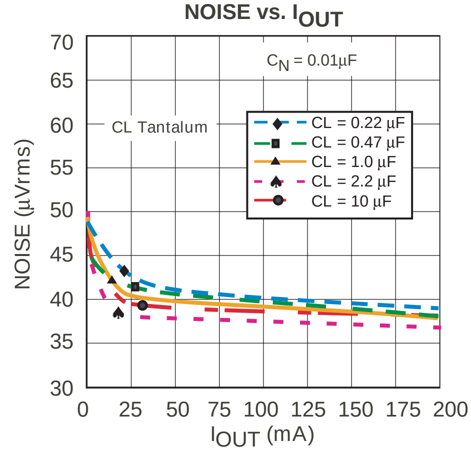
TK11130S NOISE vs. C_N



NOISE vs V_{OUT}

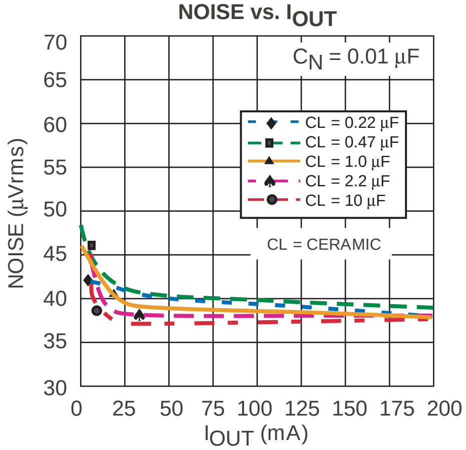


NOISE vs. I_{OUT}

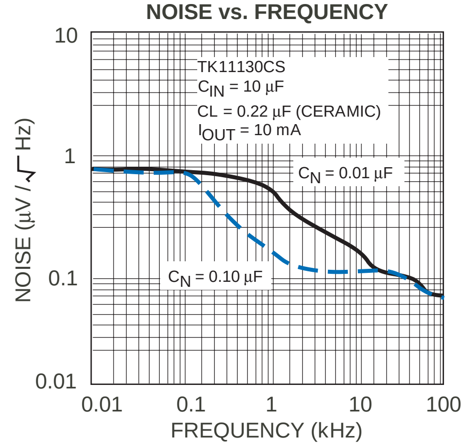


For better noise reduction, it is more effective to increase C_N without increasing CL. The recommended C_N capacitance is 6800 pF (682) or 0.01 μF (103). As the output voltage increases, the noise will also increase.

NOISE vs. I_{OUT}



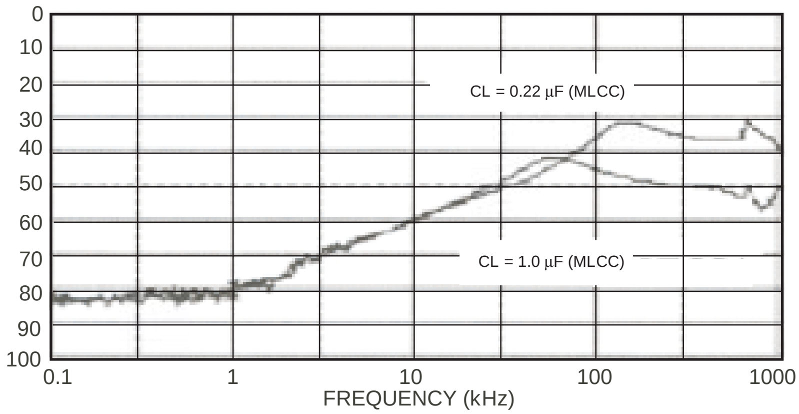
NOISE vs. FREQUENCY



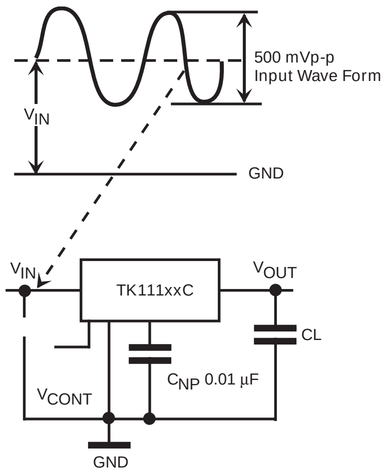
TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

T_A = 25 °C, unless otherwise specified.

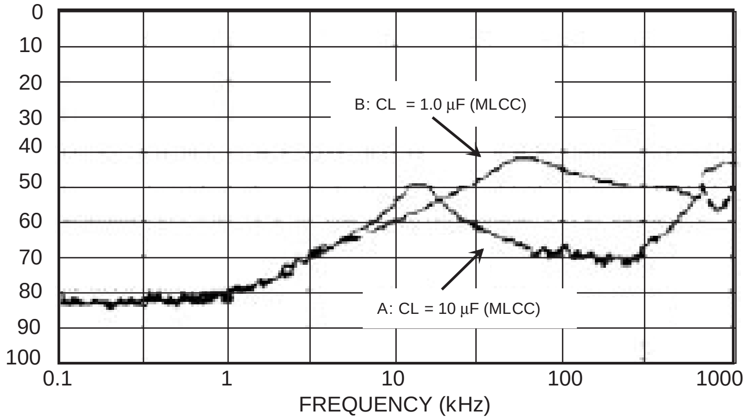
Ripple Rejection

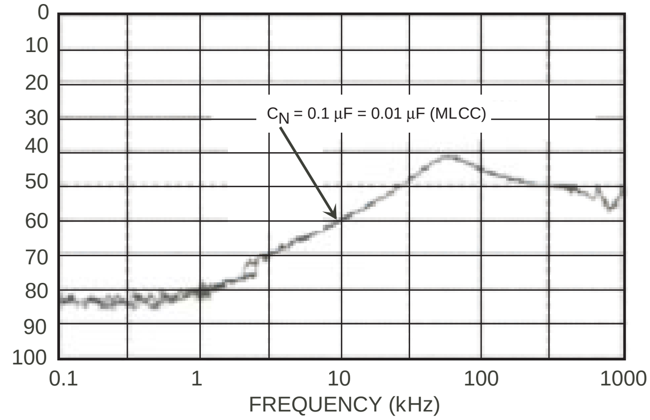


MLCC stands for Multi Layer Ceramic Capacitor.



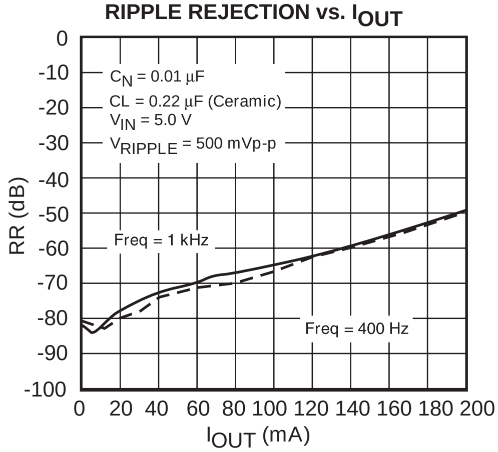
V_{IN} = 5.0 V, (V_{IN} = $V_{OUT(TYP)}$ + 2 V), V_{OUT} = 3.0 V, I_{OUT} = 10 mA
VR = 500 mVp-p, f = 100 ~ 1 MHz, C_N = 0.01 μF, C_{IN} = 0 μF



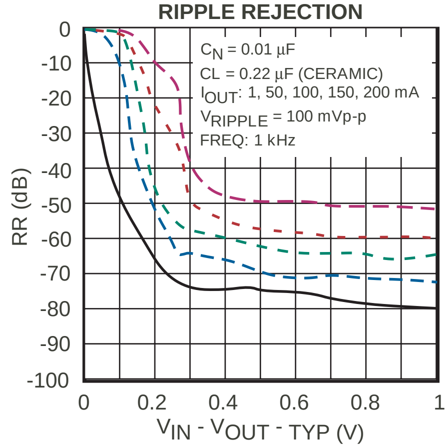


The ripple rejection characteristic depends on the characteristic and the capacitance value of the capacitor connected to the output side. The RR characterisic of 50 kHz or more varies greatly with the capacitor on the output side and the PCB pattern. If necessary, please confirm stability while operating.

RIPPLE REJECTION vs. I_{OUT}



RIPPLE REJECTION

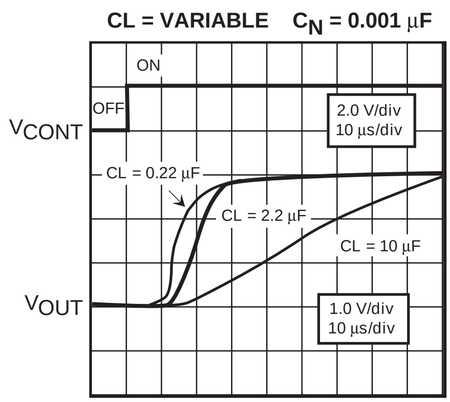


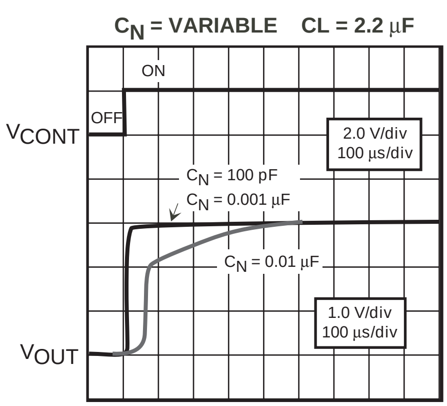
TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

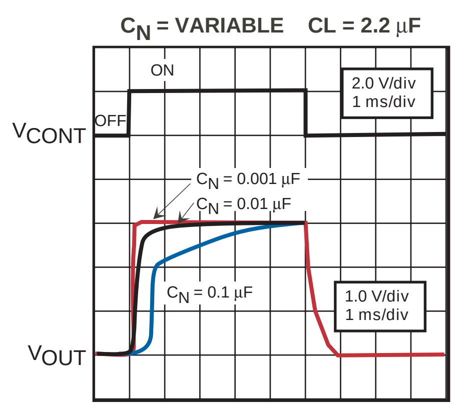
T_A = 25 °C, unless otherwise specified.

ON / OFF TRANSIENT

Condition: V_{CONT} = 0 V to 2 V, f =100 Hz, I_{OUT} = 30 mA, C_{IN} = 1.0 µF





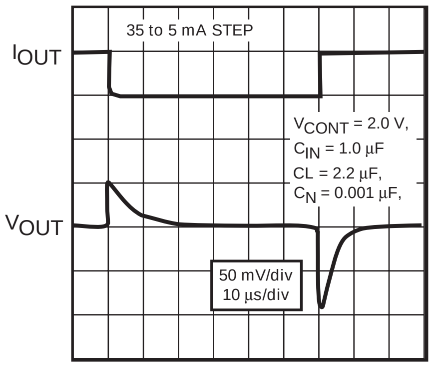


TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

T_A = 25 °C, unless otherwise specified.

LOAD TRANSIENT

LOAD TRANSIENT 1



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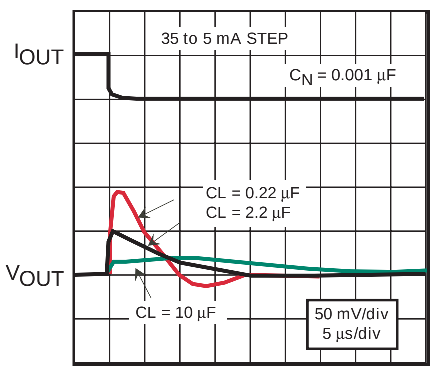
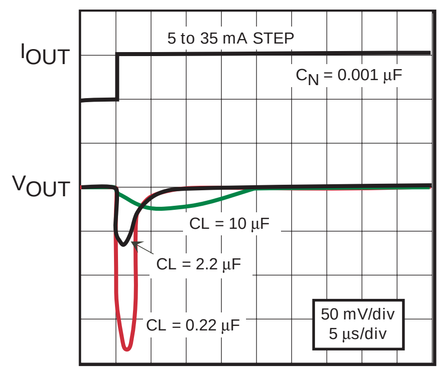
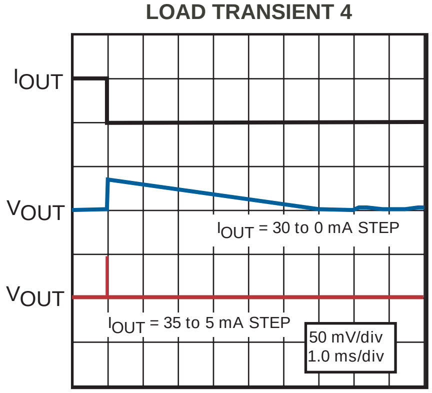


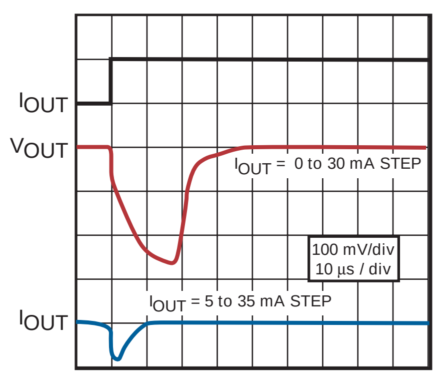
LOAD TRANSIENT 3



LOAD TRANSIENT 4



LOAD TRANSIENT 5

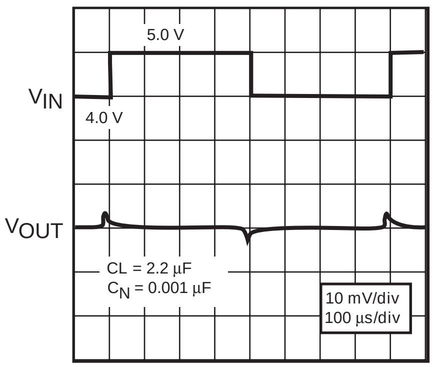


TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

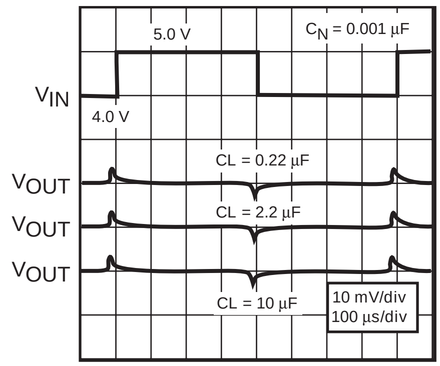
T_A = 25 °C, unless otherwise specified.

LINE TRANSIENT

LINE TRANSIENT 1

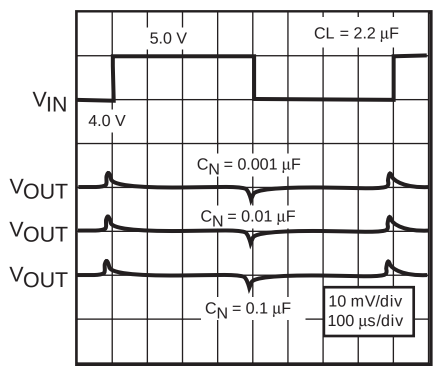


LINE TRANSIENT 2

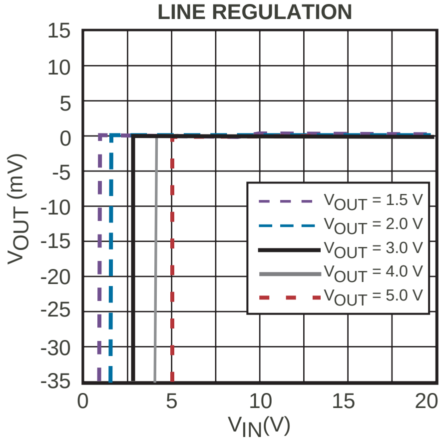


Conditions: I_{OUT} = 30 mA, V_{CONT} = 2.0 V, C_{IN} = 1.0 μF

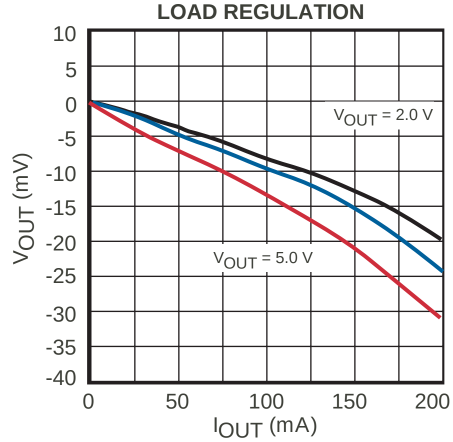
LINE TRANSIENT 3



LINE REGULATION

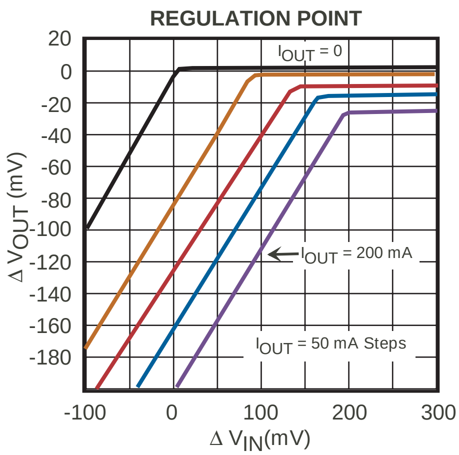


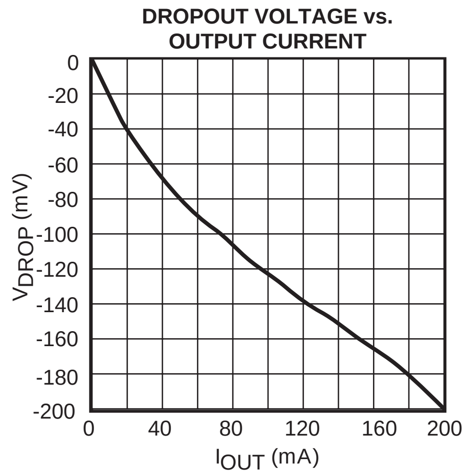
LOAD REGULATION

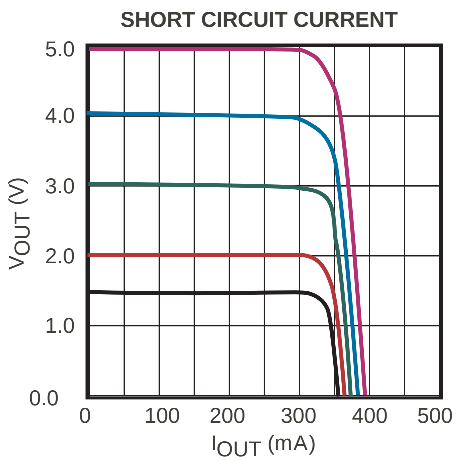


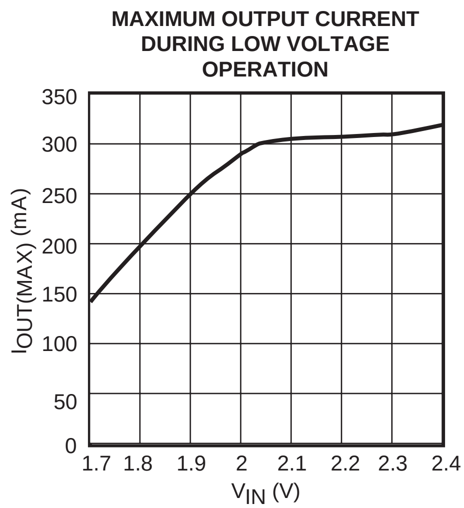
TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

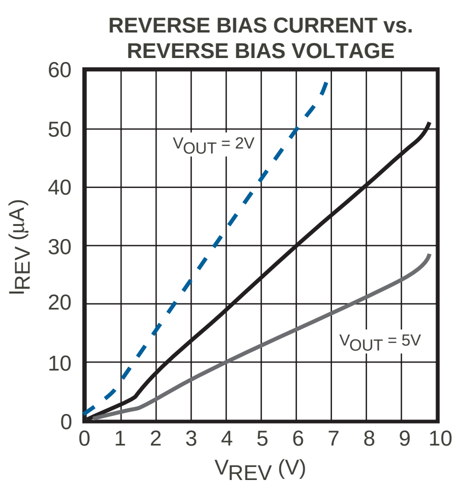
T_A = 25 °C, unless otherwise specified.

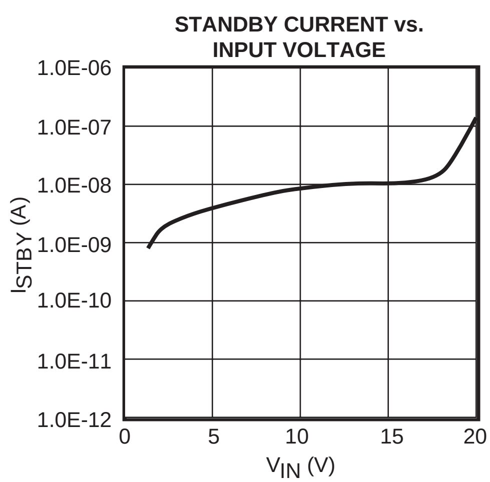






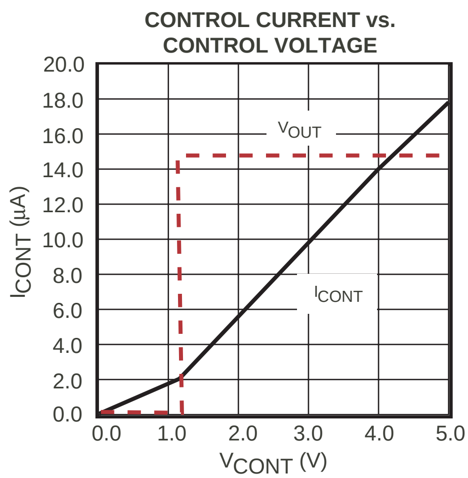


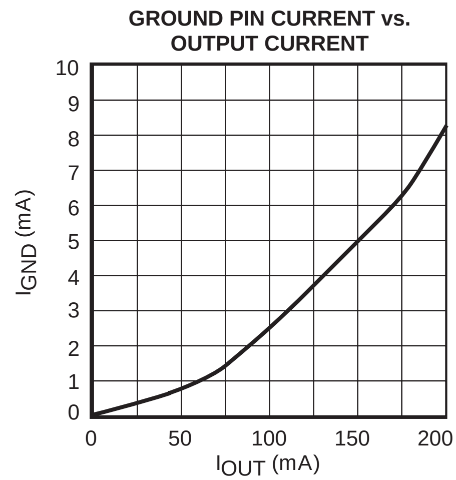


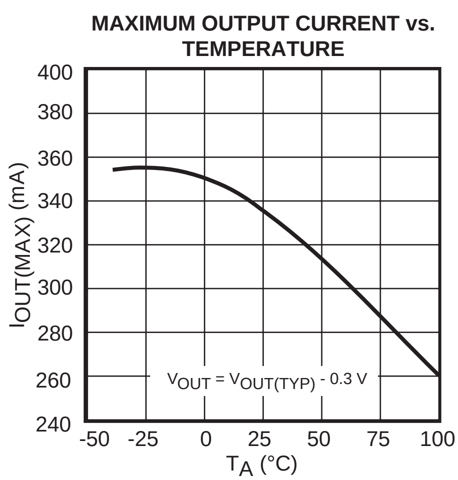


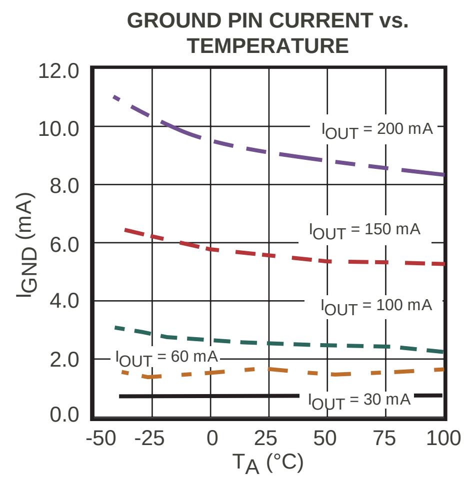
TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

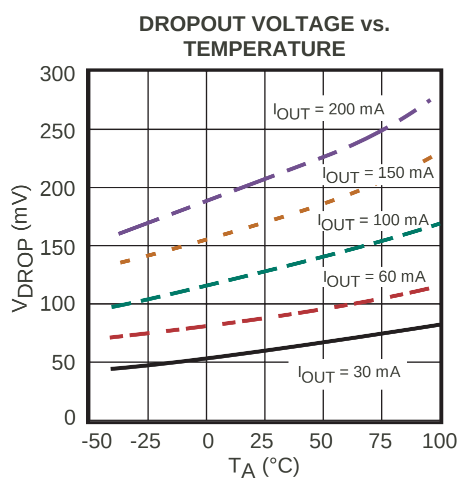
T_A = 25 °C, unless otherwise specified.

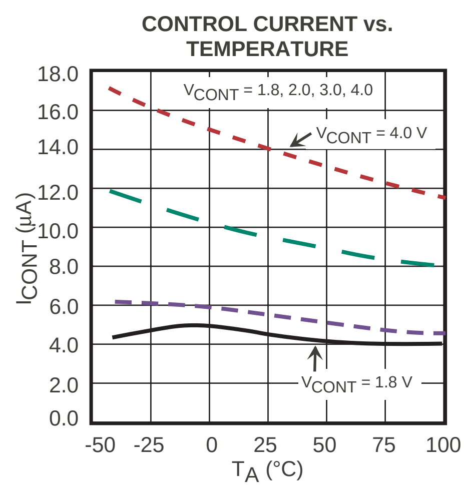








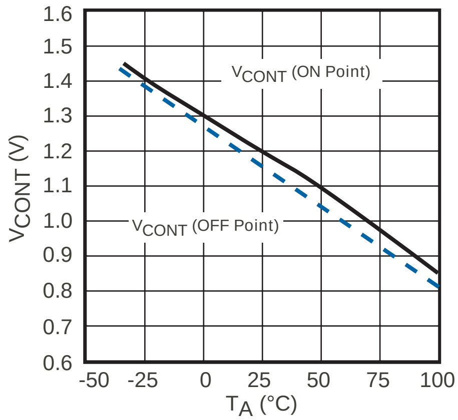




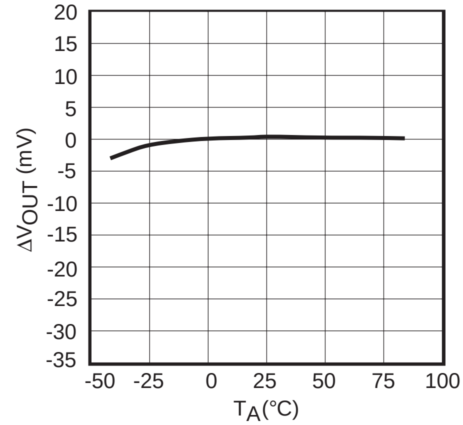
TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

T_A = 25 °C, unless otherwise specified.

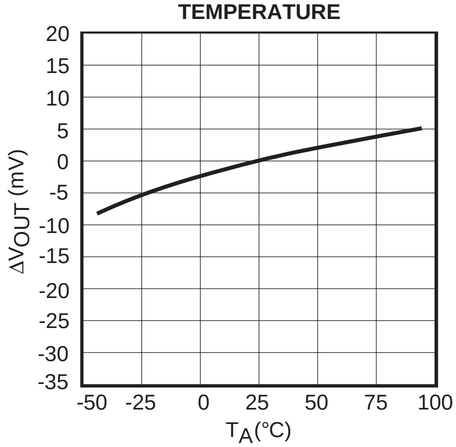
ON / OFF KNEE VOLTAGE vs. TEMPERATURE



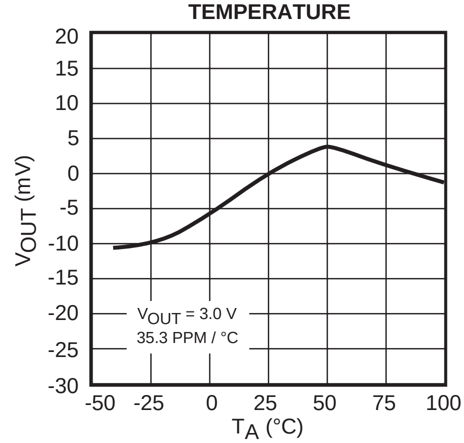
TK11115 OUTPUT VOLTAGE vs. TEMPERATURE



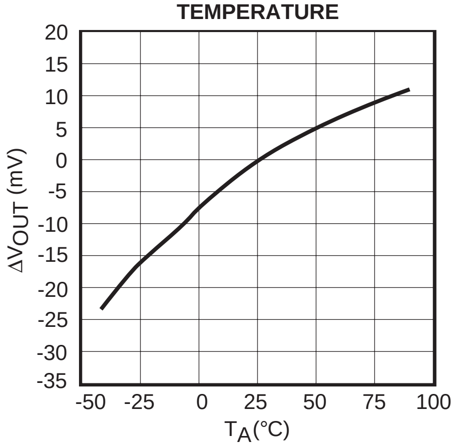
TK11120 OUTPUT VOLTAGE vs. TEMPERATURE



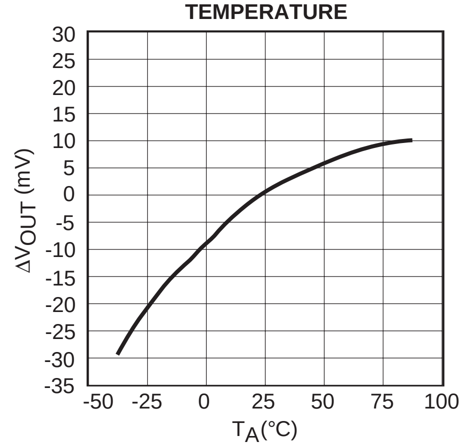
TK11130 OUTPUT VOLTAGE vs. TEMPERATURE



TK11140 OUTPUT VOLTAGE vs. TEMPERATURE



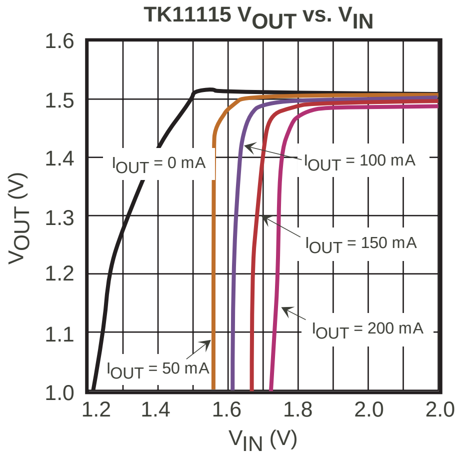
TK11150 OUTPUT VOLTAGE vs. TEMPERATURE

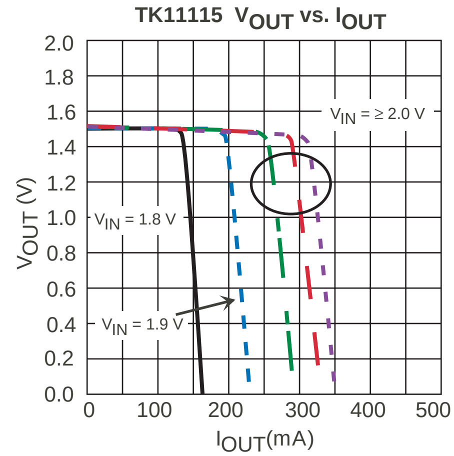


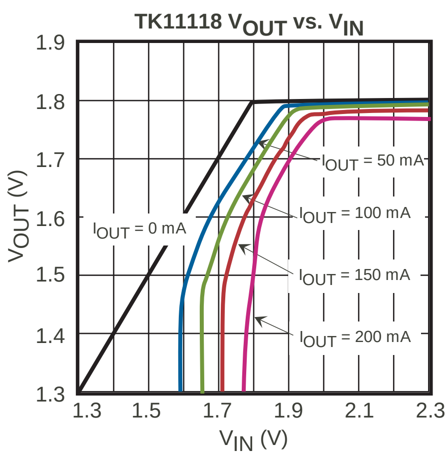
TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

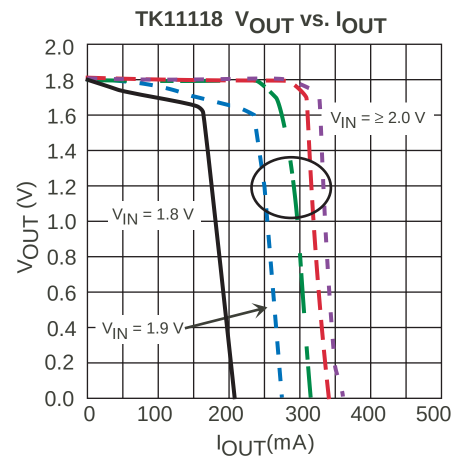
T_A = 25 °C, unless otherwise specified.

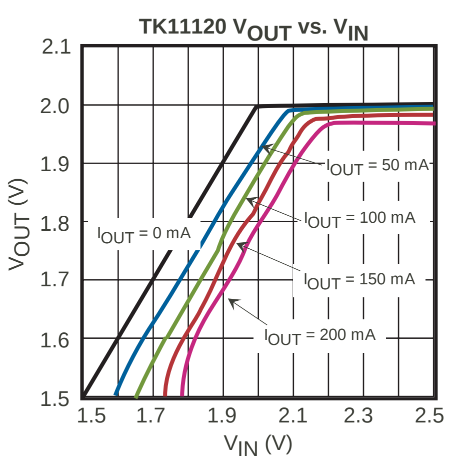
Low Output Voltage Device V_{IN} - V_{OUT} and I_{OUT} - V_{OUT} Characteristics

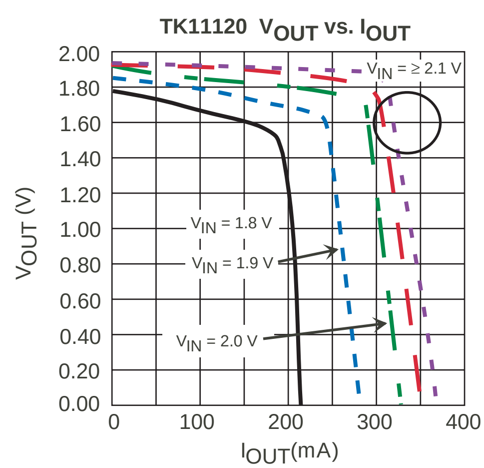












DEFINITION AND EXPLANATION OF TECHNICAL TERMS

OUTPUT VOLTAGE (V_{OUT})

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

MAXIMUM OUTPUT CURRENT ($I_{OUT(MAX)}$)

The rated output current is specified under the condition where the output voltage drops 0.9 times the value specified with $I_{OUT} = 5$ mA. The input voltage is set to $V_{OUT(TYP)}$ +1 V, and the current is pulsed to minimize any temperature effect. The output current decreases during low voltage operation . Please refer to the graphs on the previous page for 2.1 V or less.

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 (this is the point when the output voltage decreases by 100 mV). 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.

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. It is a pulsed measurement to minimize temperature effects.

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 two output current step conditions of 5 mA to 100 mA and 5 mA to 200 mA.

QUIESCENT CURRENT (I_Q)

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

GROUND PIN CURRENT(I_{GND})

The ground pin current is the current which flows through the GND terminal according to load current. It is measured by (input current-output 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 200 mV_{RMS}, 400 Hz and 1 kHz signal superimposed on the input voltage, where $V_{IN} = V_{OUT} + 1.5$ V. The output decoupling capacitor is set to 1.0 µF, the noise bypass capacitor is set to 0.01 µF, and the load current is set to 10 mA. Ripple rejection is the ratio of the ripple content of the output vs. the input and is expressed in dB. Ripple rejection can be improved by increasing the noise bypass capacitor (however, the on/off response time will increase).

STANDBY CURRENT (I_{STBY})

Standby current is the current into the regulator when the output is turned off by the control function. It is measured with an input voltage of 8 V.

OVER CURRENT SENSOR

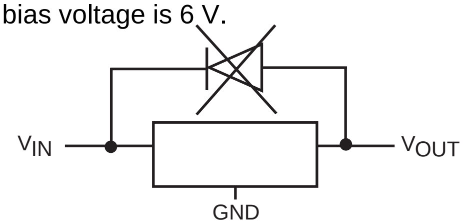
The overcurrent sensor protects the device when there is excessive output current. It also protects the device if the output is accidentally shorted to ground.

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. Toko's regulators do not need an inherent diode connected between the input and output. The maximum reverse bias voltage is 6 V.



ESD	MM	200 pF	0 Ω	200 V Min
	HBM	100 pF	1.5 kΩ	200 V Min

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 ($V_{IN} \times I_{IN}$) and the output power ($V_{OUT} \times I_{OUT}$) 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 large. When mounted on the recommended mounting pad, the power dissipation of the SOT23-5 is increased to 500 mW. For operation at ambient temperatures over 25 °C, the power dissipation of the SOT23-5 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:

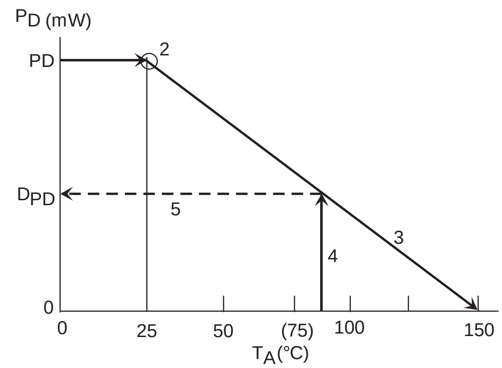
$$T_j = \theta_{jA} \times P_D + T_A$$

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

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

P_D is the value when the thermal protection circuit is activated. A simple way to determine P_D is to calculate $V_{IN} \times I_{IN}$ 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:

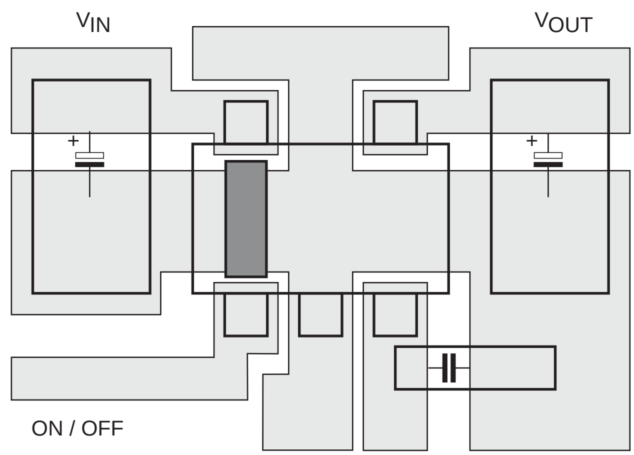
1) Find P_D
2) P_{D1} is taken to be P_D x (~0.8 - 0.9)
3) Plot P_{D1} against 25 °C
4) Connect P_{D1} to the point corresponding to the 150 °C with a straight line.
5) In design, take a vertical line from the maximum operating temperature (e.g., 75 °C) to the derating curve.
6) Read off the value of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

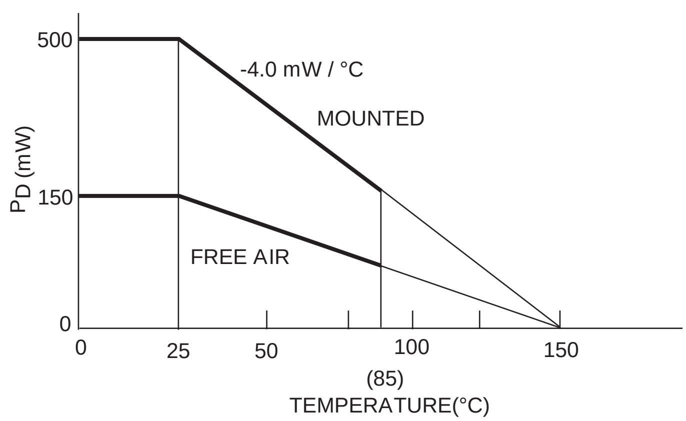
$$I_{OUT} = (D_{PD} / (V_{IN(MAX)} - V_{OUT})$$

APPLICATION INFORMATION (CONT.)

BOARD LAYOUT



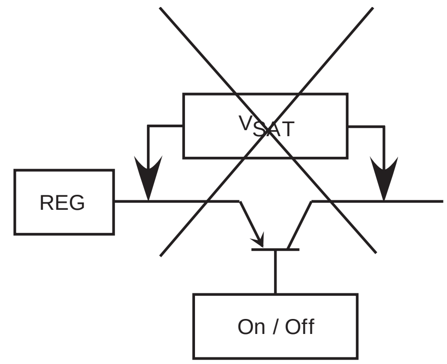
SOT23-5 BOARD LAYOUT



APPLICATION INFORMATION (CONT.)

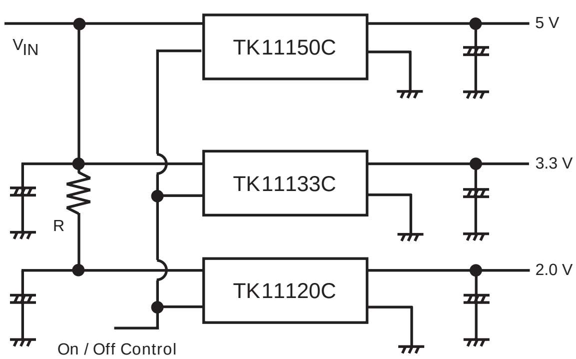
Application Hint

On / Off Control
It is recommended to turn the regulator Off when the circuit following the regulator is not operating. A design with little electric power loss can be implemented. We recommend the use of the on / off control of the regulator without using a high side switch to provide an output from the regulator. A highly accurate output voltage with low voltage drop is obtained.



Because the control current is small, it is possible to control it directly by CMOS logic. The PULLDOWN resistance is built into the control terminal (500 kΩ). The noise and ripple rejection characteristics depend on the capacitance on the Noise Bypass teminal. The ripple rejection characteristic of the low frequency region improves by increasing the capacitance of C_N. A standard value is C_N =0.0068 μF. Increase C_N in a design with important output noise and ripple rejection requirements. The IC will not be damaged if the capacitor value is increased. The switching speed of off / on changes depending on the capacitance at the Noise Bypass terminal. The switching speed slows when the capacitance is large.

Parallel Connected ON / OFF Control



If there is an overheating concern because the power loss of the low voltage output (TK11120) IC is large, it may be necessary to decrease the electric power loss by using the resistor (R) as shown in the left figure.
When the thermal protection circuit works, a decrease of the output voltage, oscillation, etc. are observed.

APPLICATION INFORMATION

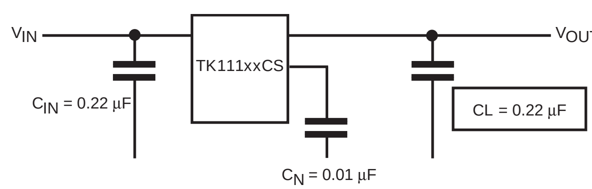
INPUT-OUTPUT CAPACITORS

Linear regulators require input and output capacitors in order to maintain the regulator's loop stability. The equivalent series resistance (ESR) of the output capacitor must be in the stable operation area. However, it is recommended to use as large a value of capacitance as is practical. The output noise and the ripple noise decrease as the capacitance value increases. The IC is never damaged by enlarging the capacitance.

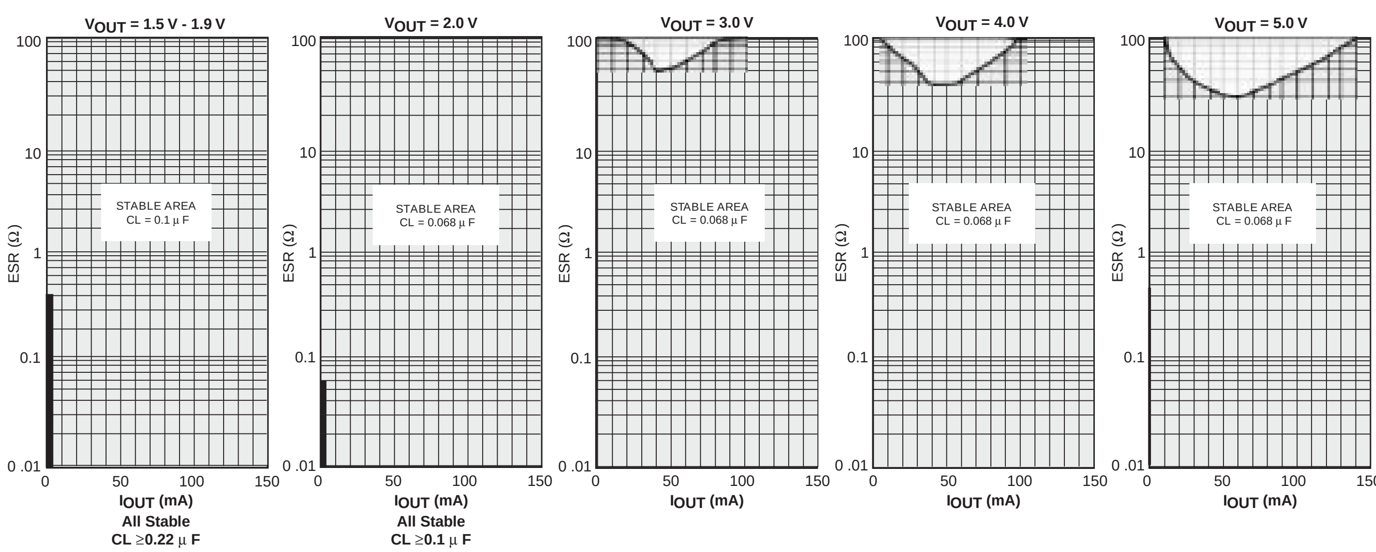
ESR values vary widely between ceramic and tantalum capacitors. However, tantalum capacitors are assumed to provide more ESR damping resistance, which provides greater circuit stability. This implies that a higher level of circuit stability can be obtained by using tantalum capacitors when compared to ceramic capacitors with similar values. The IC provides stable operation with an output side capacitor of 0.22 µF ($V_{OUT} \geq 2.0$ V). If the capacitor is 0.1 µF or more over its full range of temperature, either a ceramic capacitor or tantalum capacitor can be used without considering ESR ($V_{OUT} \geq 2.0$ V).

For output voltage device ≥ 2.0 V applications, the recommended value of CL ≥ 0.10 µF.
For output voltage device ≥ 1.5 V applications, the recommended value of CL ≥ 0.22 µF.
For load current ≤ 0.5 mA, increase the output capacitor to 1 µF.

The input capacitor is necessary when the battery is discharged, the power supply impedance increases, or the line distance to the power supply is long. This capacitor might be necessary on each individual IC even if two or more regulator ICs are used. It is not possible to determine this indiscriminately. Please confirm the stability while mounted.



STABLE OPERATION AREA vs. VOLTAGE, CURRENT AND ESR



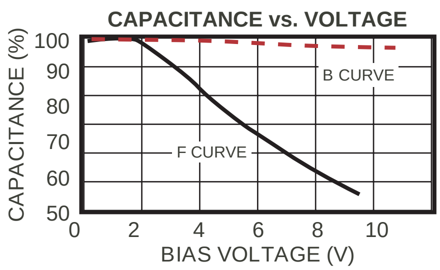
Please increase the output capacitor value when the load current is 0.5 mA or less. The stability of the regulator improves if a big output side capacitor is used (the stable operation area extends).

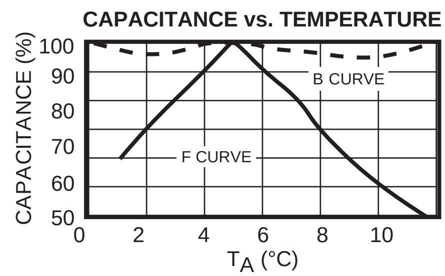
For evaluation
KYOCERA: CM05B104K10AB, CM05B224K10AB, CM105B104K16A, CM105B224K16A, CM21B225K10A
MURATA: GRM36B104K10, GRM42B104K10, GRM39B104K25, GRM39B224K10, GRM39B105K6.3

APPLICATION INFORMATION (CONT.)

Bias Voltage and Temperature Characteristics of Ceramic Capacitors

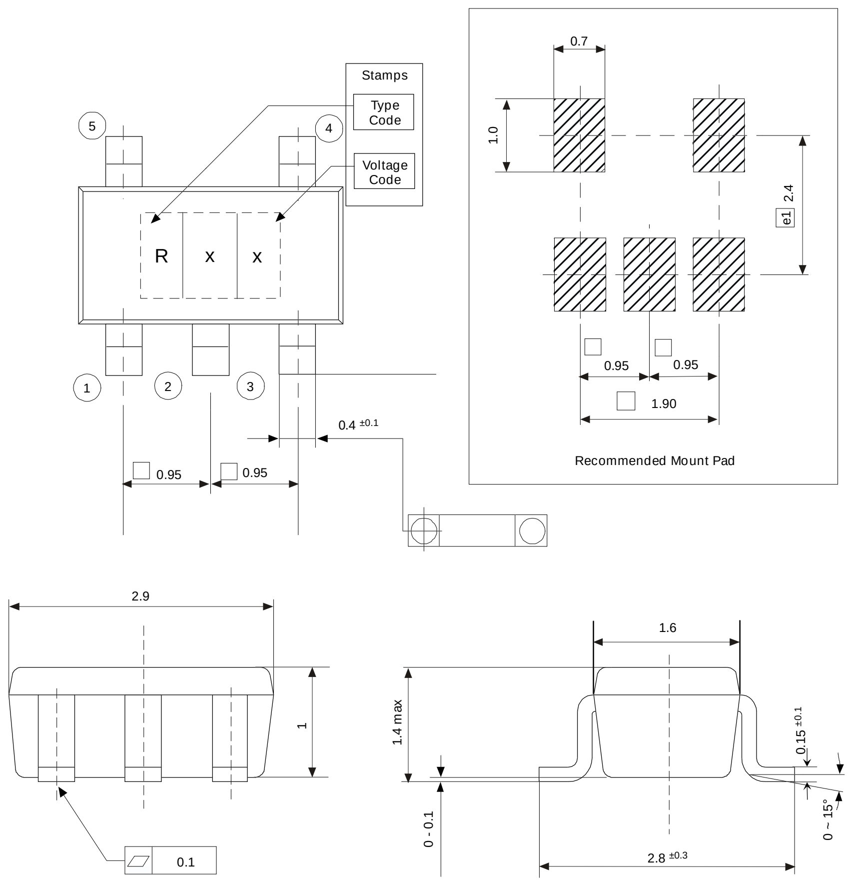
Generally, a ceramic capacitor has both a temperature characteristic and a voltage characteristic. Please consider both characteristics when selecting the part. The B curves are the recommended characteristics.





PACKAGE OUTLINE

SOT23-5



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

Marking Information

	Product Code
TK111xxCS	R

	Voltage Code
TK11115CS	15
TK11116CS	16
TK11117CS	17
TK11118CS	18
TK11119CS	19
TK11120CS	20
TK11121CS	21
TK11122CS	22
TK11123CS	23
TK11124CS	24
TK11125CS	25
TK11127CS	27
TK11128CS	28
TK11129CS	29
TK11130CS	30
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TK11132CS	32
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TK11137CS	37
TK11138CS	38
TK11139CS	39
TK11140CS	40
TK11141CS	41
TK11142CS	42
TK11143CS	43
TK11144CS	44
TK11145CS	45
TK11146CS	46
TK11147CS	47
TK11148CS	48
TK11149CS	49
TK11150CS	50

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