

HIGH-TEMPERATURE LOW-POWER SERIES VOLTAGE REGULATOR

FEATURES

- ▲ Up to 10 possible output voltages from same part:
 - 1.2V / 1.8V / 2.5V / 3.3V / 5V / 5.5V / 9V / 10V / 12V / 15V.
- ▲ Input voltage from 2.8V to 40V.
- ▲ Drop-in replacement of commercial voltage references.
- ▲ Trimming capabilities.
- ▲ Operational beyond the -60°C to +230°C temperature range.
- ▲ Output current up to 50mA @ 230°C.
- ▲ Soft-start.
- ▲ Compatible with low and high dropout voltages.
- ▲ Stable over a wide range of load capacitance (0.1µF to 10µF).
- ▲ Low intrinsic current consumption (380µA @ 230°C).
- ▲ Low temperature dependence (40ppm/°C).
- ▲ Excellent line regulation (0.75% @ 230°C).
- ▲ Active-low shutdown control.
- ▲ Monolithic design for high-reliability.
- ▲ Latch-up free SOI process.
- ▲ Ruggedized SMT and thru-hole packages.
- ▲ Also available as bare die.

APPLICATIONS

- ▲ Reliability-critical, Automotive, Aeronautics & Aerospace, Down-hole.
- ▲ Positive and negative precision regulators/references, A/D and D/A converters, current sources, bridge excitation.

DESCRIPTION

XTR75010 is a family of low-power voltage regulators/references designed for extreme reliability and high temperature applications. Being able to operate with input voltages from 2.8V to 40V, XTR75010 parts can supply up to 50mA at +230°C while providing excellent regulation characteristics. Parts from this product family operate as a 3-terminal series regulator/reference with a temperature coefficient (TC) as low as 40ppm/°C. Up to ten possible output voltages (1.2V to 15V) can be obtained from the same part.

Functionality features include shut-down mode and soft-start. XTR75010 parts can be used in a wide range of applications such as positive and negative regulators/references, adjustable power supply, current sources, as well as precision bridge excitation.

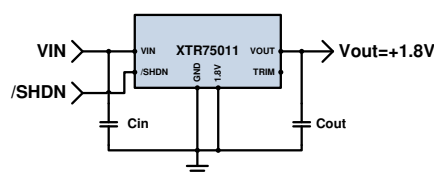
Special design techniques were used allowing XTR75010 parts to offer a precise, robust and reliable operation in critical applications. Full functionality is guaranteed from -60°C to +230°C, though operation well below and above this temperature range is achieved.

XTR75010 parts have been designed to reduce system cost and ease adoption by reducing the learning curve and providing smart and easy to use features.

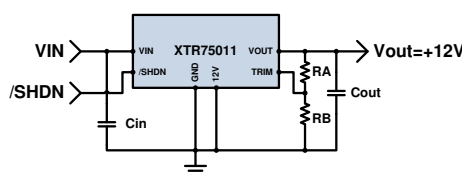
Parts from the XTR75010 family are available in ruggedized SMT and thru-hole packages. Parts are also available as bare dies. See also the Application Notes in the XTR75010 webpage.

PRODUCT HIGHLIGHT

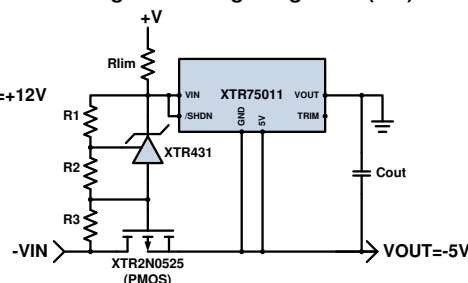
1.8V Voltage Regulator/Reference



12V Voltage Regulator with Trimming



Negative Voltage Regulator (-5V)



$$V_{OUT} = \frac{(R_{A//B} + 10k\Omega) \cdot V_{OUT_NOM} + 100k\Omega \cdot V_{REF_ACTUAL}}{(R_{A//B} + 10k\Omega) \cdot \left(1 + \frac{100k\Omega}{R_A}\right)}$$

ORDERING INFORMATION

X
↓
Source:
X = X-REL Semi

TR
↓
Process:
TR = HiTemp, HiRel

75
↓
Part family

01x
↓
Part number

x
↓
Output voltage
(XTR75012 only)
A = 1.2V F = 5.5V
B = 1.8V G = 9.0V
C = 2.5V H = 10V
D = 3.3V I = 12V
E = 5.0V J = 15V

Product Reference	Temperature Range	Package	Pin Count	Marking
XTR75010-TD	-60°C to +230°C	Tested bare die		XTR75010
XTR75011-S	-60°C to +230°C	Ceramic SOIC	16	XTR75011
XTR75011-D	-60°C to +230°C	Ceramic side brazed DIP	16	XTR75011
XTR75012x-D	-60°C to +230°C	Ceramic side brazed DIP	8	XTR75012x
XTR75012x-FE	-60°C to +230°C	Gull-wing flat pack with ePad	8	XTR75012x
XTR75014-D	-60°C to +230°C	Ceramic side brazed DIP	8	XTR75014
XTR75014-FE	-60°C to +230°C	Gull-wing flat pack with ePad	8	XTR75014
XTR75015-D	-60°C to +230°C	Ceramic side brazed DIP	8	XTR75015
XTR75015-FE	-60°C to +230°C	Gull-wing flat pack with ePad	8	XTR75015

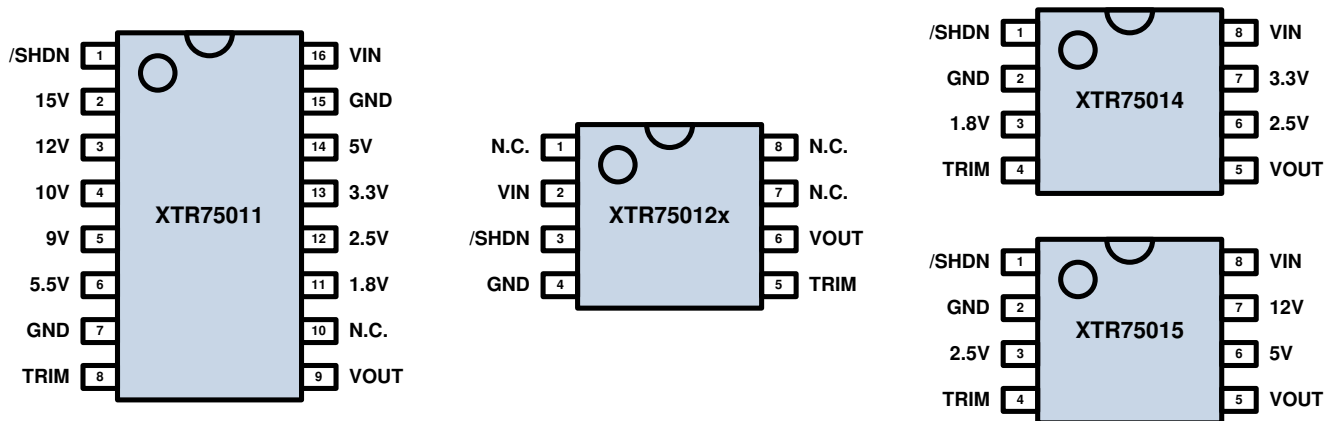
For some packages, MOQ may apply.
Other packages and packaging configurations possible upon request.

ABSOLUTE MAXIMUM RATINGS

Voltage on VIN to GND	-0.5 to 50V
Voltage on VOUT to GND	-0.5 to 17V
Voltage on /SHDN to GND	-0.5 to VIN+0.5V
Voltage on any other pin to GND	-0.5 to Min[6V, VOUT]
Storage Temperature Range	-70 °C to +230 °C
Operating Junction Temperature Range	-70 °C to +300 °C
ESD Classification	1kV HBM MIL-STD-883

Caution: Stresses beyond those listed in “ABSOLUTE MAXIMUM RATINGS” may cause permanent damage to the device. These are stress ratings only and functionality of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to “ABSOLUTE MAXIMUM RATINGS” conditions for extended periods may permanently affect device reliability.

PACKAGING

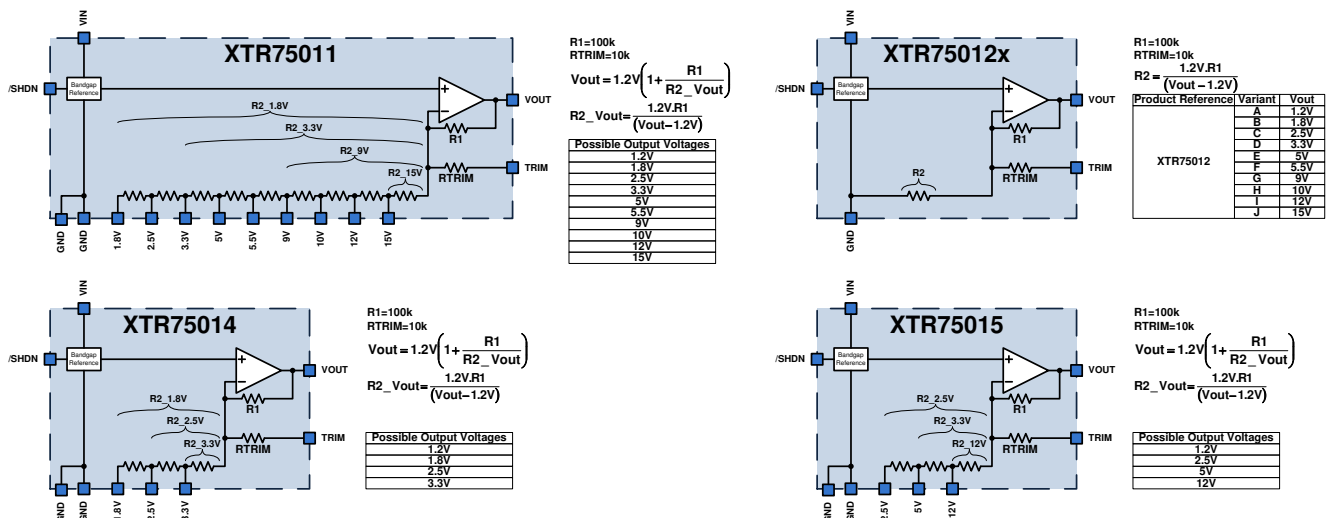


For devices with “FE” package options (CDFP8), ePAD connected to VIN.

INTERNAL BLOCK DIAGRAM

Possible output voltages depending on packaging options.

	1.2V	1.8V	2.5V	3.3V	5V	5.5V	9V	10V	12V	15V
XTR75010 (bare die)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
XTR75011	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
XTR75012 (set during assembly)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
XTR75014	✓	✓	✓	✓						
XTR75015	✓		✓		✓				✓	



PIN DESCRIPTION

XTR75011		
Pin Number	Name	Description
1	/SHDN	Active-low shut-down terminal. Connect to VIN when not used.
2	15V	Connect to GND to set $V_{OUT}=15V$.
3	12V	Connect to GND to set $V_{OUT}=12V$.
4	10V	Connect to GND to set $V_{OUT}=10V$.
5	9V	Connect to GND to set $V_{OUT}=9.0V$.
6	5.5V	Connect to GND to set $V_{OUT}=5.5V$.
7	GND	Circuit ground.
8	TRIM	Trimming input.
9	VOUT	Output voltage terminal. Decouple to GND with a capacitor of at least 100nF.
10	N.C.	No internal connection.
11	1.8V	Connect to GND to set $V_{OUT}=1.8V$.
12	2.5V	Connect to GND to set $V_{OUT}=2.5V$.
13	3.3V	Connect to GND to set $V_{OUT}=3.3V$.
14	5V	Connect to GND to set $V_{OUT}=5.0V$.
15	GND	Circuit ground.
16	VIN	Input voltage terminal.

XTR75012		
Pin Number	Name	Description
1	N.C.	No internal connection.
2	VIN	Input voltage terminal.
3	/SHDN	Active-low shut-down terminal. Connect to VIN when not used.
4	GND	Circuit ground.
5	TRIM	Trimming input.
6	VOUT	Output voltage terminal. Decouple to GND with a capacitor of at least 100nF.
7	N.C.	No internal connection.
8	N.C.	No internal connection.

XTR75014		
Pin Number	Name	Description
1	/SHDN	Active-low shut-down terminal. Connect to VIN when not used.
2	GND	Circuit ground.
3	1.8V	Connect to GND to set $V_{OUT}=1.8V$.
4	TRIM	Trimming input.
5	VOUT	Output voltage terminal. Decouple to GND with a capacitor of at least 100nF.
6	2.5V	Connect to GND to set $V_{OUT}=2.5V$.
7	3.3V	Connect to GND to set $V_{OUT}=3.3V$.
8	VIN	Input voltage terminal.

XTR75015		
Pin Number	Name	Description
1	/SHDN	Active-low shut-down terminal. Connect to VIN when not used.
2	GND	Circuit ground.
3	2.5V	Connect to GND to set $V_{OUT}=2.5V$.
4	TRIM	Trimming input.
5	VOUT	Output voltage terminal. Decouple to GND with a capacitor of at least 100nF.
6	5V	Connect to GND to set $V_{OUT}=5.0V$.
7	12V	Connect to GND to set $V_{OUT}=12V$.
8	VIN	Input voltage terminal.

THERMAL CHARACTERISTICS

Parameter	Condition	Min	Typ	Max	Units
XTR75011-S (SOIC16)					
Thermal Resistance: J-C $R_{Th\ J-C}$			22		°C/W
Thermal Resistance: J-A $R_{Th\ J-A}$			120		°C/W
XTR75011-D (DIL16)					
Thermal Resistance: J-C $R_{Th\ J-C}$			22		°C/W
Thermal Resistance: J-A $R_{Th\ J-A}$			95		°C/W
XTR7501x-D (DIL8)					
Thermal Resistance: J-C $R_{Th\ J-C}$			25		°C/W
Thermal Resistance: J-A $R_{Th\ J-A}$			100		°C/W
XTR7501x-FE (DFP8 with exposed pad)					
Thermal Resistance: J-C $R_{Th\ J-C}$	Measured on ePAD.		7		°C/W
Thermal Resistance: J-A $R_{Th\ J-A}$	ePAD thermally connected to 3cm ² PCB copper		70		°C/W

RECOMMENDED OPERATING CONDITIONS

Parameter	Min	Typ	Max	Units
Supply voltage V_{IN}	2.8		40	V
Output voltage V_{OUT}	1.2		17	V
Voltage on /SHDN to GND	0		V_{IN}	V
Voltage on TRIM to GND	0		V_{OUT}	V
Output current	100 μ A ¹		$I_{LOADMax}$	
Case Temperature ² T_C	-60		230	°C

¹ A minimum output current of 100 μ A is recommended for stability reasons under any output voltage and temperature.

² Operation beyond the specified temperature range is achieved. The -60°C to +230°C range for the case temperature is considered for the case where no current is externally drawn from pin VDD, other than to supply the XTR30010 part.

ELECTRICAL SPECIFICATIONS

Unless otherwise stated, specification applies for ($V_{IN}-V_{OUT}$)=10V, I_{LOAD} =10mA, -60°C< T_C <230°C.

Parameter	Condition	Min	Typ	Max	Units
Output Characteristics					
Nominal Output Voltages V_{OUT}			1.2 1.8 2.5 3.3 5.0 5.5 9.0 10 12 15		V
Output Voltage Accuracy $\Delta V_{OUT}/V_{OUT}$	$T_C=85^\circ\text{C}$	-2		+2	%
Dropout Voltage ($V_{IN}-V_{OUT}$) ¹	$I_{LOAD}=10\text{mA}$ $T_C=-60^\circ\text{C}$ $T_C=85^\circ\text{C}$ $T_C=230^\circ\text{C}$		200 280 410	270 350 540	mV
	$I_{LOAD}=50\text{mA}$ $T_C=-60^\circ\text{C}$ $T_C=85^\circ\text{C}$ $T_C=230^\circ\text{C}$		1.0 1.4 2.7	1.3 1.8 3.0	V
Drift with Temperature ² ($\Delta V_{OUT}/V_{OUT}$)/ ΔT	Measured for worst case V_{IN} conditions. 100 μ A $\leq I_{LOAD}\leq$ 50mA	15	45	75	ppm/°C
Line Regulation ² $\Delta V_{OUT}/V_{OUT}$	$I_{LOAD}=10\text{mA}$ $V_{OUT}\leq 1.8\text{V}$; $V_{IN}=2.8\text{V}$ to 40V $V_{OUT}\geq 2.5\text{V}$; $V_{IN}=V_{OUT}+0.5\text{V}$ to 40V $T_C=-60^\circ\text{C}$ $T_C=85^\circ\text{C}$ $T_C=230^\circ\text{C}$		0.1 0.35 0.75	0.3 0.55 1.2	%
Maximum Load Current $I_{LOADMax}$	Any V_{OUT} for ($V_{IN}-V_{OUT}$) \geq 5V, $T_C=230^\circ\text{C}$ (worst case) Any V_{OUT} for ($V_{IN}-V_{OUT}$) \geq 2V, $T_C=230^\circ\text{C}$ (worst case)	50 30	70 40		mA
	$V_{IN}=2.8\text{V}$, $T_C=230^\circ\text{C}$ (worst case) $V_{OUT}=1.2\text{V}$ $V_{OUT}=1.8\text{V}$ $V_{OUT}=2.5\text{V}$	20 15 5	30 20 7		
Load Regulation ² $\Delta V_{OUT}/\Delta I_{LOAD}$	$T_C=230^\circ\text{C}$ (worst case) $I_{LOAD}=1\text{mA}$ to 30mA, ($V_{IN}-V_{OUT}$)=2V. See Figure 15. $V_{OUT}=1.2\text{V}$ (TRIM connected to VOUT) $V_{OUT}=15\text{V}$		0.18 2.25	0.25 3.10	mV/mA
	$I_{LOAD}=1\text{mA}$ to 50mA, ($V_{IN}-V_{OUT}$)=5V. See Figure 16. $V_{OUT}=1.2\text{V}$ (TRIM connected to VOUT) $V_{OUT}=15\text{V}$		0.15 1.90	0.22 2.60	

¹ Difference between the input and output voltages that makes V_{out} to deviate by 1% from its nominal value at the same load current.

² ΔV_{OUT} is defined as $|V_{OUT_Max} - V_{OUT_min}|$ within the indicated range of temperature, input voltage or load current.

ELECTRICAL SPECIFICATIONS (CONTINUED)

Unless otherwise stated, specification applies for ($V_{IN}-V_{OUT}$)=10V, I_{LOAD} =10mA, $-60^{\circ}\text{C}<T_C<230^{\circ}\text{C}$.

Parameter	Condition	Min	Typ	Max	Units
Supply Current					
Quiescent Ground Current I_{GND}	V_{OUT} =5.0V T_C =-60°C T_C =85°C T_C =230°C		200 300 380	250 360 480	μA
Shut-down Mode Current I_{std-by}	V_{IN} =40V T_C =85°C T_C =230°C		25 38	40 60	μA
Shut-down Mode					
Enable Voltage V_{ON}	V_{IN} from 2.8V to 40V /SHDN going up. Worst case for T_C =-60°C.		1.8	2.3	V
Shut-down Voltage V_{OFF}	V_{IN} from 2.8V to 40V /SHDN going down. Worst case for T_C =230°C.	0.6	0.9		V
Shut-down Hysteresis V_{SDH}	/SHDN going up then down.	0.2	0.4		V
/SHDN Current $I_{/SHDN}$	$V_{/SHDN}$ =0V $V_{/SHDN}$ =5V	-6 -5		0 1	μA
Dynamic Characteristics					
Turn-ON Time vs. V_{IN} t_{ON-VIN}	V_{IN} steps up from 0V to 10V. See Figure 27. /SHDN connected to V_{IN} , C_{LOAD} =1μF, T_C =-60°C (worst case) V_{OUT} =1.2V V_{OUT} =5V		10 500		μs
Turn-ON Time vs. /SHDN $t_{ON-SHDN}$	/SHDN steps up from 0.6V to 2.3V. See Figure 28. V_{IN} =10V, C_{LOAD} =1μF T_C =-60°C (worst case) V_{OUT} =1.2V V_{OUT} =5V		35 550		μs
Input Voltage Rejection PSRR	Freq=1kHz		-50		dB
Input Capacitance ¹ C_{IN}			1		μF
Load Capacitance ¹ C_{OUT}		0.1	1	10	μF
Noise Characteristics					
Integrated Voltage Noise V_n	V_{IN} =10V, V_{OUT} =5.0V, C_{IN} = C_{OUT} =1μF, I_{LOAD} ≤ 50mA BW=0.1Hz to 10Hz. T_C =-60°C T_C =85°C T_C =230°C BW=10Hz to 100kHz. T_C =-60°C T_C =85°C T_C =230°C		93 56 35 181 144 134		μV _{rms}
Spectral Density	V_{IN} =10V, V_{OUT} =5.0V, C_{IN} =1μF, C_{OUT} =1μF. I_{LOAD} =0 to 50mA, 100Hz. T_C =-60°C T_C =85°C T_C =230°C		6.7 3.6 2.8		μV/√Hz

¹ For stability reasons, input and load capacitances must be of ceramic type with low ESR (≤1Ω) and connected as close as possible to the part, from the input and output nodes to ground.

TYPICAL PERFORMANCE

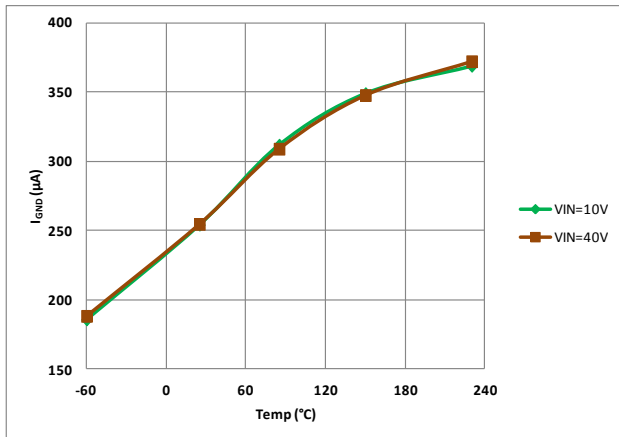


Figure 1. Ground Current (I_{GND}) vs Case Temperature in active mode.

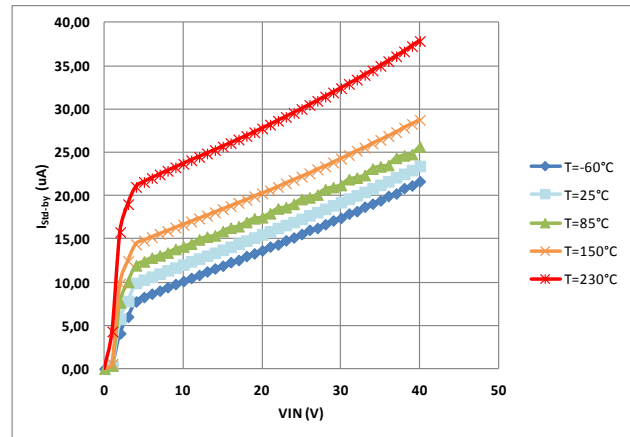


Figure 2. Stand-by current (I_{St-by}) vs Case Temperature (/SHDN=LOW).

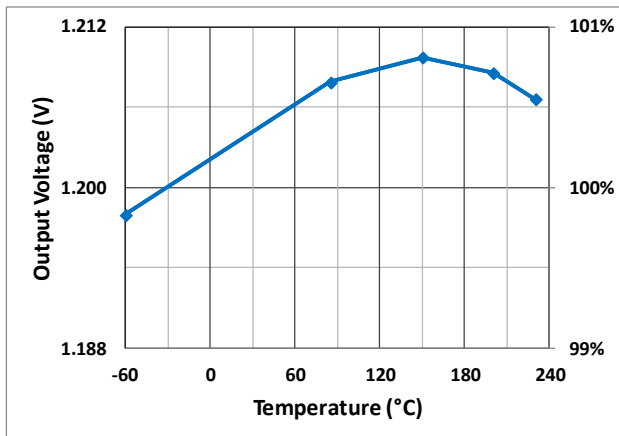


Figure 3. Output Voltage (V_{OUT}) vs Case Temperature. $I_{LOAD}=10mA$, normalized to $V_{OUT}=1,2V$.

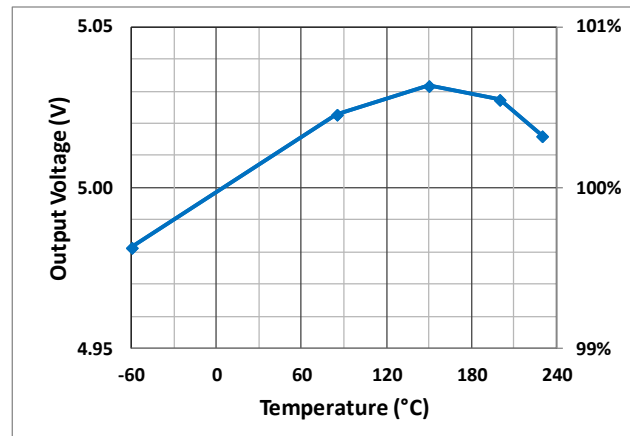


Figure 4. Output Voltage (V_{OUT}) vs Case Temperature. $I_{LOAD}=10mA$, normalized to $V_{OUT}=5,0V$.

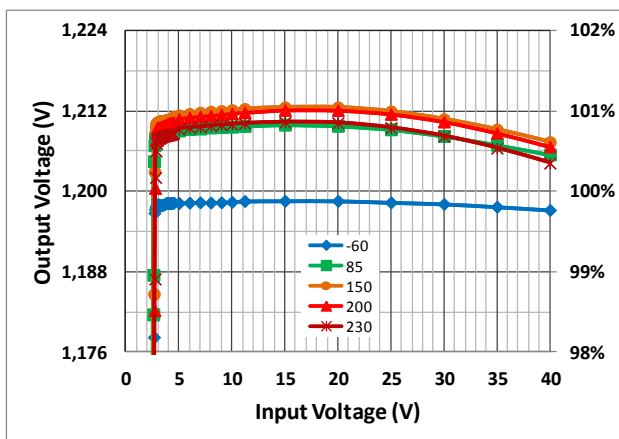


Figure 5. Output Voltage (V_{OUT}) vs Input Voltage for different case temperatures. $I_{LOAD}=0.1mA$, normalized to $V_{OUT}=1,2V$.

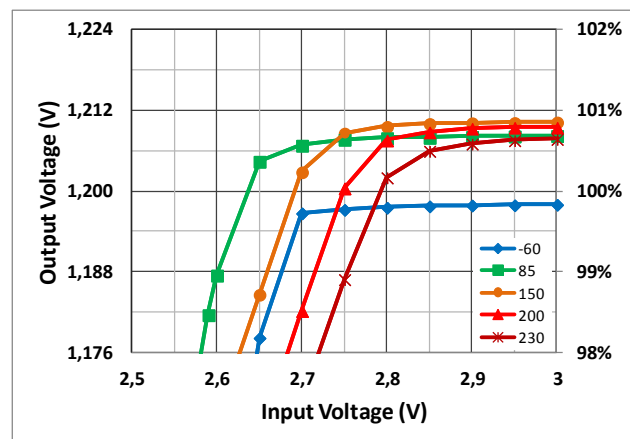


Figure 6. Zoom on the start-up showing Output Voltage (V_{OUT}) vs Input Voltage for different case temperatures. $I_{LOAD}=0.1mA$, normalized to $V_{OUT}=1,2V$.

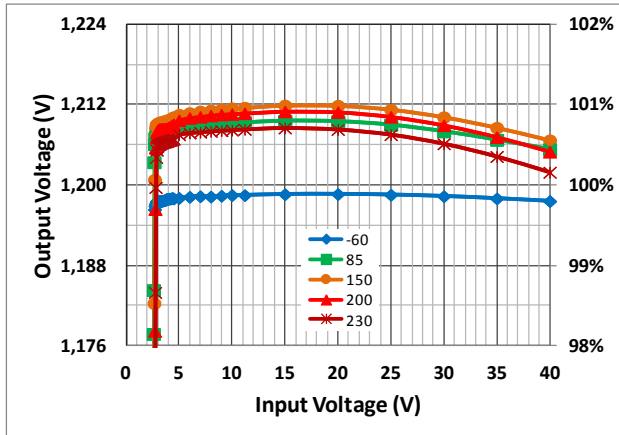


Figure 7. Output Voltage (V_{OUT}) vs Input Voltage for different case temperatures. $I_{LOAD}=10mA$, normalized to $V_{OUT}=1.2V$.

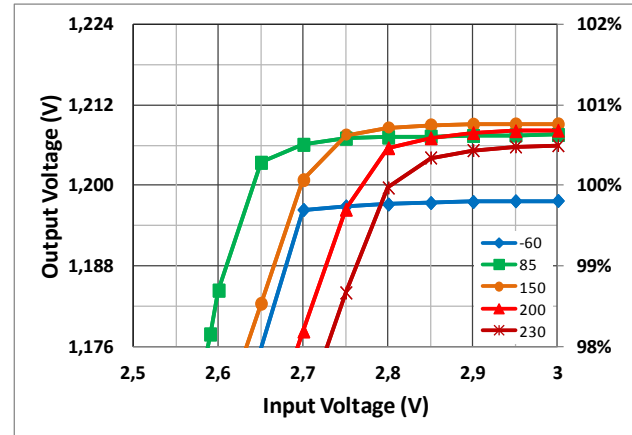


Figure 8. Zoom on the start-up showing Output Voltage (V_{OUT}) vs Input Voltage for different case temperatures. $I_{LOAD}=10mA$, normalized to $V_{OUT}=1.2V$.

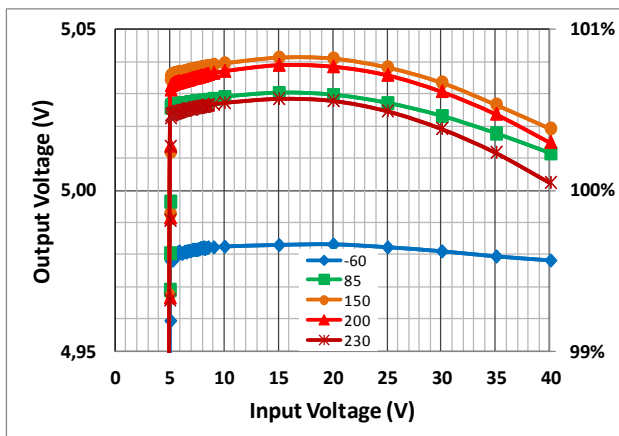


Figure 9. Output Voltage (V_{OUT}) vs Input Voltage for different case temperatures. $I_{LOAD}=0.1mA$, normalized to $V_{OUT}=5V$.

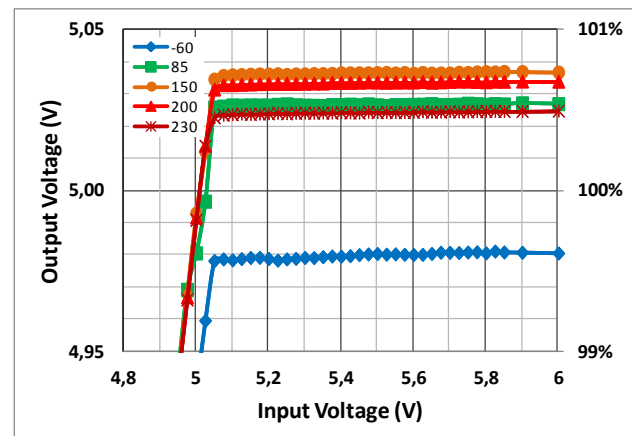


Figure 10. Zoom on the start-up showing Output Voltage (V_{OUT}) vs Input Voltage for different case temperatures. $I_{LOAD}=0.1mA$, normalized to $V_{OUT}=5V$.

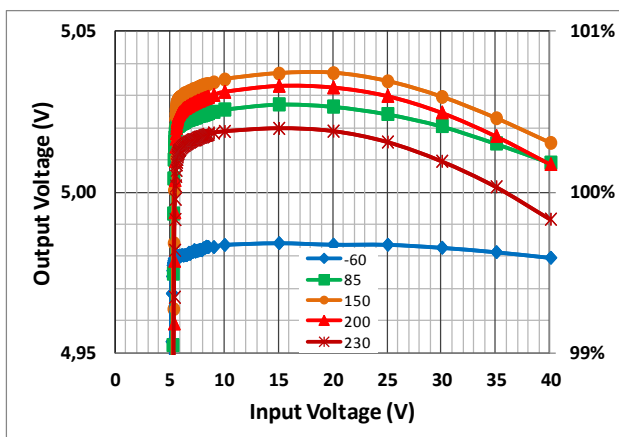


Figure 11. Output Voltage (V_{OUT}) vs Input Voltage for different case temperatures. $I_{LOAD}=10mA$, normalized to $V_{OUT}=5V$.

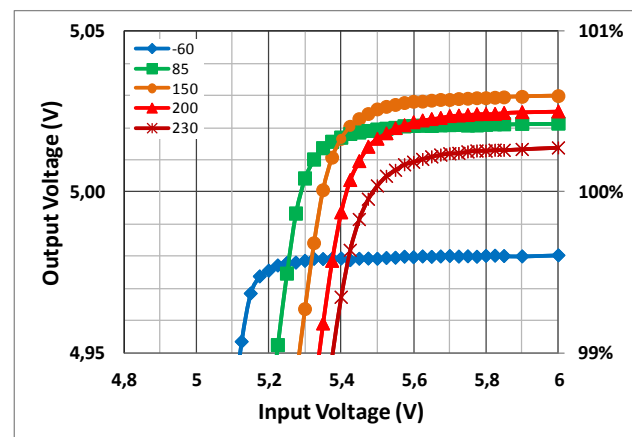


Figure 12. Zoom on the start-up showing Output Voltage (V_{OUT}) vs Input Voltage for different case temperatures. $I_{LOAD}=10mA$, normalized to $V_{OUT}=5V$.

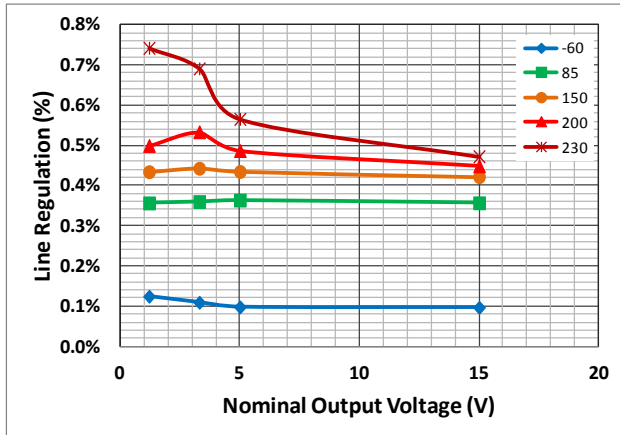


Figure 13. Line Regulation vs Output Voltage for different case temperatures. $I_{LOAD}=10mA$, V_{IN} swept from Max[2.8V; $V_{OUT}+0.5V$] to 40V.

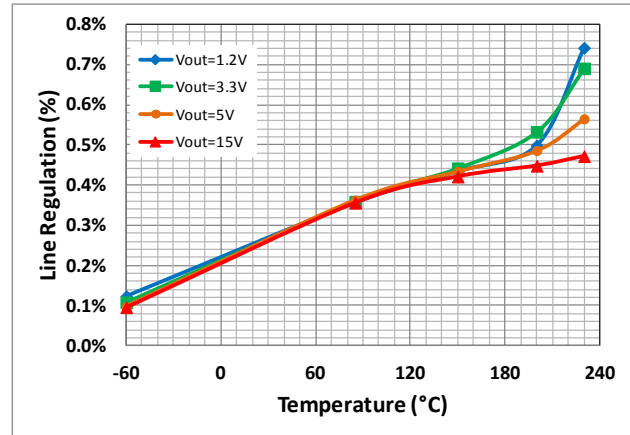


Figure 14. Line Regulation vs Case Temperature for different output voltages. $I_{LOAD}=10mA$, V_{IN} swept from Max[2.8V; $V_{OUT}+0.5V$] to 40V.

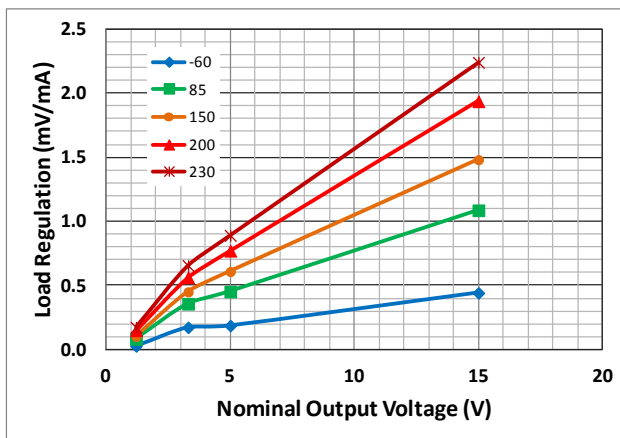


Figure 15. Load Regulation vs Nominal Output Voltage for different case temperatures. Load current swept from 1mA to 30mA, $(V_{IN}-V_{OUT})=2V$.

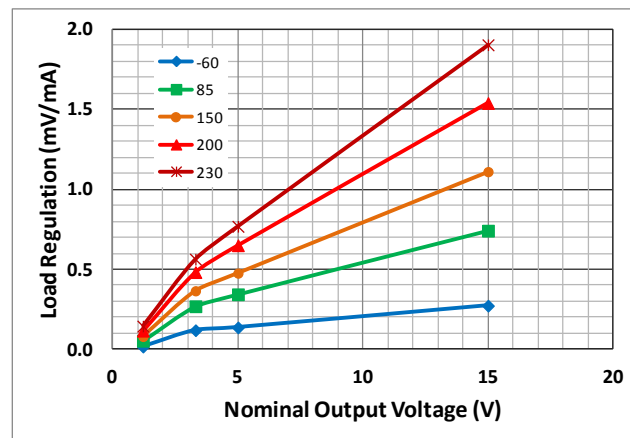


Figure 16. Load Regulation vs Nominal Output Voltage for different case temperatures. Load current swept from 1mA to 50mA, $(V_{IN}-V_{OUT})=5V$.

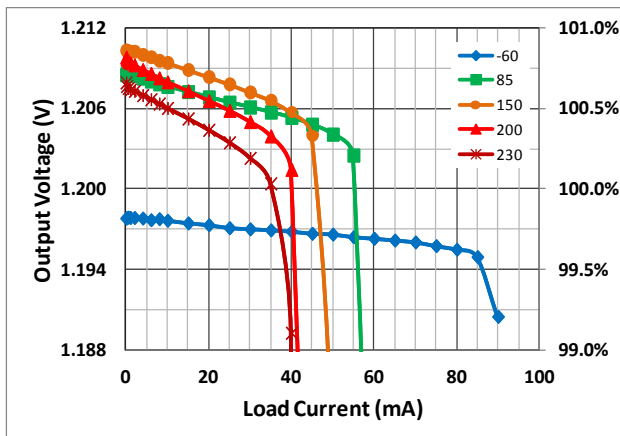


Figure 17. Output Voltage (V_{OUT}) vs Load Current for different case temperatures. $V_{OUT}=1.2V$, $(V_{IN}-V_{OUT})=2V$.

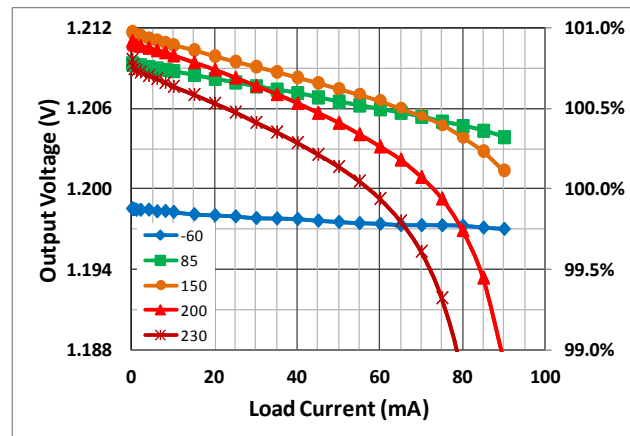


Figure 18. Output Voltage (V_{OUT}) vs Load Current for different case temperatures. $V_{OUT}=1.2V$, $(V_{IN}-V_{OUT})=5V$.

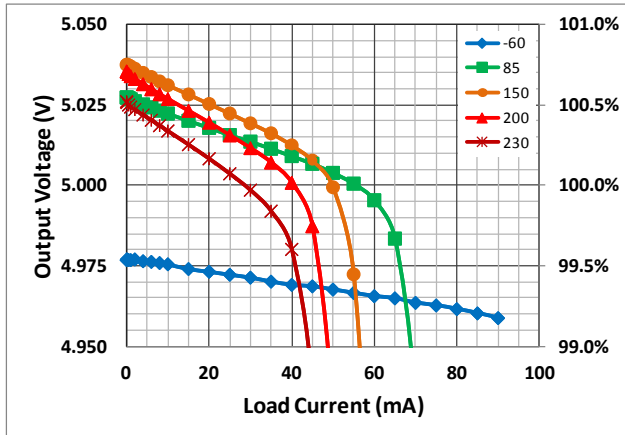


Figure 19. Output Voltage (V_{OUT}) vs Load Current for different case temperatures. $V_{OUT}=5V$, $(V_{IN}-V_{OUT})=2V$.

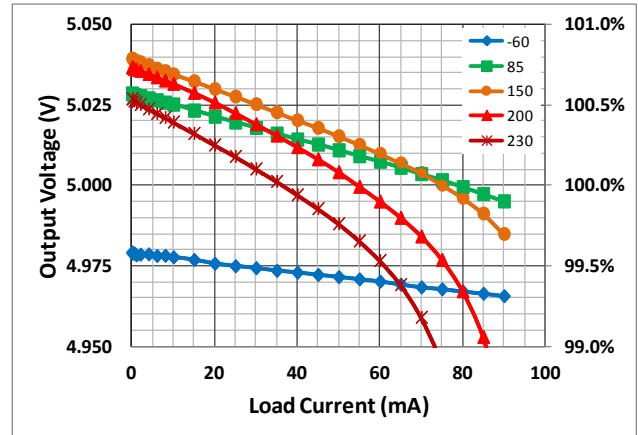


Figure 20. Output Voltage (V_{OUT}) vs Load Current for different case temperatures. $V_{OUT}=5V$, $(V_{IN}-V_{OUT})=5V$.

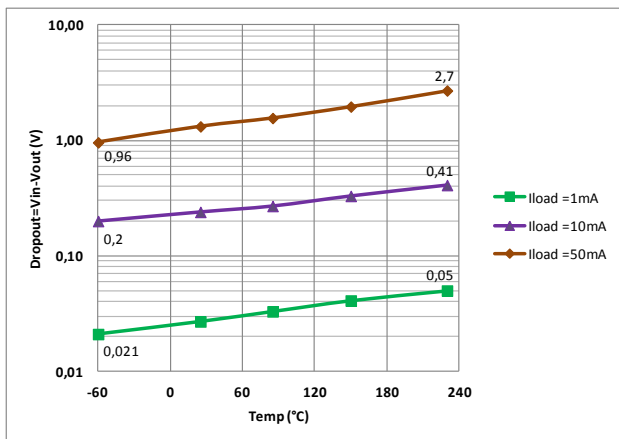


Figure 21. Minimum dropout ($V_{IN}-V_{OUT}$) vs Case Temperature for different load currents. $V_{OUT}=5V$.

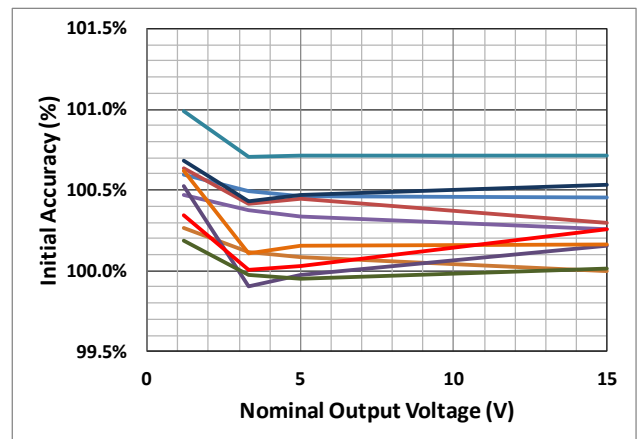


Figure 22. Spread of normalized initial output voltage accuracy $(V_{OUT}-V_{OUT_Nom})/V_{OUT_Nom}$ over ten typical samples vs nominal output voltage. $T_C=85^\circ C$, $I_{LOAD}=1mA$ and $(V_{IN}-V_{OUT})=2V$.

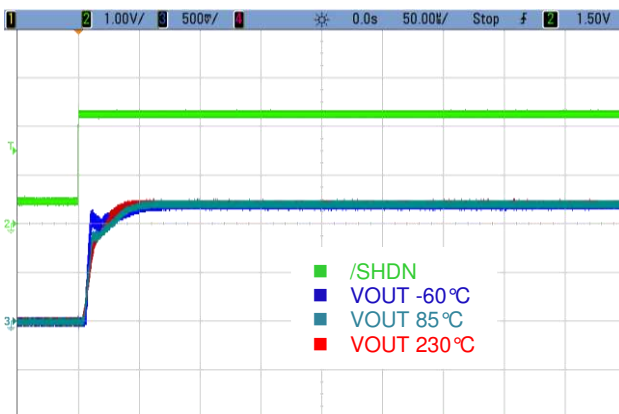


Figure 23. Start-up at $V_{OUT}=1.2V$ for several case temperatures when $/SHDN$ swept from 0.5V to 2.3V. $V_{IN}=10V$, $C_{OUT}=1\mu F$, $I_{LOAD}=10mA$. Overlap of curves from 10 different devices.

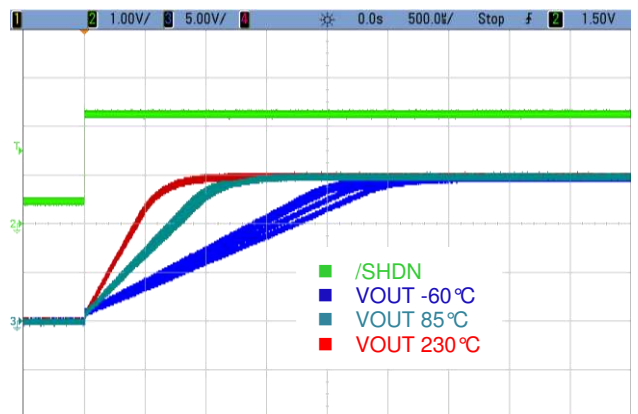


Figure 24. Start-up at $V_{OUT}=15V$ for several case temperatures when $/SHDN$ swept from 0.5V to 2.3V. $V_{IN}=20V$, $C_{OUT}=1\mu F$, $I_{LOAD}=10mA$. Overlap of curves from 10 different devices.

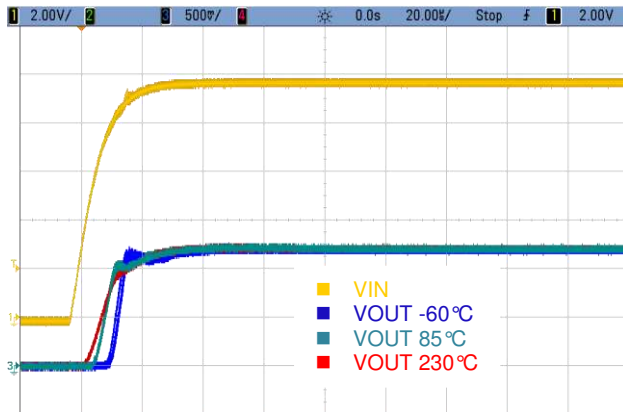


Figure 25. Start-up at $V_{OUT}=1.2V$ for several case temperatures when V_{IN} swept from 0V to 10V. /SHDN connected to V_{IN} , $C_{OUT}=1\mu F$, $I_{LOAD}=10mA$. Overlap of curves from 10 different devices.

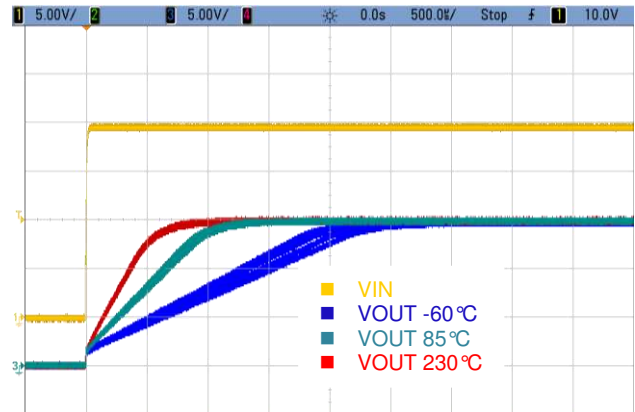


Figure 26. Start-up at $V_{OUT}=15V$ for several case temperatures. V_{IN} swept from 0V to 20V. /SHDN connected to V_{IN} , $C_{OUT}=1\mu F$, $I_{LOAD}=10mA$. Overlap of curves from 10 different devices.

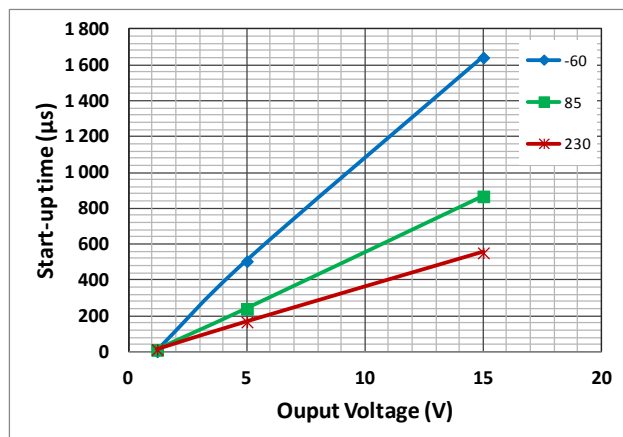


Figure 27. Start-up time vs nominal output voltage for several case temperatures when V_{IN} is swept from 0V to 10V. /SHDN connected to V_{IN} , $C_{OUT}=1\mu F$, $I_{LOAD}=10mA$.

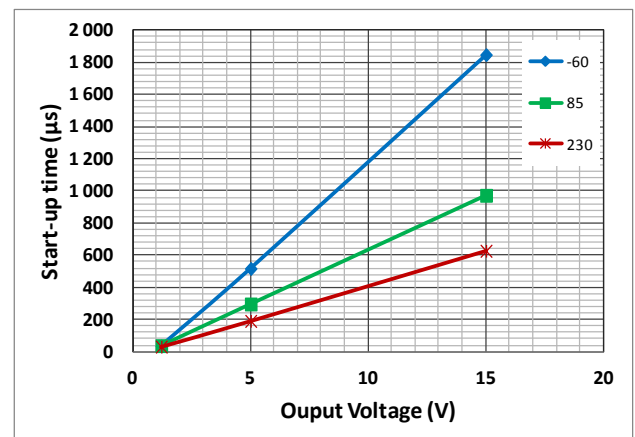


Figure 28. Start-up time vs nominal output voltage for several case temperatures when /SHDN is swept from $V_{OFF}=0.6V$ to $V_{ON}=2.3V$ with V_{IN} constant. $C_{OUT}=1\mu F$, $I_{LOAD}=10mA$.

THEORY OF OPERATION

Introduction

Product description

The XTR75010 is a full CMOS series voltage regulator able to operate from $-60^{\circ}C$ to $+230^{\circ}C$, with input voltages from 2.8V to 40V. Depending on packaging options, up to ten different output voltages from the same part (XTR75011) or pin-to-pin compatibility with other commercial voltage references can be obtained. An active LOW shut-down functionality feature is provided, helping reduce power consumption in power-critical applications. A trimming input allows a fine tuning of the output voltage to the desired value.

Using the XTR75011 and XTR75012

The XTR75011 is the full-featured version in the family. All voltages are available from the same 16-pin package, so there is no need to order a XTR75011 with given output voltage.

The XTR75012 has a preselected output voltage and must be ordered with the variant code corresponding to the desired output voltage (see the Ordering Information section).

To select an output voltage in the XTR75011, just connect to GND the terminal corresponding to the desired output voltage.

The following two figures show how to use the XTR75011 (in DIP16 or SOIC16 packages) in order to provide output voltages of 3.3V and 10V. In each case, the terminal corresponding to the desired output voltage is connected to GND. By doing this, the appropriate resistor tap (see internal diagram of XTR75011 in the Internal Block Diagram section) is grounded, thus providing the appropriate division factor in the feedback.

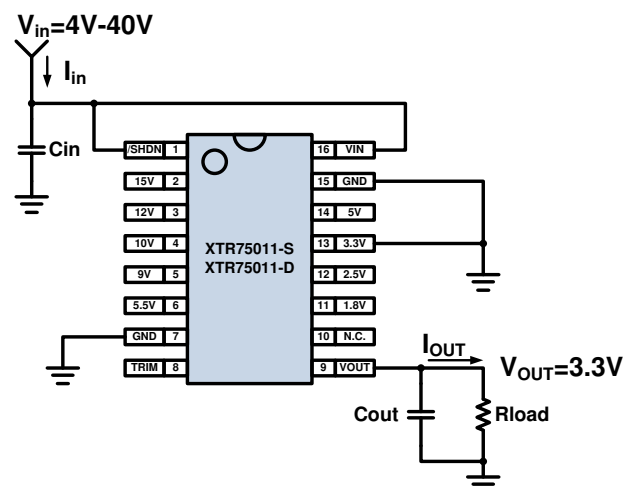


Figure 29. Application of XTR75011 providing 3.3V.

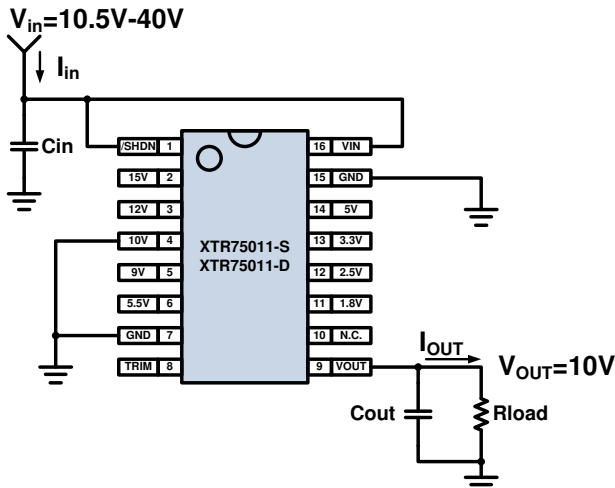


Figure 30. Application of XTR75011 providing 10V.

The usage of the XTR75012 is straightforward as no setting is needed from the user in order to obtain the desired output voltage (preset at assembly phase).

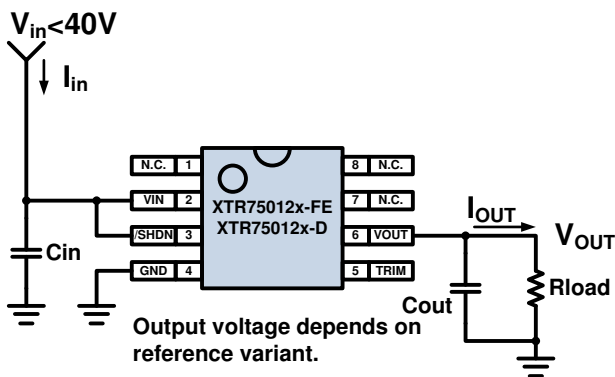


Figure 31. Application of XTR75012.

Input and output bypassing

Appropriate input bypassing is mandatory with the use of every linear regulator as the XTR75011 and XTR75012. This bypassing is needed in order to filter out input noise and provide a low AC impedance power supply to ensure stability.

In the final application, in general, the power supply is well decoupled and the parasitic inductance between the power supply and the regulator's input is low.

However, during the first evaluations of a product in the laboratory, it may happen that the part is just placed on a breadboard connected to a power supply by means of relatively long cables. In this case, the equivalent circuit would be as shown in Figure 32.

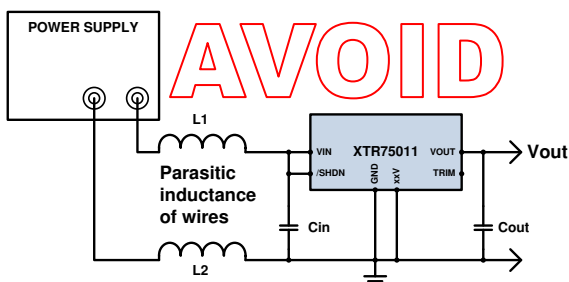


Figure 32. Non-optimum breadboard connection with voltage regulator.

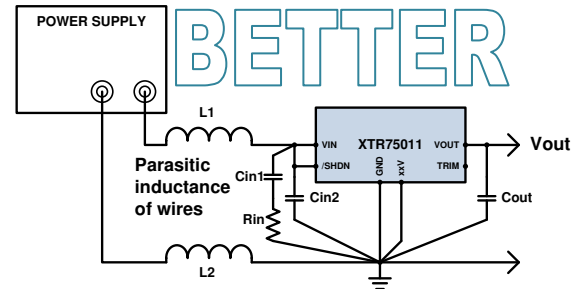


Figure 33. Better breadboard connection with voltage regulator.

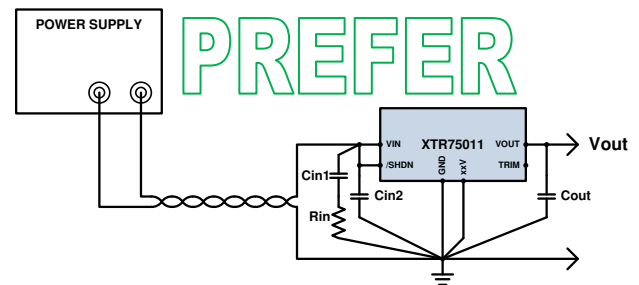


Figure 34. Preferred breadboard connection with voltage regulator.

The role of R_{IN} in Figure 33 and Figure 34 is to reduce the quality factor of the LC input circuit and provide a damping factor. Use values for C_{IN} starting from 50-100nF and C_{OUT} values between 0.1μF to 10μF.

$$C_{IN} > 50-100nF$$

$$100nF < C_{OUT} < 10\mu F$$

These capacitors are required with low ESR-ESL and as close as possible from the XTR75010 parts. Then other capacitors with larger ESR-ESL can be used in parallel to the main input and output bypassing capacitors.

General Considerations

Thermal considerations

The XTR75010 has no internal thermal shutdown feature, allowing it to operate even above the -60°C to $+230^{\circ}\text{C}$ range. The user must ensure that the junction temperature does not exceed the temperature indicated in the Absolute Maximum Ratings and remain within the recommended temperature range whenever possible. Functionality can be achieved up to nearly 250°C at the expenses of reducing product lifetime.

Notice that there is no short circuit current limitation. The maximum short circuit current depends on input and output voltages, as well as on initial ambient temperature, being able to exceed 150mA in certain cases.

Ground connection

The XTR75010 ground pin should always be connected to the supply ground prior applying any input voltage. Accidental disconnecting of the ground terminal under operation could damage the part and its load.

Regulator input shorting

For a nominal output voltage $V_{OUT} \geq 2.5V$, connecting the input voltage to ground while the output capacitance is fully charged can create a large reverse current through the regulator pass element. If the load capacitance is large enough, the reverse current duration can be such that the regulator gets damaged.

Current sinking capabilities

XTR75010 parts **are not able** to sink any current. Doing so would pull the output voltage above its nominal value and could damage the regulator and its load.

Minimum input voltage

The minimum input voltage required for a correct operation of the internal circuitry is 2.8V. In other words, to be within speci-

cations, V_{IN} should be larger than $\text{Max}[2.8V, V_{OUT} + \text{dropout}]$ where the dropout value depends on the required output current.

Dropout

The minimum dropout of the regulator is a function of the load current, temperature and the minimum desired line regulation. The architecture of the regulator is such that the line regulation remains at very low values even for the maximum allowed input voltage. However, thermal aspects must be considered as to not overheating the parts.

Functional Features

Start-up and transient behavior

The start-up of the regulator is guaranteed over the whole operating temperature range. Once in operation, the input voltage should not present large and fast negative voltage steps (5V with slopes higher than 100V/ms). Large and fast negative steps on V_{IN} could briefly turn off the regulator.

As most linear voltage regulators, the line rejection decreases at higher frequencies so that a large and fast V_{IN} step could generate a large transient on the regulator output and damage its load.

At start-up, the regulator needs to charge the output capacitance to V_{OUT} . Internal provisions are made to have the regulator to present a soft-start phase. This gives a soft ramp-up of the output voltage. However, at start-up, some output overshoot (350mV) can be observed for $V_{OUT}=1.2V$ when using a low-value load capacitance (100nF) and a large and fast positive step on V_{IN} (5V with slopes higher than 100V/ms). The overshoot duration is observed to last for about 10-20 μ sec. However, for a load capacitance of 1 μ F or higher, there is no observable overshoot on the output, even for the 1.2V mode.

Shut-down functionality

Shut-down feature allows to securely turn off the regulator when a voltage smaller than 0.6V is applied on /SHDN terminal (a current up to 8 μ A can go out of this lead in this condition). In such condition, the regulator output goes to high impedance and the residual current consumption of the regulator is below 10% of the nominal operation current consumption.

In order to turn the regulator on, the /SHDN input must see a voltage of at least 2.3V (with a possible input current of up to 1 μ A). The /SHDN input must be directly connected to V_{IN} if not used.

Considerations concerning possible output overshoot when /SHDN is pulled-up are the same than the one mentioned earlier at V_{IN} start-up.

Start-up times when using the /SHDN input control are quite similar to those obtained by applying a V_{IN} ramp-up.

Stability

The regulator is stable as long as it sees the minimum required input and load capacitance with an ESR $\leq 1\Omega$ placed as close as possible from the V_{IN} and V_{OUT} nodes to GND. Other capacitors with any ESR can further be added in parallel at some distance from the regulator.

To ensure the part is stable for any output voltage and under any input voltage and temperature conditions, a minimum load current of 100 μ A is recommended.

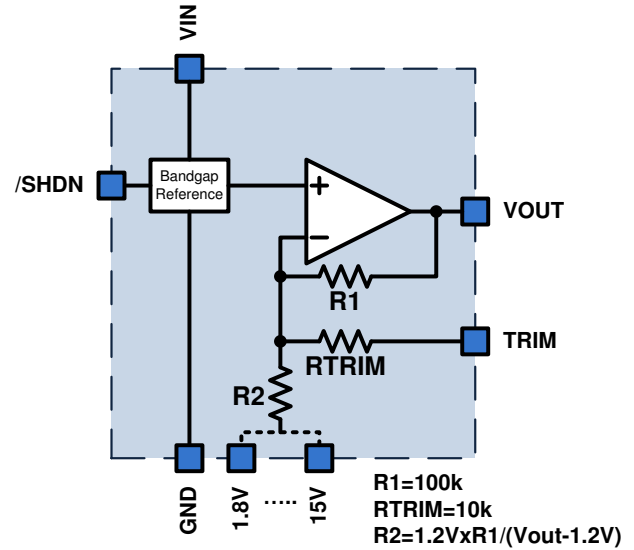
When selecting $V_{OUT}=1.2V$, it is recommended to connect terminal TRIM to terminal V_{OUT} . This not only improves the stability region, also it greatly improves the load regulation.

Output voltage trimming

XTR75010 parts can be used as voltage regulators or as references due to their intrinsic very good stability against input voltage, load current and temperature variations.

When a highly accurate output voltage is needed, parts in the XTR75010 family have a terminal which allows the final user to fine trim the output voltage: the TRIM terminal.

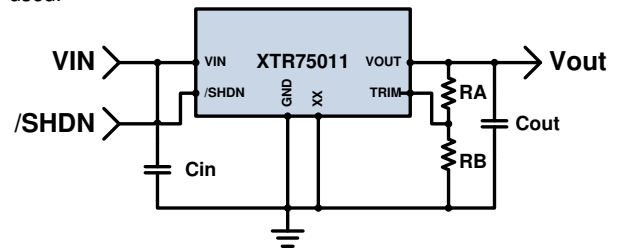
The TRIM terminal has an input impedance of 10k Ω which allows modifying the feedback ratio, hence changing the output voltage.



From the block diagram it can be seen that, if the TRIM feature is not used (left floating), the nominal output voltage is given by

$$V_{OUT_NOM} = 1.2V \cdot \left(1 + \frac{R_1}{R_2}\right)$$

The following figure shows a regulator with fine trimming feature used.



Terminal "XX" represents any terminal from "1.8V" to "15V". In this case the exact output voltage is given by

$$V_{OUT} = \frac{(R_{A//B} + 10k\Omega) \cdot \frac{V_{OUT_NOM}}{1.2V} + 100k\Omega}{10k\Omega + R_{A//B} \cdot \left(1 + \frac{100k\Omega}{R_A}\right)} \cdot V_{REF_ACTUAL}$$

V_{OUT_NOM} is the nominal output voltage, V_{REF_ACTUAL} is the actual (untrimmed) internal reference voltage ($1.2V \pm 2\%$) and $R_{A//B}$ is the parallel reduction of R_A and R_B . The following table shows the value of R_B for $R_A=100k\Omega$, supposing a spread of $\pm 2\%$ on nominal value of the reference voltage.

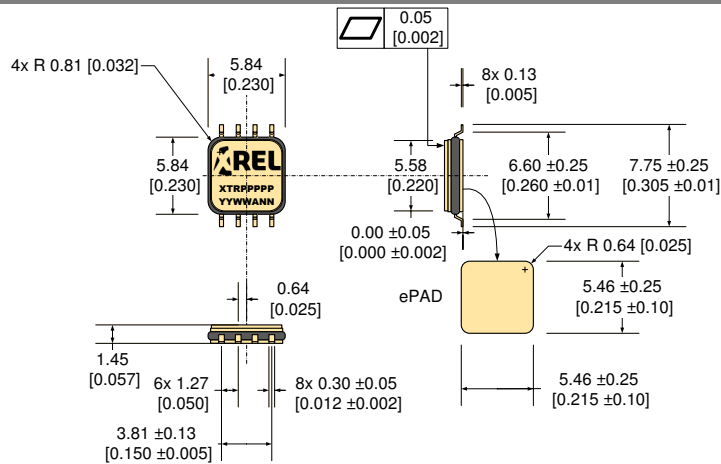
V_{OUT_NOM}	R_B (k Ω)	
	$V_{REF_NOM} - 2\%$	$V_{REF_NOM} + 2\%$
1.8V	176.67	228.86
2.5V	84.92	100.66
3.3V	53.24	61.43
5.0V	29.64	33.66
5.5V	26.21	29.72
9.0V	14.44	16.39
10V	12.78	14.54
12V	10.39	11.87
15V	8.10	9.33

See also [product webpage](#) for Application Notes on how to trim and get different output voltages from the XTR75010.

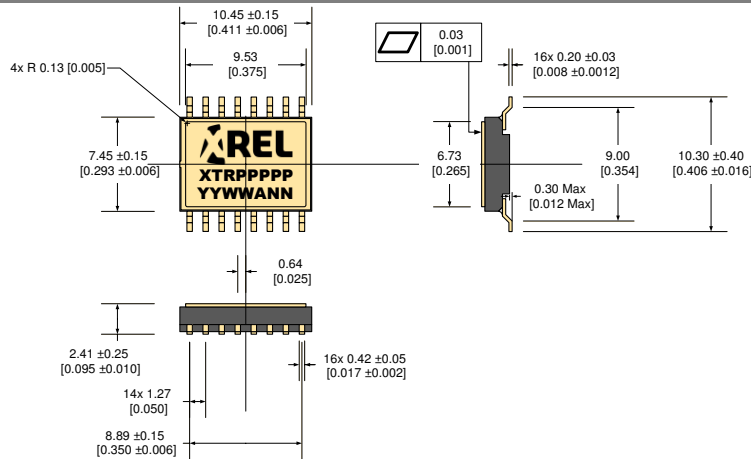
PACKAGE OUTLINES

Dimensions shown in mm [inches]. Tolerances ± 0.13 mm [± 0.005 in] unless otherwise stated.

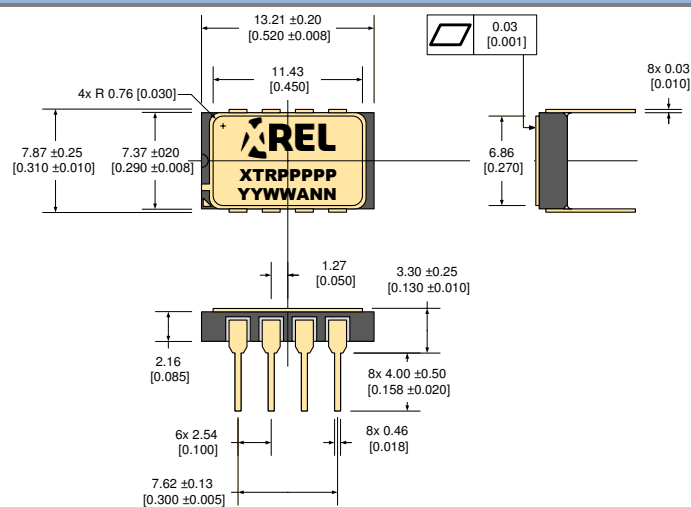
Ceramic Gull-wing Flat pack with ePad DFP8



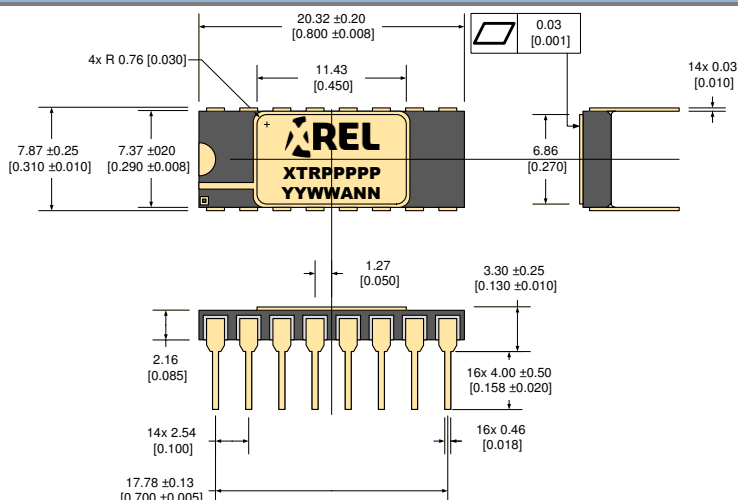
Ceramic Small Outline IC SOIC16



Ceramic Side Brazed Dual In-line DIP8



Ceramic Side Brazed Dual In-line DIP16



Part Marking Convention

Part Reference: XTRPPPPPP	
XTR	X-REL Semiconductor, high-temperature, high-reliability product (XTRM Series).
PPPPP	Part number (0-9, A-Z).
Unique Lot Assembly Code: YYWWANN	
YY	Two last digits of assembly year (e.g. 11 = 2011).
WW	Assembly week (01 to 52).
A	Assembly location code.
NN	Assembly lot code (01 to 99).

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X-REL Semiconductor

90, Avenue Léon Blum
38100 Grenoble
France