TEXAS INSTRUMENTS

REG71050, REG71055, REG710

SBAS221H – DECEMBER 2001 – REVISED OCTOBER 2015

REG710xx Buck-Boost Charge Pump with up to 60-mA Output Current

1 Features

- Wide Input Voltage Range: 1.8 V to 5.5 V
- Automatic Step-Up and Step-Down Operation
- Low Input Current Ripple
- Low Output Voltage Ripple
- Minimum Number of External Components—No Inductors
- 1-MHz Internal Oscillator Allows Small Capacitors
- Shutdown Mode
- Thermal and Current Limit Protection
- Six Fixed Output Voltages Available:
  - 2.5 V, 2.7 V, 3 V, 3.3 V, 5 V, 5.5 V

2 Applications

- White LED Driver
- Smart Card Readers
- SIM Cards
- Handheld devices
- Modems
- PCMCIA Cards
- LCD Displays
- Battery Backup Supplies

3 Description

The REG710 family of devices are switched capacitor voltage converters that generate regulated, low-ripple output voltage from an unregulated input voltage. A wide input supply voltage from 1.8 V to 5.5 V makes the REG710 family of devices ideal for a variety of battery sources, such as single-cell Li-Ion, or 2-cell and 3-cell nickel-based or alkaline-based chemistries.

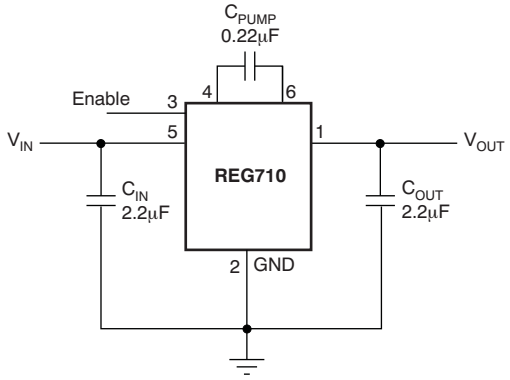
The input voltage may vary above and below the output voltage and the output remains in regulation. The device works as step-up or step-down converters without the need of an inductor, providing low EMI DC-DC conversion. The high switching frequency allows the use of small surface-mount capacitors, saving board space and reducing cost. The REG710 device is thermally protected and current limited, protecting the load and the regulator during fault conditions. Typical ground pin current (quiescent current) is 65 µA with no load, and less than 1 µA in shutdown mode.

Device Information(1)

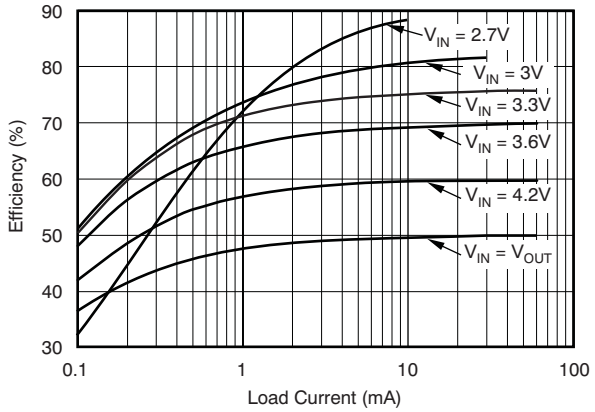
PART NUMBER	PACKAGE	BODY SIZE (NOM)
REG710	SOT-23 (6)	2.90 mm × 1.60 mm
REG71050	SOT (6)	2.90 mm × 1.60 mm
	SON (6)	2.00 mm × 2.00 mm
REG71055	SOT-23 (6)	2.90 mm × 1.60 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Typical Operating Circuit



Efficiency vs Load Current

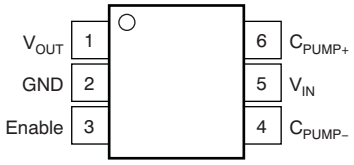


5 Device Comparison Table

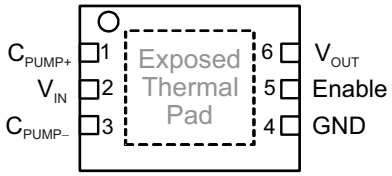
ORDER NUMBER	OUTPUT VOLTAGE
REG71055	5.5 V
REG710NA-5	5 V
REG71050	
REG710NA-3.3	3.3 V
REG710NA-3	3 V
REG710NA-2.7	2.7 V
REG710NA-2.5	2.5 V

6 Pin Configuration and Functions

DDC and DBV Package
6-Pin SOT and SOT-23
Top View



DRV Package
6-Pin SON With Exposed Thermal Pad
Top View



Pin Functions

PIN			I/O	DESCRIPTION
NAME	DDC/DBV	DRV		
C_{pump-}	4	3	–	Connect to the flying capacitor
C_{pump+}	6	1	–	Connect to the flying capacitor
Enable	3	5	I	Hardware Enable/Disable pin (high=enable)
GND	2	4	–	Ground
V_{in}	5	2	I	Input supply pin. Connect the input capacitor to this pin.
V_{out}	1	6	O	Output supply. Connect the output capacitor to this pin.

7 Specifications

7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)

		MIN	MAX	UNIT
V_{IN}	Supply voltage	–0.3	6	V
Enable	Enable input	–0.3	V_{IN}	
	Output short-circuit duration	Indefinite		
T_A	Operating ambient temperature	–55	125	°C
T_J	Operating ambient temperature	–55	150	
T_{stg}	Storage temperature	–55	150	

7.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)	±2000	V
		Charged device model (CDM), per JEDEC specification JESD22-C101 (2)	±500	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

7.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
INPUT VOLTAGE					
Tested Startup (1)	REG71055	3		5.5	V
	REG710-5	2.7		5.5	V
	All other models	1.8		5.5	V
T_A	Operating ambient temperature range	–40		85	°C

(1) See conditions under Output Voltage with a resistive load no lower than typical V_{OUT}/I_{OUT} in *Electrical Characteristics*.

7.4 Thermal Information

THERMAL METRIC (1)		REG710			UNIT
		DRV	DDC	DBV	
		6 PINS	6 PINS	6 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	119.1	204.6	184.4	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	110.5	50.5	124.6	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	88.7	54.3	30.6	°C/W
ψ_{JT}	Junction-to-top characterization parameter	7.7	0.8	22.1	°C/W
ψ_{JB}	Junction-to-board characterization parameter	89	52.8	30.1	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	61.8	n/a	n/a	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953.

7.5 Electrical Characteristics

T_A = -40ºC to 85ºC, typical values are at T_A = 25°C (unless otherwise noted), V_{IN} = (V_{OUT} / 2 + 0.75 V), I_{OUT} = 10 mA, C_{IN} = C_{OUT} = 2.2 µF, C_{PUMP} = 0.22 µF, and V_{ENABLE} = 1.3 V, unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SUPPLY						
V_{IN}	Input voltage range. Tested Startup.	See conditions under Output Voltage with a resistive load no lower than typical V_{OUT}/I_{OUT}.				V
	REG71055		3		5.5	
	REG710-5		2.7		5.5	
	All other models		1.8		5.5	
I_Q	Operating quiescent current	I_{OUT} = 0 mA, T_A = 25°C		65	100	µA
I_{SD}	Shutdown current	V_{IN} = 1.8 V to 5.5 V, Enable = 0 V, T_A = 25°C		0.01	1	µA
CONTROL SIGNALS (ENABLE)						
	Logic high input voltage	V_{IN} = 1.8 V to 5.5 V	1.3		V_{IN}	V
	Logic low input voltage	V_{IN} = 1.8 V to 5.5 V	–0.2		0.4	V
	Logic high input current	V_{IN} = 1.8 V to 5.5 V, T_A = 25°C			100	nA
	Logic low input current	V_{IN} = 1.8 V to 5.5 V, T_A = 25°C			100	nA
OSCILLATOR FREQUENCY (1)				1		MHz

(1) The converter regulates by enabling and disabling periods of switching cycles. The switching frequency is the oscillator frequency during an active period.

Electrical Characteristics (continued)

T_A = -40ºC to 85ºC, typical values are at T_A = 25°C (unless otherwise noted), V_{IN} = (V_{OUT} / 2 + 0.75 V), I_{OUT} = 10 mA, C_{IN} = C_{OUT} = 2.2 µF, C_{PUMP} = 0.22 µF, and V_{ENABLE} = 1.3 V, unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
OUTPUT						
	REG71055	I_{OUT} ≤ 10 mA, 3 V ≤ V_{IN} ≤ 5.5 V	5.2	5.5	5.8	V
		I_{OUT} ≤ 30 mA, 3.25 V ≤ V_{IN} ≤ 5.5 V	5.2	5.5	5.8	V
	REG710-5, REG71050	I_{OUT} ≤ 10 mA, 2.7 V ≤ V_{IN} ≤ 5.5 V	4.7	5	5.3	V
		I_{OUT} ≤ 30 mA, 3 V ≤ V_{IN} ≤ 5.5 V	4.7	5	5.3	V
		I_{OUT} ≤ 60 mA, 3.3 V ≤ V_{IN} ≤ 4.2 V	4.6	5	5.4	V
	REG710-3.3	I_{OUT} ≤ 10 mA, 1.8 V ≤ V_{IN} ≤ 5.5 V	3.1	3.3	3.5	V
		I_{OUT} ≤ 30 mA, 2.2 V ≤ V_{IN} ≤ 5.5 V	3.1	3.3	3.5	V
	REG710-3	I_{OUT} ≤ 10 mA, 1.8 V ≤ V_{IN} ≤ 5.5 V	2.82	3	3.18	V
		I_{OUT} ≤ 30 mA, 2.2 V ≤ V_{IN} ≤ 5.5 V	2.82	3	3.18	V
	REG710-2.7	I_{OUT} ≤ 10 mA, 1.8 V ≤ V_{IN} ≤ 5.5 V	2.54	2.7	2.86	V
		I_{OUT} ≤ 30 mA, 2 V ≤ V_{IN} ≤ 5.5 V	2.54	2.7	2.86	V
	REG710-2.5	I_{OUT} ≤ 10 mA, 1.8 V ≤ V_{IN} ≤ 5.5 V	2.35	2.5	2.65	V
		I_{OUT} ≤ 30 mA, 2 V ≤ V_{IN} ≤ 5.5 V	2.35	2.5	2.65	V
I_{out}	Nominal output current	T_A = 25°C	30			mA
I_{sc}	Short circuit output current	T_A = 25°C		100		mA
RIPPLE VOLTAGE (2)		I_{OUT} = 30 mA, T_A = 25°C		35		mV_{PP}
EFFICIENCY (3)		I_{OUT} = 10 mA, V_{IN} = 1.8 V, REG710-3.3, T_A = 25°C		90%		
THERMAL SHUTDOWN						
	Shutdown temperature			160		°C
	Shutdown recovery			140		°C

(2) Effective series resistance (ESR) of capacitors is < 0.1 Ω.
(3) See efficiency curves for other V_{IN}/V_{OUT} configurations.

7.6 Typical Characteristics

At T_A = 25°C, V_{IN} = (V_{OUT} / 2 + 0.75 V), I_{OUT} = 5 mA, C_{IN} = C_{OUT} = 2.2 µF, C_{PUMP} = 0.22 µF, and V_{ENABLE} = 1.3 V, unless otherwise noted.

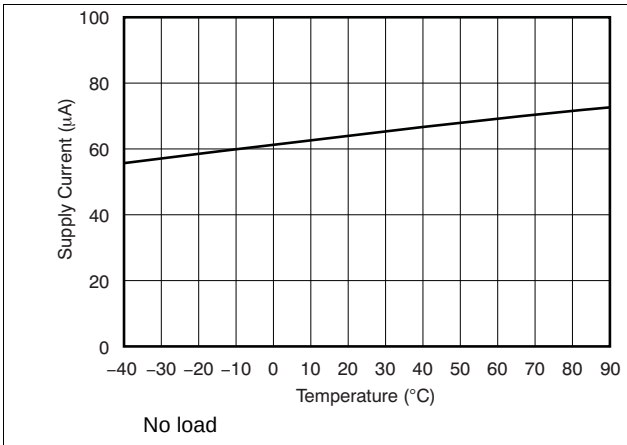


Figure 1. Supply Current vs Temperature

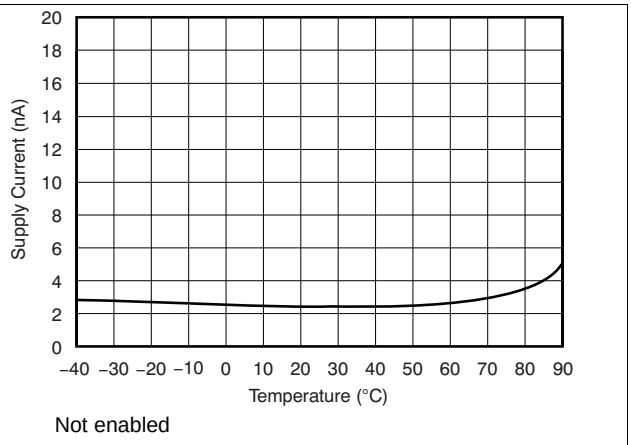


Figure 2. Supply Current vs Temperature

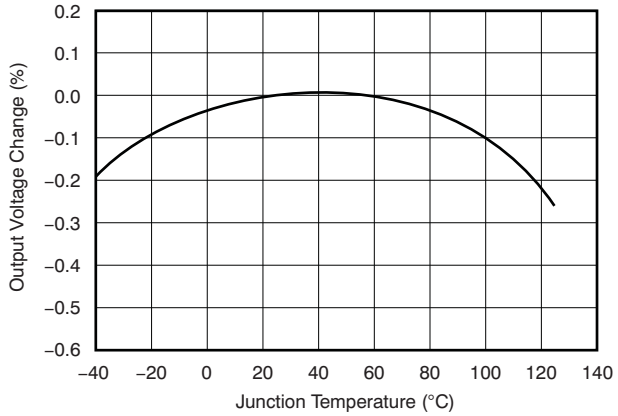


Figure 3. Output Voltage vs Temperature

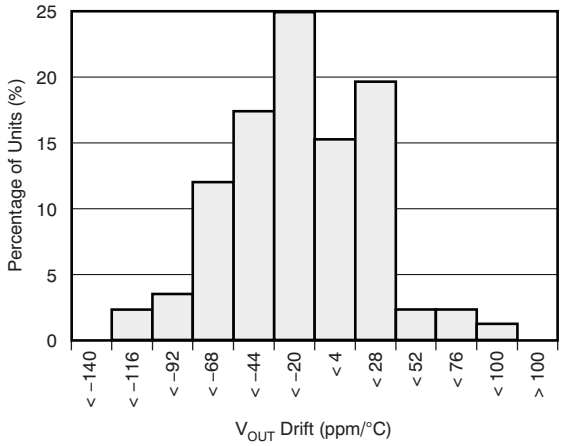


Figure 4. Output Voltage Drift Histogram

9 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

The REG710 is a switched capacitor voltage converter that produces a regulated, low-ripple output voltage from an unregulated input voltage range from 1.8 V to 5.5 V. The high switching frequency allows the use of small surface-mount capacitors. The following section gives guidance to choose external components to complete the power supply design. Application curves are included for the typical application shown below.

9.2 Typical Applications

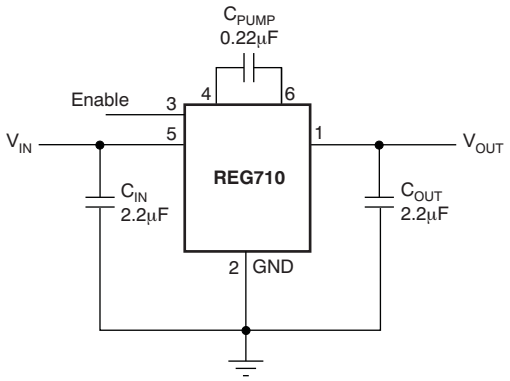


Figure 7. Typical Operating Circuit

9.2.1 Design Requirements

The REG710 family of switched capacitor voltage converters offers a variety of regulated fixed output voltages. This family supports unregulated input voltages which can have values that are lower or higher than the regulated output voltage. Only input and output capacitors as well as a pump capacitor are required to have a fully functional converter. The following design procedure is adequate for the whole V_{IN}, V_{OUT} and load current range of REG710.

9.2.2 Detailed Design Procedure

9.2.2.1 Capacitor Selection

For minimum output voltage ripple, the output capacitor C_{OUT} should be a ceramic, surface-mount type. Tantalum capacitors generally have a higher effective series resistance (ESR) and may contribute to higher output voltage ripple. Leaded capacitors also increase ripple due to the higher inductance of the package itself. To achieve best operation with low input voltage and high load current, the input and pump capacitors (C_{IN} and C_{PUMP}, respectively) should also be surface-mount ceramic types. In all cases, X7R or X5R dielectric are recommended. See the typical operating circuit shown in Figure 7 for component values.

With light loads or higher input voltage, a smaller 0.1-µF pump capacitor (C_{PUMP}) and smaller 1-µF input and output capacitors (C_{IN} and C_{OUT}, respectively) can be used. To minimize output voltage ripple, increase the output capacitor, C_{OUT}, to 10 µF or larger.

The capacitors listed in Table 2 can be used with the REG710. This table is only a representative list of compatible parts.

Table 2. Suggested Capacitors

MANUFACTURER	PART NUMBER	VALUE	TOLERANCE	DIELECTRIC MATERIAL	PACKAGE SIZE	RATED WORKING VOLTAGE
Kemet	C1206C255K8RAC	2.2 µF	±10%	X7R	1206	10 V
	C1206C224K8RAC	0.22 µF	±10%	X7R	1206	10 V
Panasonic	ECJ−2YBOJ225K	2.2 µF	±10%	X5R	805	6.3 V
	ECJ−2VBIC224K	0.22 µF	±10%	X7R	805	16 V
	ECJ−2VBIC104	0.1 µF	±10%	X7R	805	16 V
Taiyo Yuden	EMK316BJ225KL	2.2 µF	±10%	X7R	1206	16 V
	TKM316BJ224KF	0.22 µF	±10%	X7R	1206	25 V

9.2.3 Application Curves

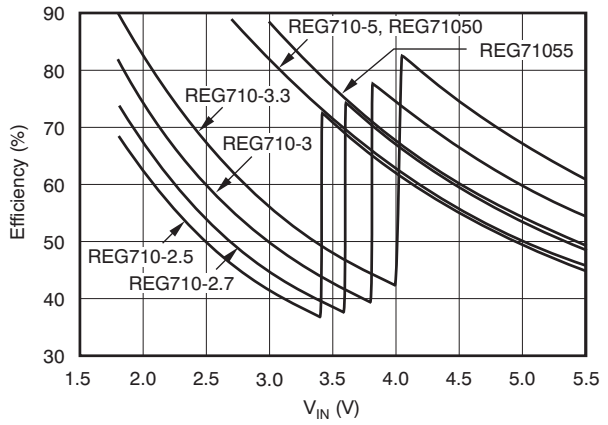


Figure 8. Efficiency vs V_{IN}

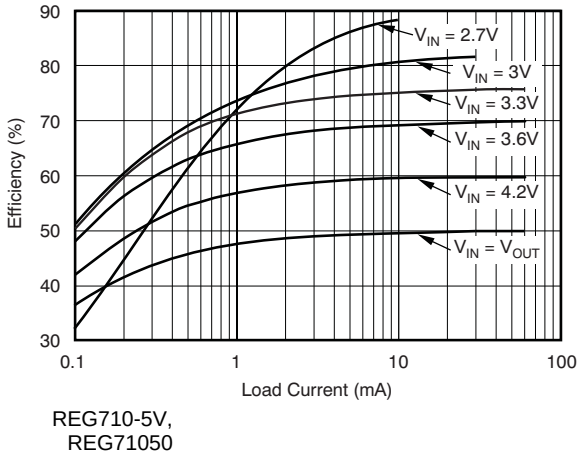


Figure 9. Efficiency vs Load Current

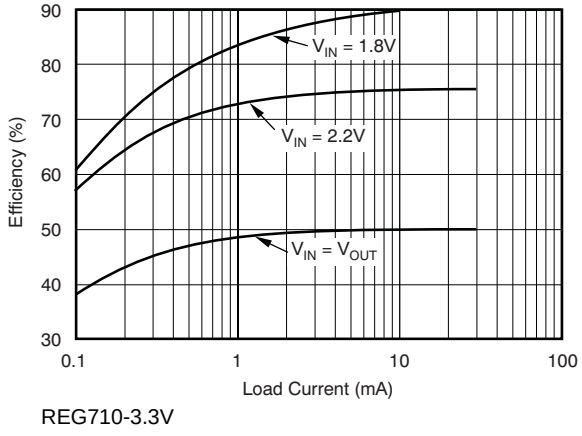


Figure 10. Efficiency vs Load Current

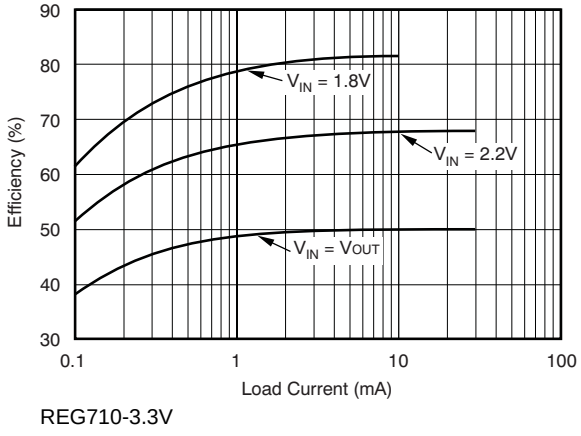
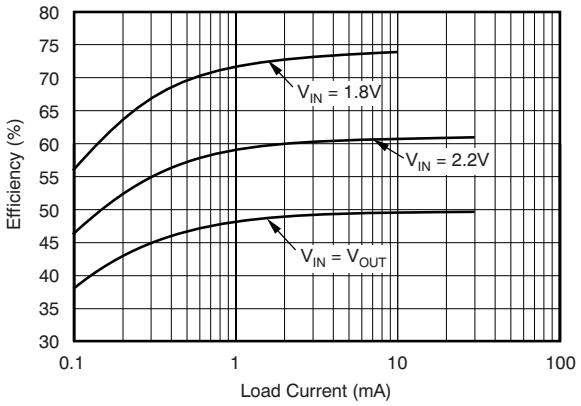
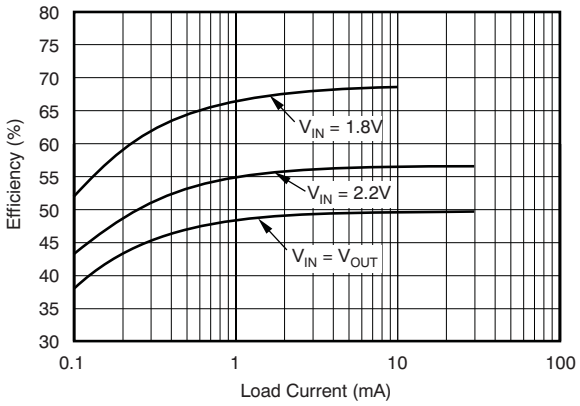


Figure 11. Efficiency vs Load Current



REG710-2.7V

Figure 12. Efficiency vs Load Current



REG710-2.5

Figure 13. Efficiency vs Load Current

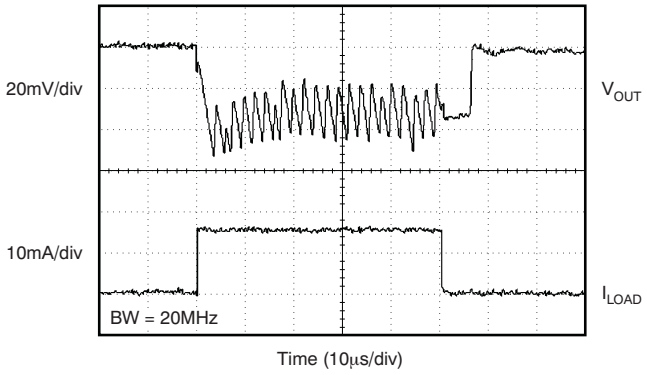


Figure 14. Load Transient Response

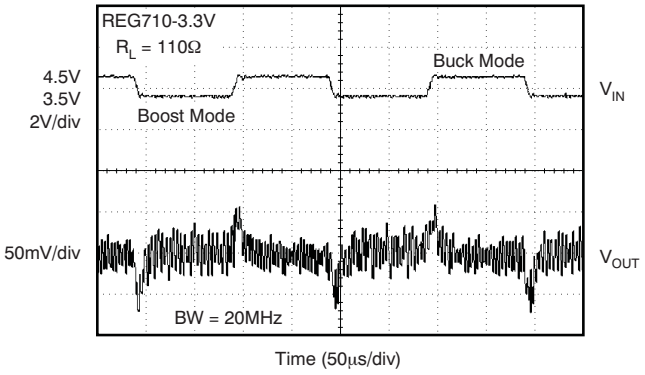


Figure 15. Line Transient Response

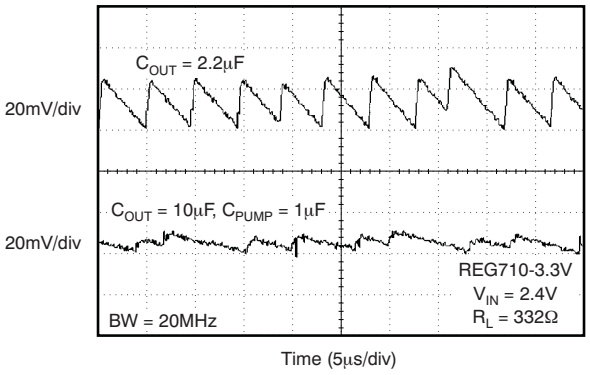
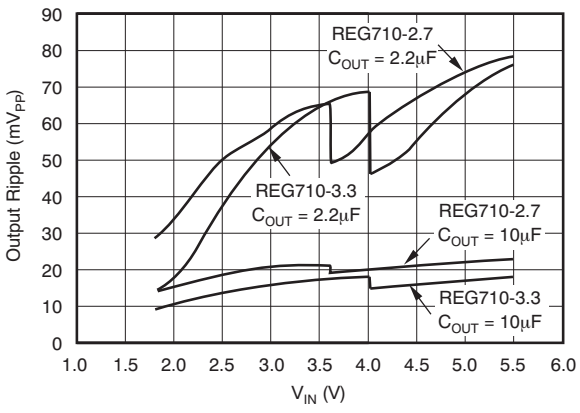


Figure 16. Output Ripple Voltage



REG710-2.7V
REG710-3.3V

Figure 17. Output Ripple Voltage vs V_{IN}

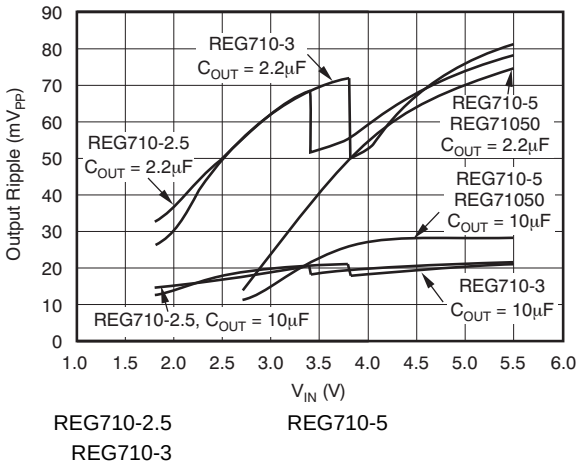


Figure 18. Output Ripple Voltage vs V_{IN}

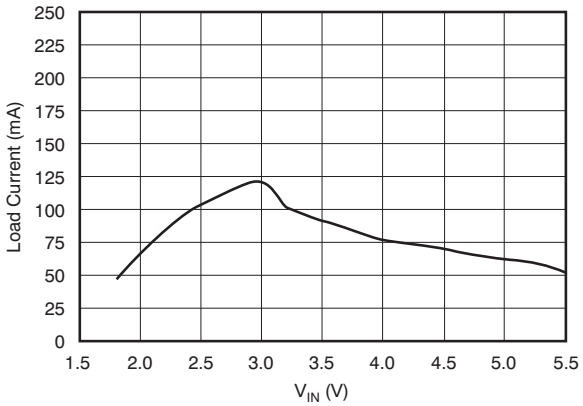


Figure 19. Short-Circuit Load Current vs V_{IN}

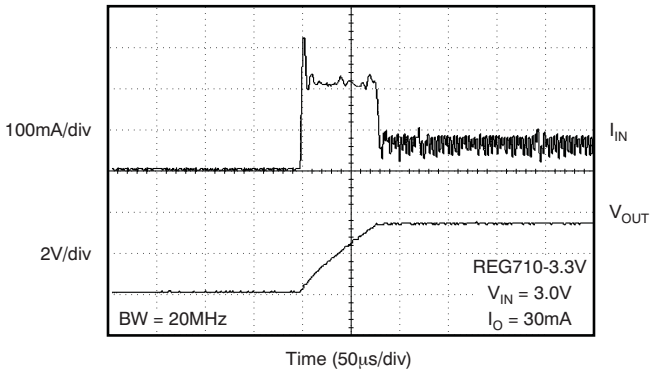


Figure 20. Input Current at Turn-On