Various Applications for Voltage-Tracking LDO

Mixed Signal Automotive

-- Automotive Value Line

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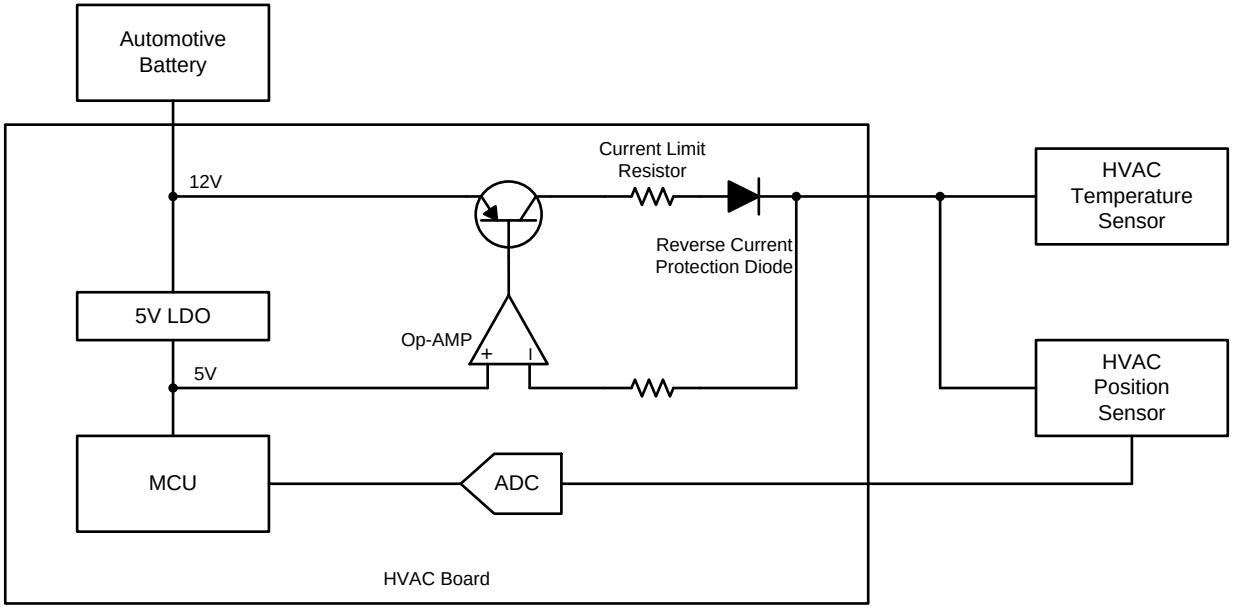
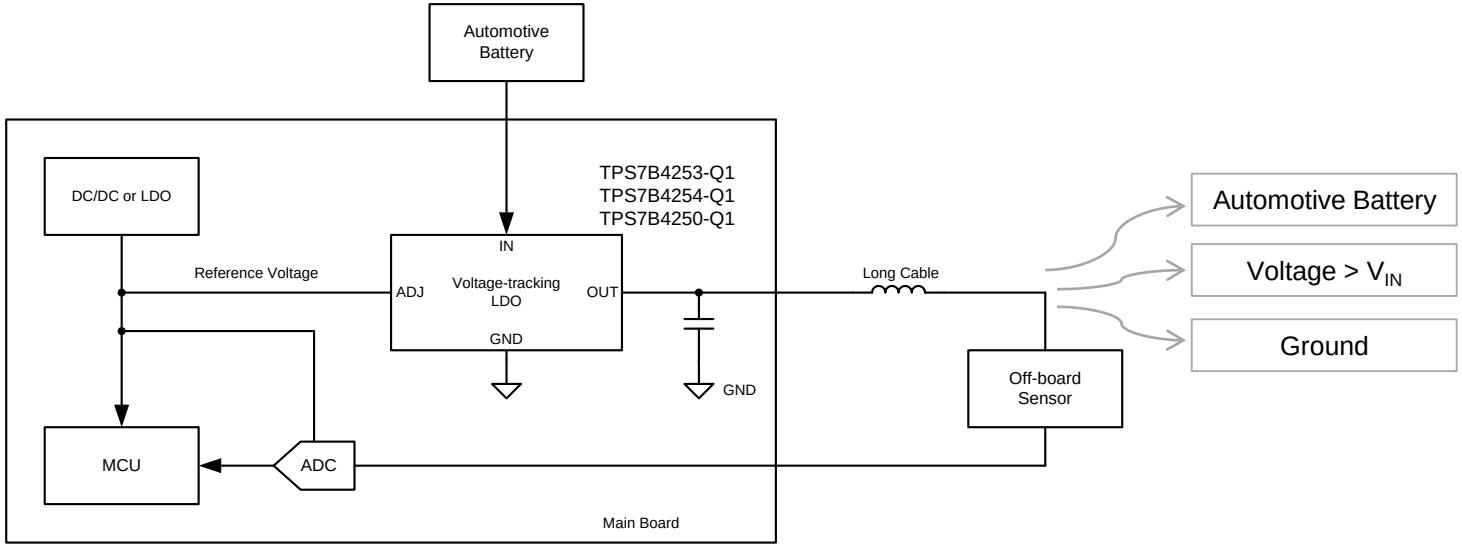
What is Voltage-Tracking Power Supply?

Off-board sensors exist everywhere in Automotive

For example: Discrete Voltage-Tracking Solution in HVAC



What is Voltage-Tracking LDO?

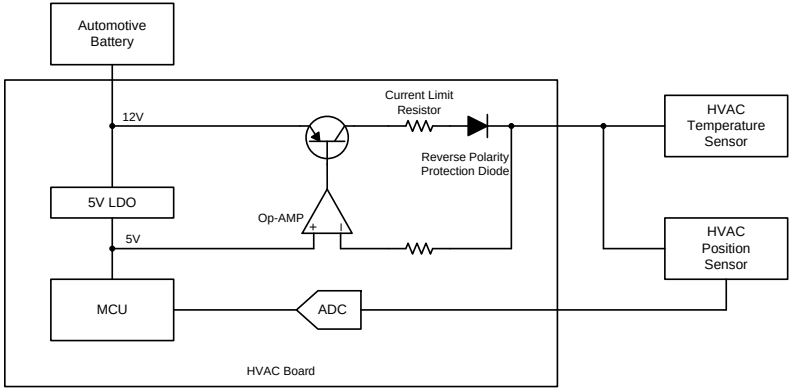


Tracking LDO is mainly used for off-board sensors power supply

- Many automotive sensors are off-board. There are long cables between sensors and main board, which leads to high potential risk of been short to ground or short to battery if cable is broken.
- Voltage-Tracking LDO TPS7B425x-Q1 implements full protections, includes over current protection, input reverse polarity protection and off-board protections
- If the cable is broken and it is short to ground or battery, the voltage-tracking LDO will protect the itself and the previous power stage from damage.

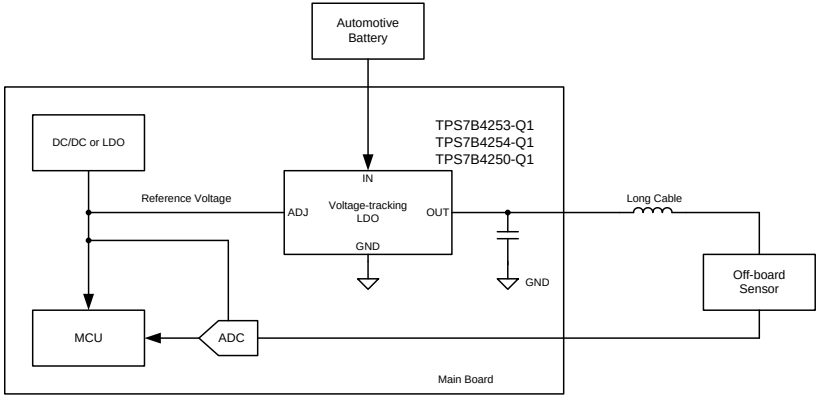
Voltage-Tracking LDO vs. Discrete Tracking Solution

Discrete Solution



Discrete Solution Components:
Op-AMP, Transistor, Diode, Resistors

Voltage-Tracking LDO



Voltage Tracking LDO:
TPS7B4250-Q1, TPS7B4254-Q1 and TPS7B4253-Q1

Voltage-Tracking LDO Advantages:

- Much Better Tracking Accuracy, ±4mV (TPS7B4254/3-Q1) and ±5mV TPS7B4250-Q1 under all conditions
- Much Lower Quiescent Current (~60uA) and Dropout Voltage
- Integrated Short to GND, Short to Battery, and Reverse current Protection
- BOM Cost Saving and PCB Space Saving

MSA AVL Voltage-Tracking LDO Products

	TPS7B4250-Q1	TPS7B4254-Q1	TPS7B4253-Q1
VIN	4 to 40V (-20 to 45V)	4 to 40V (-40 to 45V)	4 to 40V (-40 to 45V)
VOUT	1.5 to 18V	2 to 40V	1.5 to 40V
IOUT	50mA	150mA	300mA
Voltage-Tracking Accuracy	±5mV	±4mV	±4mV
Load Regulation (max)	4mV	4mV	4mV
Line Regulation (max)	3mV	4mV	4mV
Dropout Voltage (max)	1V @ 50mA	260mV @ 100A	520mV @ 200A
Output Cap	1uF to 50uF	10uF to 500uF	10uF to 500uF
Output Cap ESR	<20Ω	<20Ω	<20Ω
Protections	RP, RC, SC, TSD	RP, RC, SC, TSD	RP, RC, SC, TSD
Package	SOT23-5	SO PowerPAD™-8	HTSSOP-20, SO PowerPAD™-8
Comments	Small package	Good thermal performance	Separate EN pin to provide flexibility (HTSSOP-20)

Protections:
RP = Reverse Polarity, RC = Reverse Current, SC = Short Circuit (to battery/ground), TSD = Thermal Shutdown

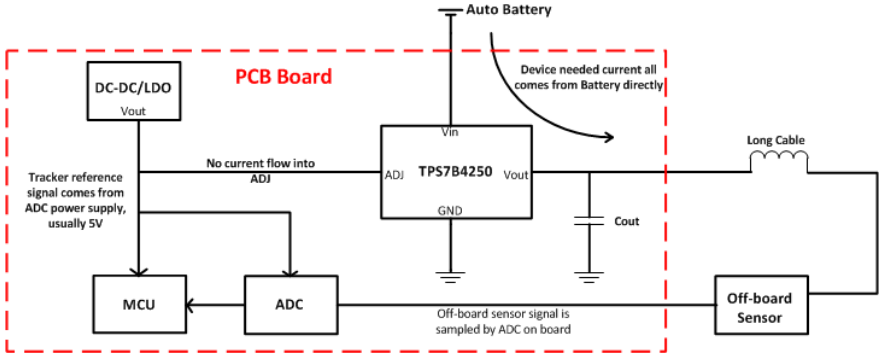
TPS7B4250-Q1 – 50mA 40-V Voltage-Tracking LDO

Features

- AEC-Q100 Qualified for automotive applications
- -20 to 45-V Wide Input-Voltage Range
- Output Voltage Range: 1.5 to 18 V
- 50-mA Output Current Capability
- Ultra-Low Output Tracking Tolerance, ±5 mV
- 150-mV Low Dropout Voltage when IOUT = 10mA
- Low Quiescent Current (IQ):
  - 40 µA (Typical) at Light Loads
- Extremely Wide ESR Range to use Ceramic Capacitor
  - Stable With 1- to 50-µF Output Capacitance
  - ESR 1 mΩ to 20 Ω
- Reverse Polarity Protection
- Current-Limit and Thermal-Shutdown Protection
- Output Short-Circuit Proof to Ground and Supply
- SOT23-5

Benefits

- Ultra-low tracking tolerance to support high precision data acquisition for off-board sensors
- Full protection to power off-board loads to increase system reliability
- Low quiescent current in both Shutdown mode and Light load mode
- Wide ESR and Capacitance Range to lower the system cost for C_{OUT} Selection



Applications

- Off-board Sensor Power Supply
- High Precision Voltage Tracking

Key Parameter Overview

Input Voltage Range	4 ~ 40	V
Load Dump	45	V
Output Voltage Range	1.5 ~ 18	V
Output max. Current	50	mA
Output Voltage Tracking Tolerance	±5	mV

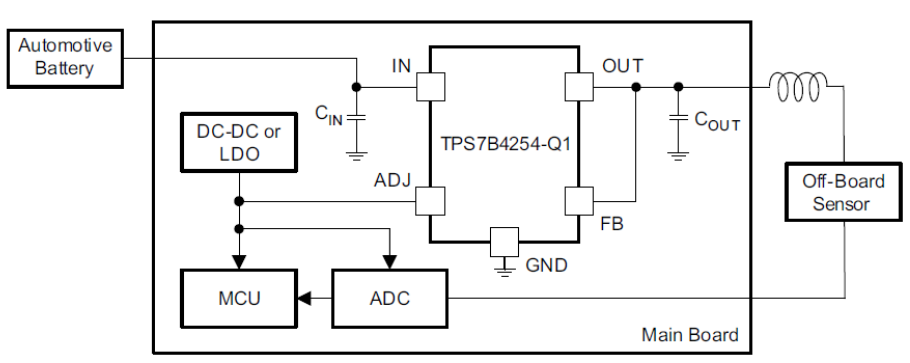
TPS7B4254-Q1 – 150mA 40-V Voltage-Tracking LDO

Features

- AEC-Q100 Qualified for automotive applications
- -40 to 45-V Wide Input-Voltage Range
- Output Voltage Range: 2 to 40 V
- 150-mA Output Current Capability
- Ultra-Low Output Tracking Tolerance, ±4 mV
- 160-mV Low Dropout Voltage when IOUT = 100mA
- Low Quiescent Current (IQ):
  - < 4 µA when ADJ = LOW
  - 60 µA (Typical) at Light Loads
- Extremely Wide ESR Range to use Ceramic Capacitor
  - Stable With 10- to 500-µF Output Capacitance
  - ESR 1 mΩ to 20 Ω
- Reverse Polarity Protection
- Current-Limit and Thermal-Shutdown Protection
- Output Short-Circuit Proof to Ground and Supply
- Inductive Clamp at OUT Pin
- SO PowerPAD™-8

Benefits

- Ultra-low tracking tolerance to support high precision data acquisition for off-board sensors
- Full protection to power off-board loads to increase system reliability
- Low quiescent current in both Shutdown mode and Light load mode
- Wide ESR and Capacitance Range to lower the system cost for C_{OUT} Selection



Applications

- Off-board Sensor Power Supply
- High Precision Voltage Tracking
- Power Switch for Off-board Loads

Key Parameter Overview

Input Voltage Range	4 ~ 40	V
Load Dump	45	V
Output Voltage Range	2 ~ 40	V
Output max. Current	150	mA
Output Voltage Tracking Tolerance	±4	mV

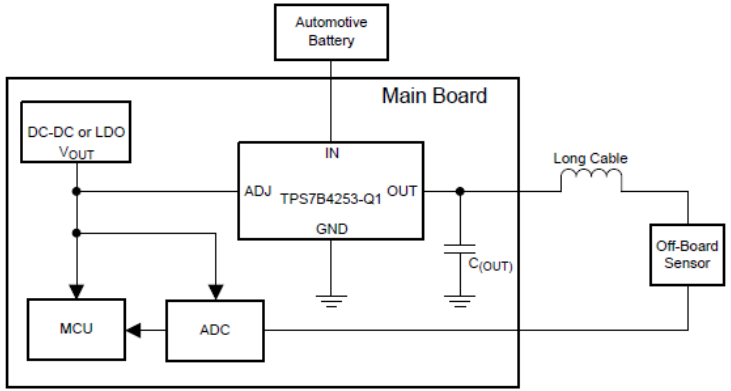
TPS7B4253-Q1 – 300mA 40-V Voltage-Tracking LDO

Features

- AEC-Q100 Qualified for automotive applications
- -40 to 45-V Wide Input-Voltage Range
- Output Voltage Range
  - 1.5 to 40 V (HTSSOP)
  - 2 to 40 V (SO PowerPAD™)
- 300-mA Output Current Capability
- **Ultra-Low Output Tracking Tolerance, ±4 mV**
- 320-mV Low Dropout Voltage when IOUT = 200mA
- Separate Pins for Enable and Tracking Inputs (HTSSOP only)
- **Low Quiescent Current (IQ):**
  - **< 4 µA when EN/ADJ = LOW**
  - **60 µA (Typical) at Light Loads**
- **Extremely Wide ESR Range to use Ceramic Capacitor**
  - **Stable With 10- to 500-µF Output Capacitance**
  - **ESR 1 mΩ to 20 Ω**
- **Reverse Polarity Protection**
- **Current-Limit and Thermal-Shutdown Protection**
- **Output Short-Circuit Proof to Ground and Supply**
- **Inductive Clamp at OUT Pin**
- SO PowerPAD™-8, HTSSOP-20

Benefits

- Ultra-low tracking tolerance to support high precision data acquisition for off-board sensors
- Full protection to power off-board loads to increase system reliability
- Low quiescent current in both Shutdown mode and Light load mode
- Wide ESR and Capacitance Range to lower the system cost for C_{OUT} Selection



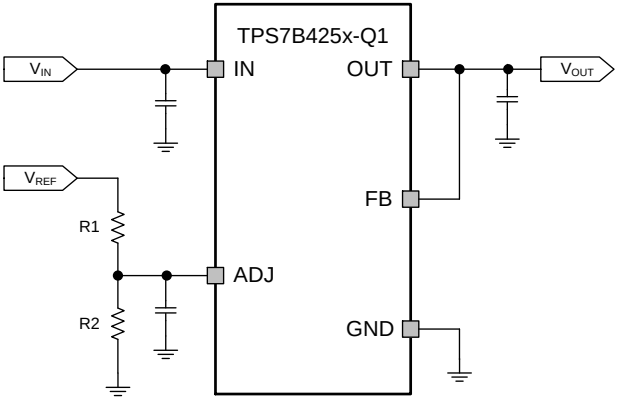
Applications

- Off-board Sensor Power Supply
- High Precision Voltage Tracking
- Power Switch for Off-board Loads

Key Parameter Overview

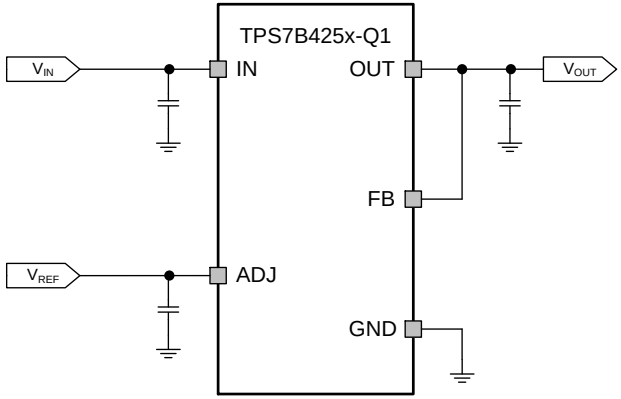
Input Voltage Range	4 ~ 40	V
Load Dump	45	V
Output Voltage Range	1.5 ~ 40	V
Output max. Current	300	mA
Output Voltage Tracking Tolerance	±4	mV

Voltage-Tracking LDO Applications: General LDO



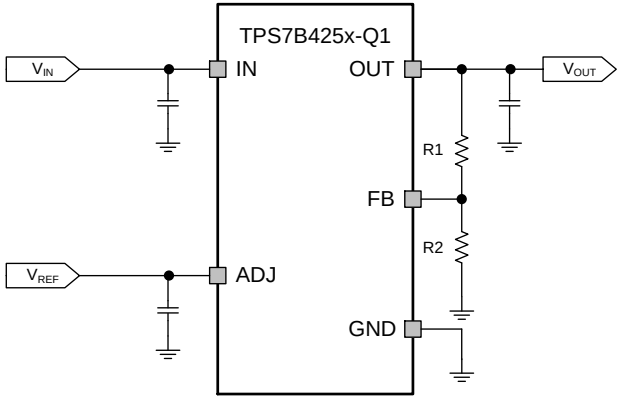
1. V_{OUT} lower than V_{REF}

$$V_{OUT} = V_{REF} \times \frac{R_2}{R_1 + R_2}$$



2. V_{OUT} equals to V_{REF}

$$V_{OUT} = V_{REF}$$

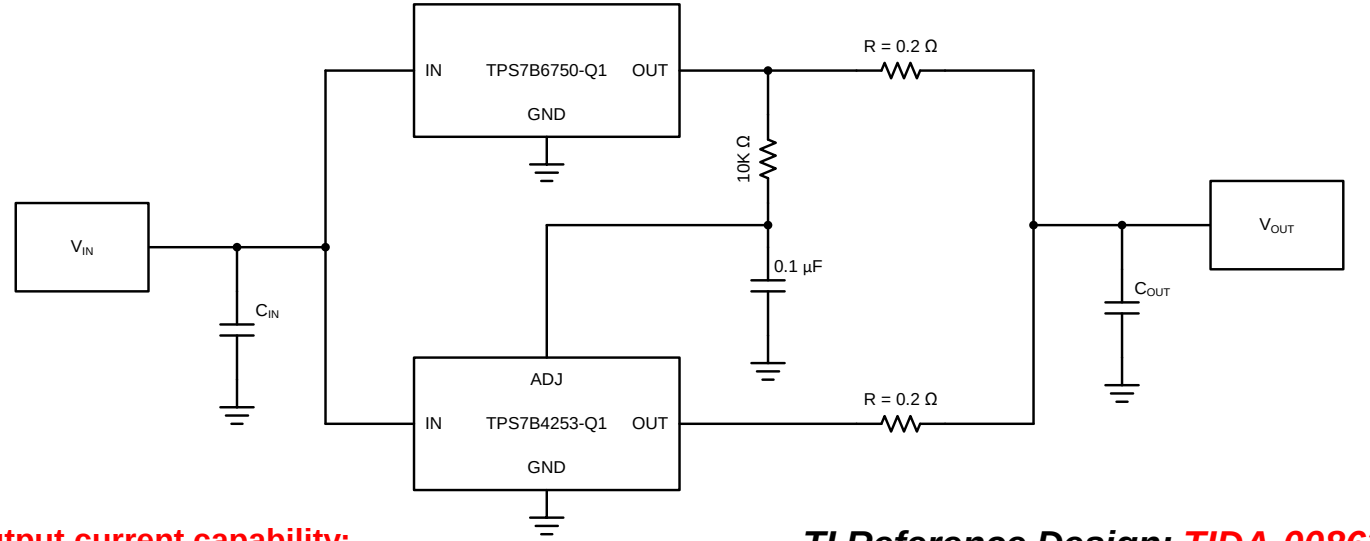


3. V_{OUT} higher than V_{REF}

$$V_{OUT} = V_{REF} \times \frac{R_1 + R_2}{R_2}$$

* FB pin is connected to OUT internally, this mode not available for TPS7B4250-Q1

Voltage-Tracking LDO Applications: LDO Parallel Connection



Maximum output current capability:

$$I_{OUT,MAX} = 300mA \times 2 = 600mA$$

Maximum current difference between two channels:

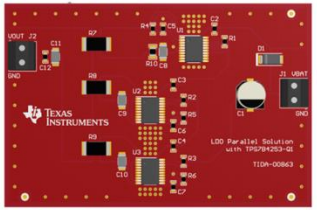
$$\Delta I = \frac{\Delta V}{R} = \frac{\pm 4mV}{0.2\Omega} = \pm 20mV$$

TI Reference Design: TIDA-00863

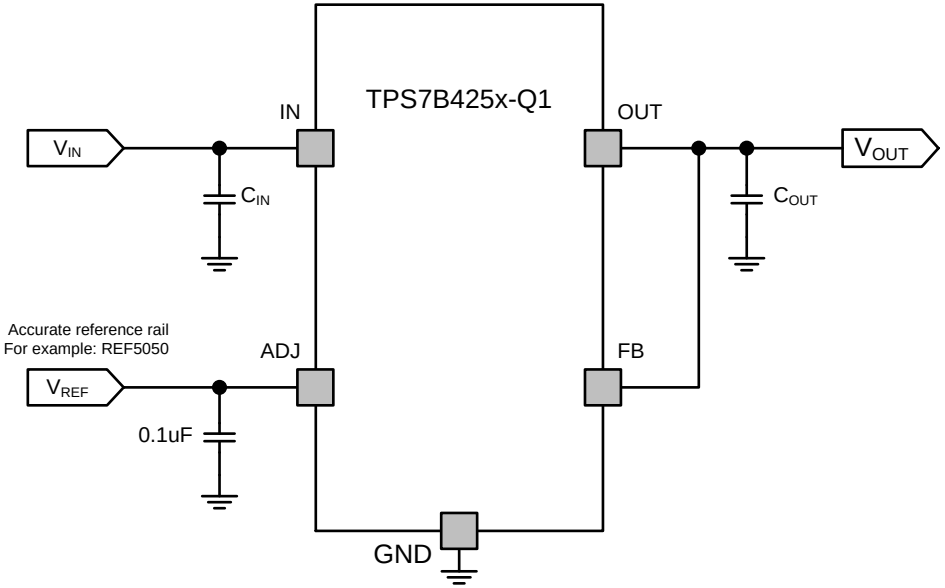
40-V LDO Parallel Circuitry Reference Design

- Output current up to 900mA
- 4- to 40-V wide input-voltage range
- Stable with wide range of output capacitor
- Linear power solution to relieve EMC/EMI concerns
- Good thermal performance under large load conditions

View reference design now

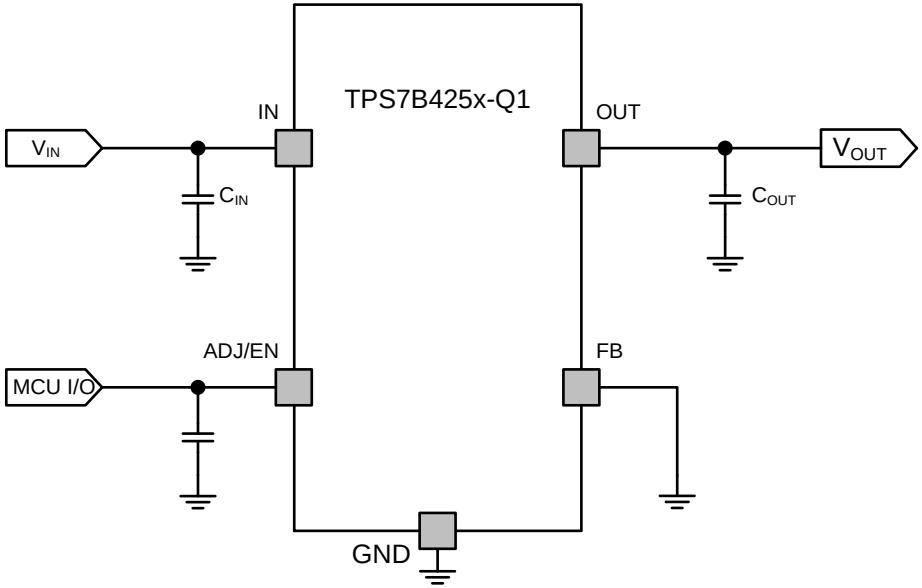


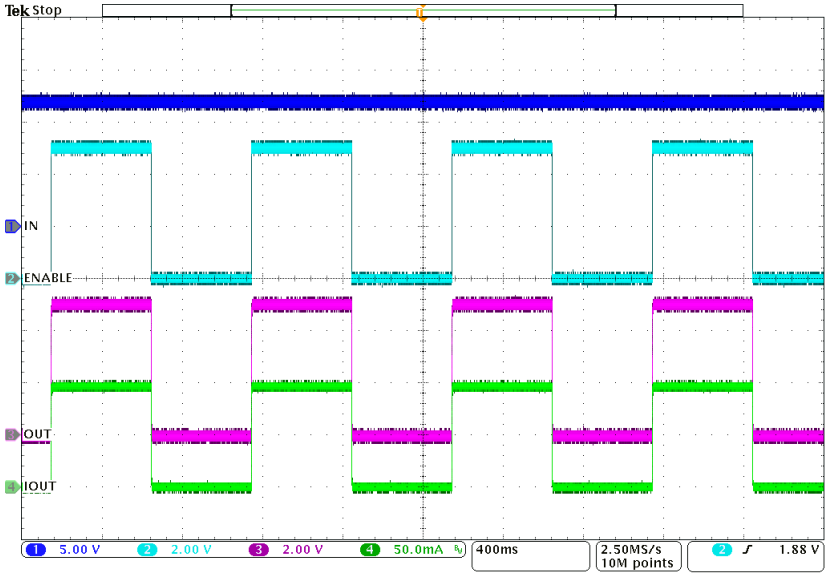
Voltage-Tracking LDO Applications: High Accuracy LDO



$$Accuracy_{VOUT} = \frac{V_{REF} \times 0.1\% + 4mV}{V_{REF}} = \frac{5 \times 0.1\% + 0.004}{5} \times 100\% = 0.18\%$$

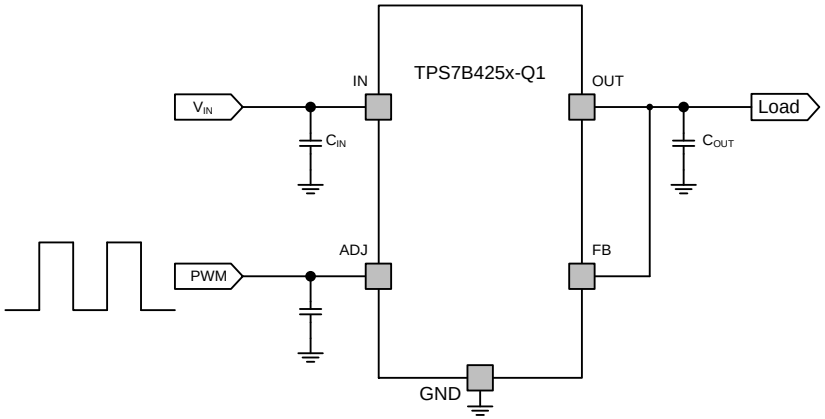
Voltage-Tracking LDO Applications: High Side Switch

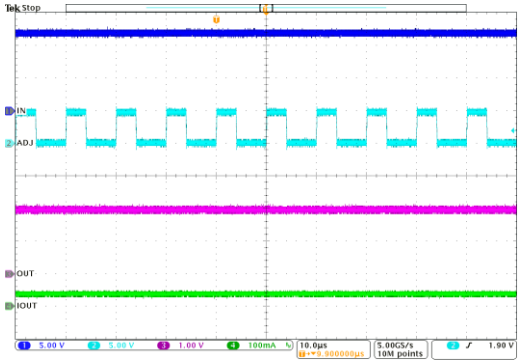




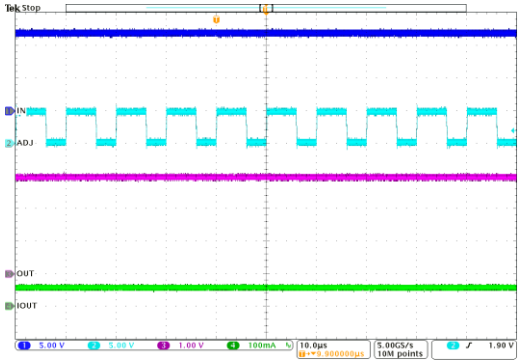
V_{IN} = 14 V, EN/ADJ = 0 or 5 V, 100 mA load at the output

Voltage-Tracking LDO Applications: VOUT Linear Adjusting

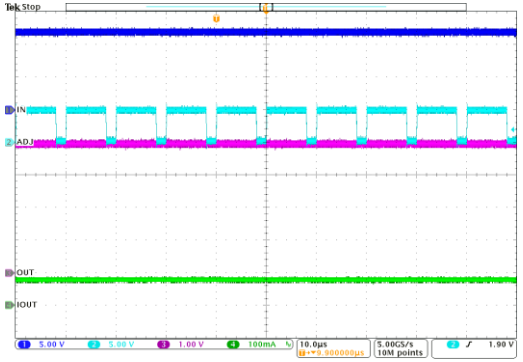




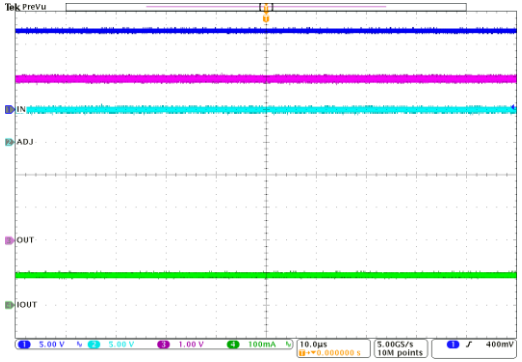
ADJ_{HIGH}=5V, 40% duty cycle, V_{OUT}=2V



ADJ_{HIGH}=5V, 60% duty cycle, V_{OUT}=3V



ADJ_{HIGH}=5V, 80% duty cycle, V_{OUT}=4V



ADJ_{HIGH}=5V, 100% duty cycle, V_{OUT}=5V

V_{OUT} is proportional to the PWM duty cycle at ADJ pin

$$V_{OUT} = ADJ_{HIGH} \times D \qquad 2V \le V_{OUT} \le \min\{V_{IN}, ADJ\}$$