AN5988

Powering Infotainment Electronics in Automotive Start-Stop Systems

Author: *Abhishek Newaskar*
Microchip Technology Inc.

SYSTEM OVERVIEW

Start-Stop Systems, commonly found in modern automobiles, represent a fuel and emission saving technology, designed to reduce engine idling by automatically shutting off the engine when the vehicle comes to a halt, such as at a traffic light or a train crossing, and restarting it when the driver is ready to move. This system relies on sensors to monitor driving conditions, engine and driver inputs to manage the Auto Start-Stop. For example, the Start-Stop system monitors engine and cabin temperature, as well as steering inputs, to activate the Start-Stop function. However, when the engine restarts, the battery voltage is likely to drop below 5V. This voltage dip can cause the infotainment electronics, such as the music and navigation systems, to reset during the car's restart. Therefore, it is crucial to ensure these systems receive a consistent 12V output, regardless of any fluctuations in the battery voltage. MCP19061 is a four switch buck-boost controller that can be used to provide stable output voltage to maintain seamless operation during the Start-Stop events.

HARDWARE

MCP19061 is an AEC-Q100 qualified four switch buck-boost analog front end controller with an input voltage range of 4.5V to 36V. It offers a fully configurable output voltage and current settings with constant voltage and constant current operation. This device includes configurable protections such as overvoltage, overcurrent, load dump, and overtemperature, to name a few. The output voltage, current, and protection values are dynamically configurable via I^2C.

Figure 1 illustrates the typical schematic connections for MCP19061. The HG1 and LG1 pins drive the high side and low side of the buck leg of the MOSFET bridge, respectively. Similarly, the HG2 and LG2 pins drive high side and low side of the boost leg. The HS1 and HS2 pins are connected to the switch nodes of the buck and boost side. VIN is the input power connection pin of the device. Minimum 6V is required at the VIN pin for the chip to function properly. However, during the Start-Stop event, the voltage of the battery can dip to as low as 4.5V, hence, to maintain operation VIN is supplied from both input and output using a logical OR with diodes D1 and D2, as shown in Figure 2. This setup ensures the continuous operation of the device during transient dips in the battery voltage. The VDD_IO should be supplied with 5V from a linear regulator like MCP1792T/5V. Additionally, the VOUT_REF pin should be connected to the Output Ground to achieve accurate V_{OUT}.

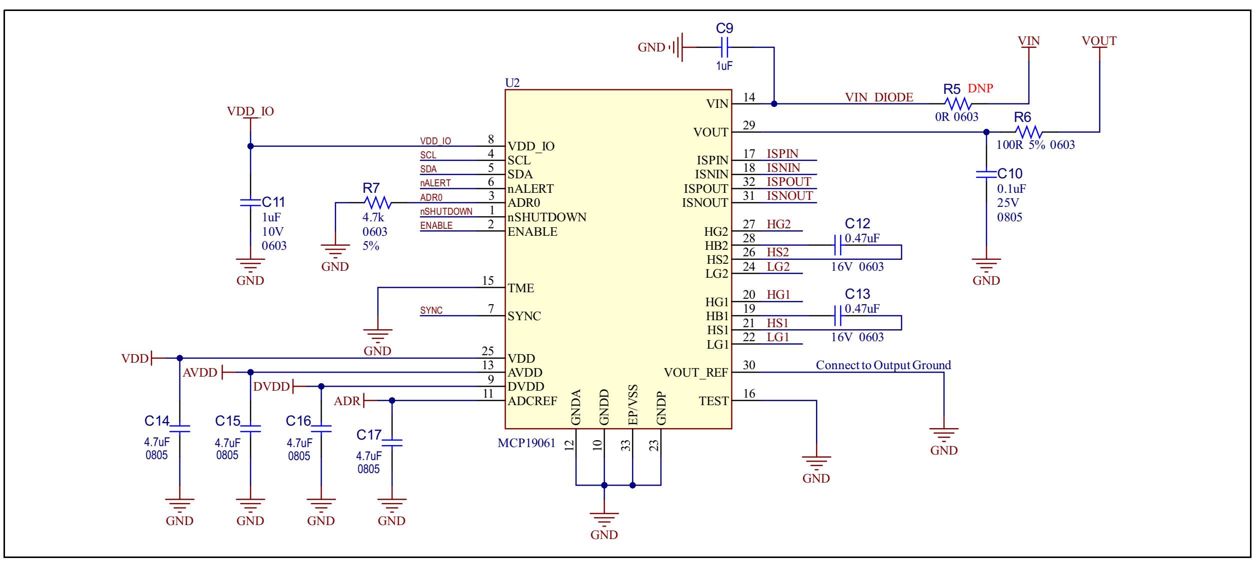

FIGURE 1: *MCP19061 Schematic Connections.*

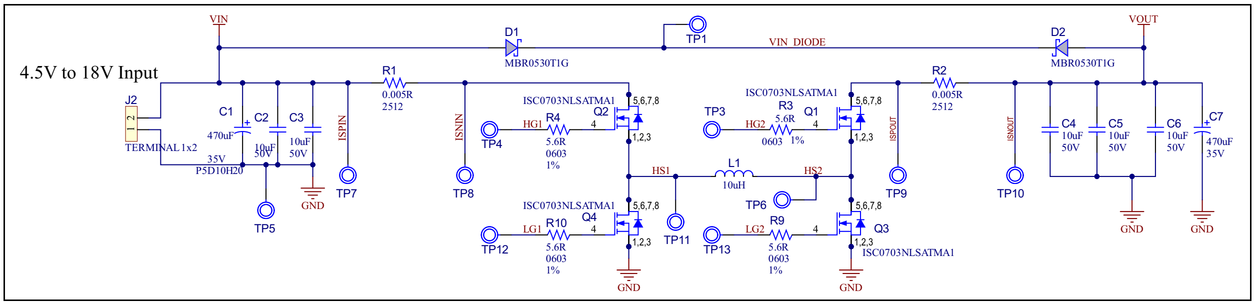

FIGURE 2: MCP19061 Schematic - Power Stage.

In the Start-Stop application, the MCP19061 power supply is operated for the following design parameters:

- V_{IN} = 6V to 18V
- V_{MIN} = 4.5V (during the engine start event)
- $I_{OUT(MAX)}$ = 5A (2A during engine start event)
- F_{SW} = 450 kHz.

OPERATION

During normal operation, the battery voltage is 12V and the MCP19061 operates in Buck-Boost mode. All four MOSFETs operate at 50% duty cycle and the output is maintained at 12V. The typical battery voltage is 12V. However, in the event of a rise in the battery voltage, for example, due to charging of battery from the alternator, the MCP19061 operates in Buck mode maintaining the output steady at 12V. If the battery voltage is lower than 12V, the MCP19061 switches to Boost mode to maintain the output at 12V. This Buck-Boost operation makes the MCP19061 particularly useful in infotainment devices, which often include amplifiers and circuits that require a stable 12V supply.

In the event of an engine crank, the voltage may momentarily dip to 4.5V. However, the MCP19061 can still maintain operation providing a maximum output current of 2A Figure 3 illustrates the relationship between the maximum output current and input voltage. It is important to note that the MCP19061 requires a minimum input voltage greater than 6V to start operation. It cannot start operation at 4.5V.

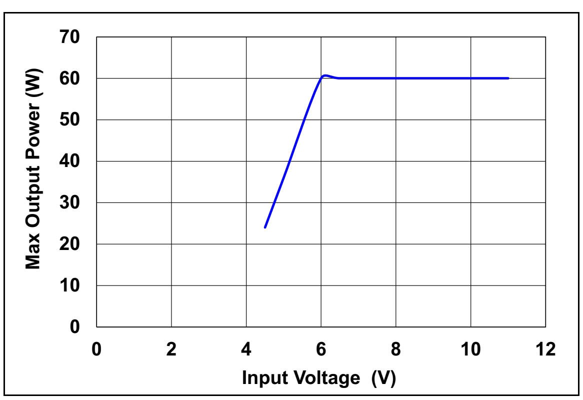

FIGURE 3: Maximum Output Power vs. Input Voltage.

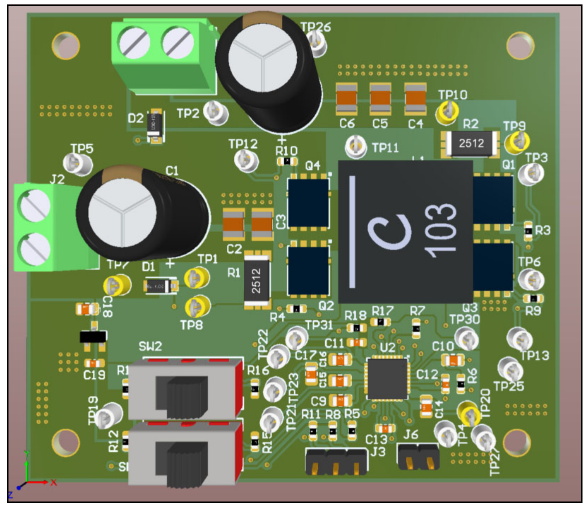

FIGURE 4: MCP19061 Start-Stop Evaluation Board.

TEST REPORT

The Evaluation Board depicted in Figure 4 was developed in accordance with the schematics presented in Figures 1 and 2. The results from the MCP19061 testing in accordance with the LV124 specification are as follows. Crank pulse tests (refer to Figures 4 and 5) were conducted as per MBN LV124-1 E11 (2013-03) with a fixed output voltage of 12V, and output currents of 1A and 2A on the evaluation board.

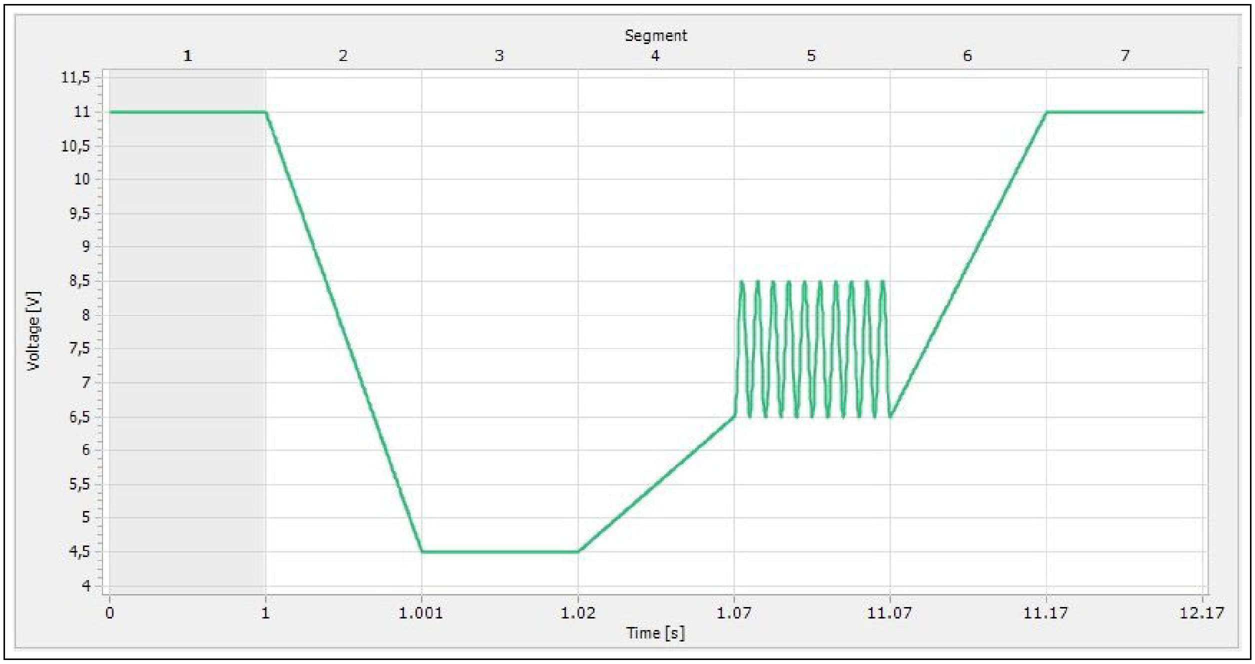

FIGURE 5: *Cold Crank Pulse.*

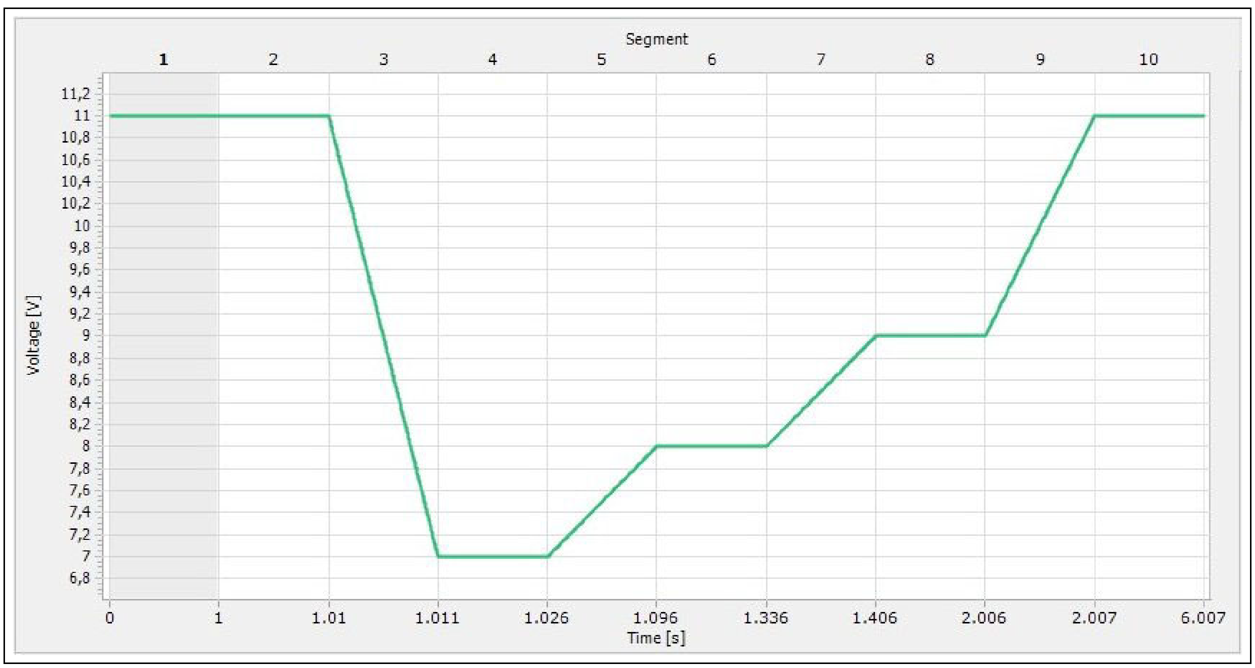

FIGURE 6: *Warm Crank Pulse.*

Test Equipment

- Automotive Signal Generator EM-Test Autowave
- Transient Generator EM-Test VDS 200N10
- Passive Loads of 1A, 2A
- Digital Oscilloscope, Multimeter.

RESULTS

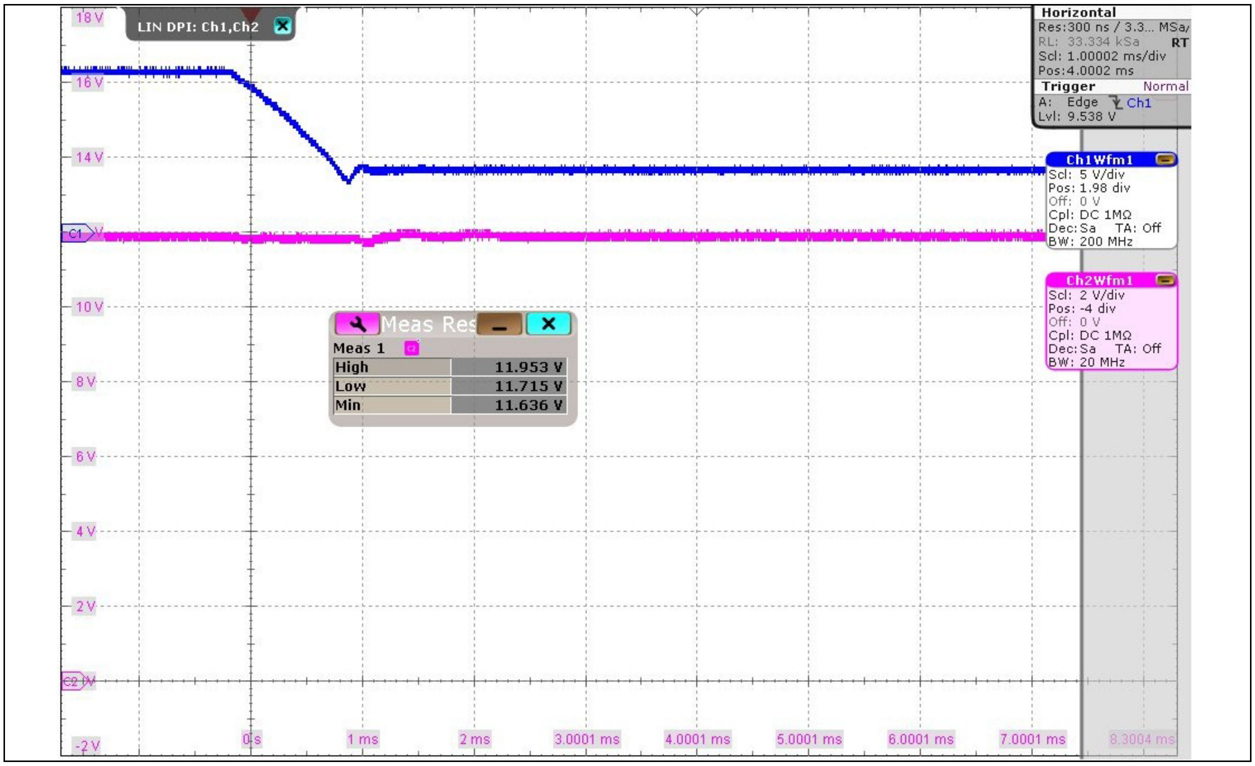

FIGURE 7: *Test Result for Cold Cranking Test (Normal Severity), Output Current 1A; CH1 = V_{IN}, CH2 = V_{OUT}.*

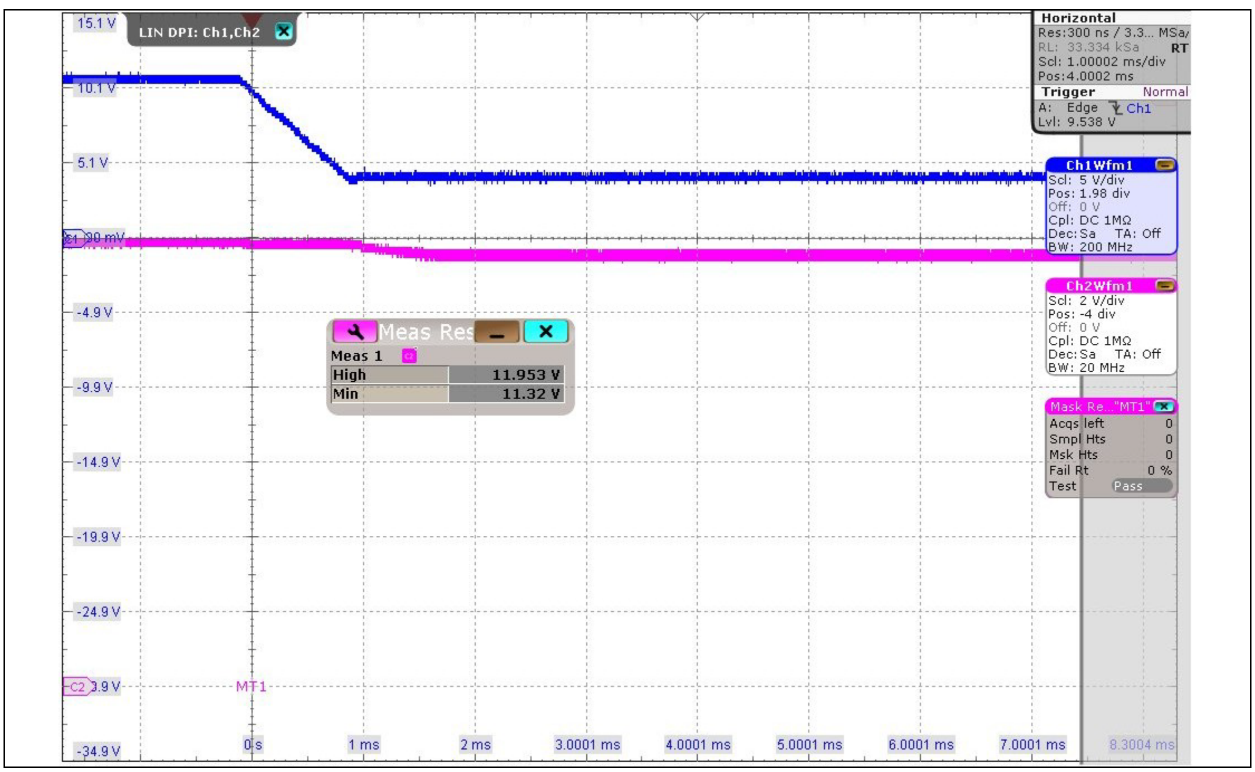

FIGURE 8: *Test Result for Cold Cranking Test (Normal Severity), Output Current 2A; CH1 = V_{IN}, CH2 = V_{OUT}.*

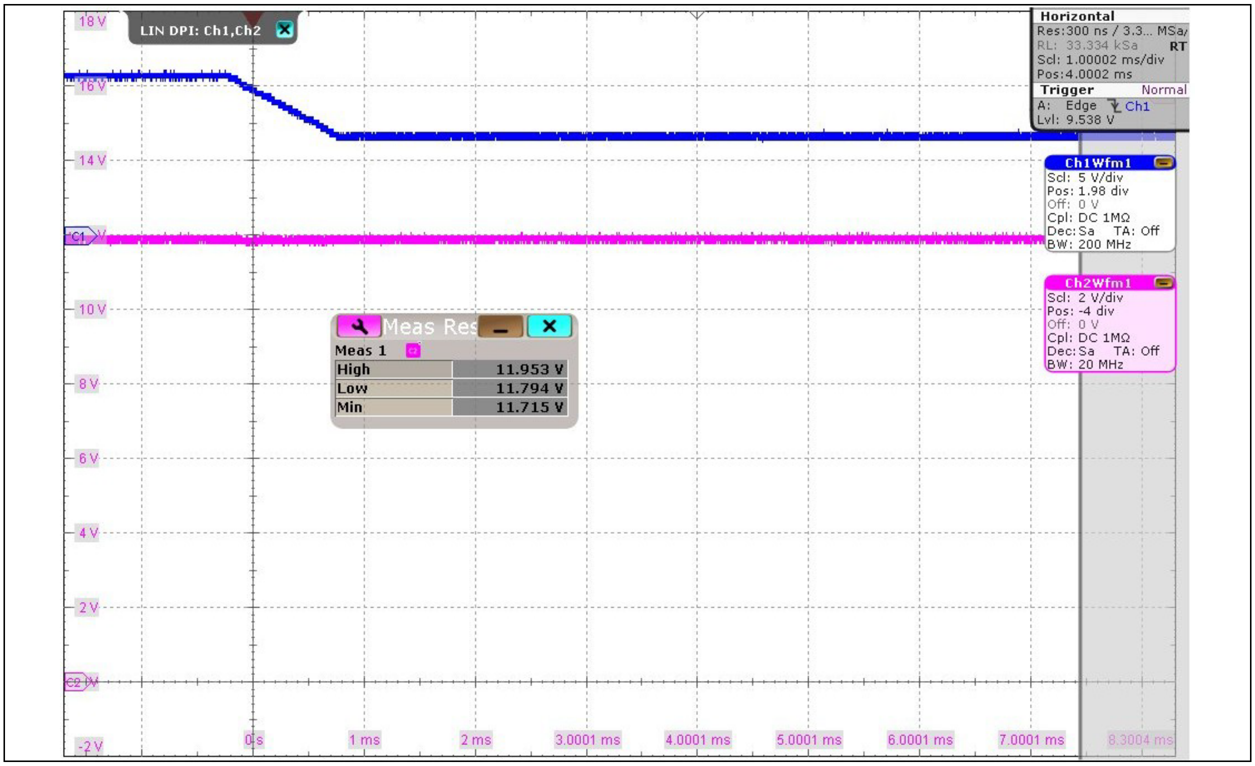

FIGURE 9: *Test Result for Warm Cranking Test (Normal Severity), Output Current 1A; CH1 = V_{IN}, CH2 = V_{OUT}.*

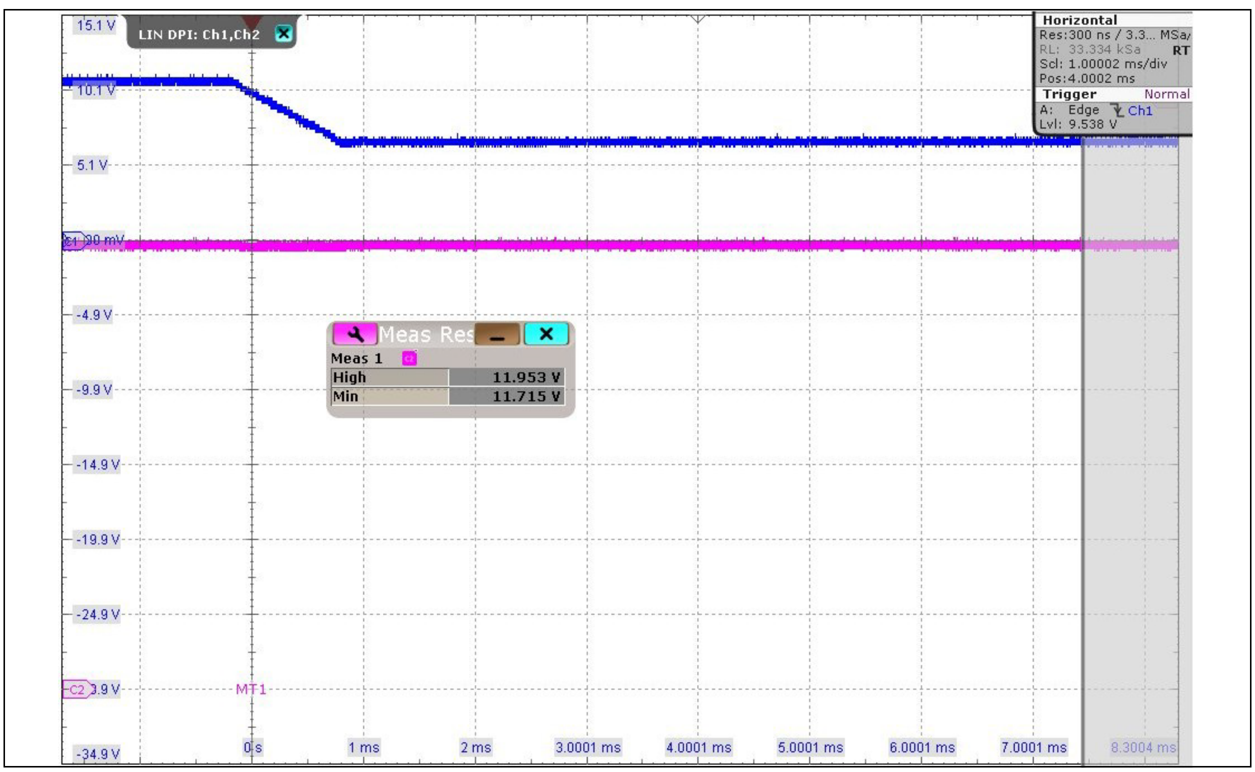

FIGURE 10: *Test Result for Warm Cranking Test (Normal Severity), Output Current 2A; CH1 = V_{IN}, CH2 = V_{OUT}.*

Based on the results presented, it is clear that the output voltage remains within 10% of the nominal voltage in case of cold cranking and almost at nominal voltage in case of warm cranking.

CONCLUSIONS

Automotive Start-Stop systems are a great resource when it comes to reducing fuel consumption and minimizing emissions. However, a significant level of caution is required when powering these devices, as the systems can reset when the car battery voltage drops during the engine crank. MCP19061 provides a solution by maintaining the output voltage within the target output level, making it ideal for use in automobiles equipped with Start-Stop systems.

REFERENCES

1. MCP19061 Data Sheet, *"Synchronous Four Switch Buck-Boost Analog Front End"*, Microchip Technology Inc., 2024, (DS20006888).
2. *"MCP19061 Four Switch Buck-Boost Evaluation Board User Guide"*, Microchip Technology Inc., 2024, (DS50003664).

TABLE 1: BILL OF MATERIALS

Qty.	Reference	Description	Manufacturer	Part Number
2	C1, C7	Capacitor, aluminum, 470 µF, 35V, Radial	Taiwan Chinsan Electronics Industrial Co., Ltd.	EK1V471MP51016EU
5	C2, C3, C4, C5, C6	Capacitor, ceramic, 10 µF, 50V, ±20%, X7R, 1210	TDK Corporation	C3225X7R1H106M250AC
1	C9	Capacitor, ceramic, 1 µF, 50V, ±10%, X7R, 0805	Murata Manufacturing Co., Ltd.	GRM21BR71H105KA12L
1	C10	Capacitor, ceramic, 0.1 µF, 25V, ±10%, X7R, 0805	Yageo Corporation	CC0805KRX7R8BB104
1	C11	Capacitor, ceramic, 1 µF, 10V, ±10%, X7R, 0603	Samsung Electro-Mechanics America, Inc.	CL10B105KP8NNNC
2	C12, C13	Capacitor, ceramic, 0.47 µF, 16V, ±10%, X7R, 0603	Murata Manufacturing Co., Ltd.	GRM188R71C474KA88D
4	C14, C15, C16, C17	Capacitor, ceramic, 4.7 µF, 10V, ±20%, X7R, 0805	TDK Corporation	C2012X7R1A475M125AC
1	C18	Capacitor, ceramic, 2.2 µF, 25V, ±10%, X7R, 0805	Wurth Electronik	885012207079
1	C19	Capacitor, ceramic, 2.2 µF, 10V, ±10%, X7R, 0603	Wurth Electronik	885012206027
2	D1, D2	Diode, Schottky, 30V, 500 mA, surface mount, SOD-123	onsemi™	MBR0530T1G
2	J1, J2	2-Position wire to board terminal block, horizontal with board 0.197", 5 mm, through hole	Phoenix Contact	PT1,5/2-5.0-H
1	J3	Connector, header, vertical, 3 POS, 2.54 mm	Samtec, Inc.	TSW-150-07-T-S
1	J6	Connector, header, through hole, 2 POS, 2.54 mm	Wurth Electronik	61300211121
1	L1	Inductor, 10 µH, 22A, 20%, 9 mΩ, SMD, AEC-Q200	Coilcraft	XAL1510-103MEB
4	Q1, Q2, Q3, Q4	Transistor, MOSFET, N-Channel, 60V, 13A (Ta), 57A (Tc), 3W (Ta), 44W (Tc), surface mount, PG-TDSON-8	Infineon Technologies AG	IRF540NPBF
2	R1, R2	Resistor, Thick Film, 0.01Ω, 1%, 2W, SMD, 2512, 900 ppm/°C, AEC-Q200	TT Electronics/Welwyn Components	LRF2512-R010FW
4	R3, R4, R9, R10	Resistor, thick film, 5.6Ω, 1%, 0.1W, 1/10W, 0603, AEC-Q200	Vishay Intertechnology, Inc.	CRCW06035R60FKEA
1	R6	Resistor, thick film, 100Ω, ±5%, 0.1W, 1/10W, SMD, 0603, AEC-Q200	Vishay Intertechnology, Inc.	CRCW0603100RJNEA
9	R7, R8, R11, R12, R13, R15, R16, R17, R18	Resistor, thick film, 4.7 kΩ, ±5%, 0.1W, 1/10W, SMD, 0603, AEC-Q200	Panasonic® - ECG	ERJ-3GEYJ472V
2	SW1, SW2	Switch, slide, SPDT, through hole	C&K Components	1101M2S3CQE2

Note 1: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

TABLE 1: BILL OF MATERIALS (CONTINUED)

1	U1	IC, linear regulator, positive fixed, 1 output, 100 mA, SOT-23A-3	Microchip Technology Inc.	MCP1792T-5002H/CB
1	U2	Buck-Boost regulator, positive output, step-up/step-down, I^2C DC-DC controller, IC, 32-VQFN (5x5)	Microchip Technology Inc.	MCP19061

Note 1: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

Microchip Information

Trademarks

The “Microchip” name and logo, the “M” logo, and other names, logos, and brands are registered and unregistered trademarks of Microchip Technology Incorporated or its affiliates and/or subsidiaries in the United States and/or other countries (“Microchip Trademarks”). Information regarding Microchip Trademarks can be found at https://www.microchip.com/en-us/about/legalinformation/microchip-trademarks.

ISBN: 979-8-3371-1325-8

Legal Notice

This publication and the information herein may be used only with Microchip products, including to design, test, and integrate Microchip products with your application. Use of this information in any other manner violates these terms. Information regarding device applications is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. Contact your local Microchip sales office for additional support or, obtain additional support at www.microchip.com/en-us/support/design-help/client-support-services.

THIS INFORMATION IS PROVIDED BY MICROCHIP "AS IS". MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF NON-INFRINGEMENT, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE, OR WARRANTIES RELATED TO ITS CONDITION, QUALITY, OR PERFORMANCE.

IN NO EVENT WILL MICROCHIP BE LIABLE FOR ANY INDIRECT, SPECIAL, PUNITIVE, INCIDENTAL, OR CONSEQUENTIAL LOSS, DAMAGE, COST, OR EXPENSE OF ANY KIND WHATSOEVER RELATED TO THE INFORMATION OR ITS USE, HOWEVER CAUSED, EVEN IF MICROCHIP HAS BEEN ADVISED OF THE POSSIBILITY OR THE DAMAGES ARE FORESEEABLE. TO THE FULLEST EXTENT ALLOWED BY LAW, MICROCHIP'S TOTAL LIABILITY ON ALL CLAIMS IN ANY WAY RELATED TO THE INFORMATION OR ITS USE WILL NOT EXCEED THE AMOUNT OF FEES, IF ANY, THAT YOU HAVE PAID DIRECTLY TO MICROCHIP FOR THE INFORMATION.

Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

Microchip Devices Code Protection Feature

Note the following details of the code protection feature on Microchip products:

- Microchip products meet the specifications contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is secure when used in the intended manner, within operating specifications, and under normal conditions.
- Microchip values and aggressively protects its intellectual property rights. Attempts to breach the code protection features of Microchip product is strictly prohibited and may violate the Digital Millennium Copyright Act.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of its code. Code protection does not mean that we are guaranteeing the product is “unbreakable”. Code protection is constantly evolving. Microchip is committed to continuously improving the code protection features of our products.