1. Introduction

Board mount DC-DC converters typically come with an output voltage adjustment feature. This provides the flexibility to change the output voltage setpoint within the specified adjustment range of the converter and allows for output voltage fine tuning to optimize the load or system performance. For converters with wide output adjustment range, it can help minimize the number of part numbers (SKU's) to manage in the BOM since one part number can be used to support other DC voltage rails in the application. This feature is usually employed by connecting an external resistor on the Trim/Adjust pin terminal. However, some applications may find it much more convenient to change the output voltage by digital means.

This application note provides a design example of how to adjust the output voltage using a digital device connected to the output trim pin.

2. Design Considerations

- This application note is applicable to the non-isolated DC-DC converters such as the i3A, i6A, i7A, or i7C series.
- The design is NOT fully characterized. This remains in the responsibility of the end user.
- Contact TDK-Lambda Technical Support for further assistance.

IMPORANT INFORMATION

- Observe proper safety and laboratory procedures when testing electronic products. This list serves as general guide only and not a substitute for common sense and best practices.
- Before applying power, double check and ensure all connections to the evaluation board interface are correct (e.g. Input source polarity connections, etc…).
- Although highly efficient, these high power density modules can dissipate significant amounts of power, especially at heavy load. Care should be taken to ensure adequate cooling is provided and the modules are operated within the thermal specifications outlined in the product data sheets.
- This evaluation kit is designed for general laboratory use. It is not intended for installation in end customer product or equipment.
- Please check the pertinent product datasheets and specifications for complete information.

3. Related Products

Product Series	Type	Output Power (W)	Description
i3A	DC-DC Buck Converter	100	Input 9-53V, Output 5-30V / 4.5A; 3.3-16.5V / 8A
i6A	DC-DC Buck Converter	250	Input 9-53V, Output 5-30V / 4.5A; 3.3-16.5V / 8A
i6AN	DC-DC Buck Converter	75	Input 9-40V, Negative Output -3.3 to -30V / 8A
i6A4W	DC-DC Buck Converter	250	Input 9-53 V, Output 5-30V / 4.5A; 3.3-16.5V / 8A
i7A	DC-DC Buck Converter	500–750	Input 18-60V or 18-32V, Output 3.3-24V / 33A or 3.3-18V / 45A
i7C	DC-DC Buck-Boost Converter	300	Input 9-53V or 9-36V, Output 9.6-48V / 8A or 8-24V / 20A

4. Typical TRIM Circuit

Figure 1 shown on the right is the typical Trim circuit inside the DCDC converter. The user places Rext between TRIM terminal and Vout(-)/GND terminal. The nominal output voltage, Vout(+), is determined by the value of Rext and can be calculated by solving some equations. The required internal values are provided in the full product specification or by contacting TDK-Lambda technical support at powersolutions@us.tdk-lambda.com.

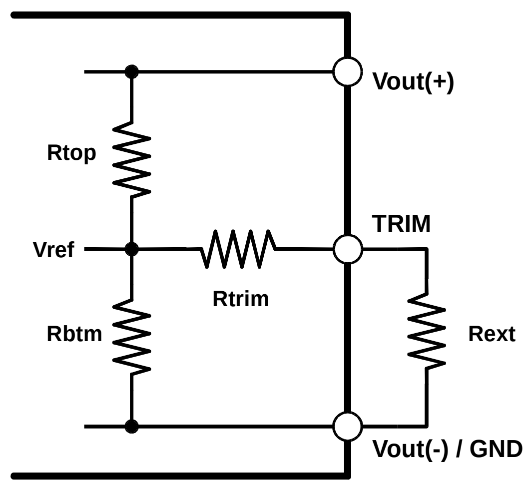
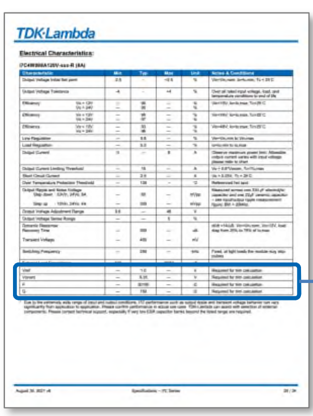


Figure 1

This is an example of Output TRIM equation for the i7C4W008A120V series that is provided in the full product specification.

$$Rext = \frac{Vref \times F}{Vout - Vonom} - G$$



Vref	---	1.0	---	V	Required for trim calculation
Vonom	---	9.35	---	V	Required for trim calculation
F	---	30100	---	Ω	Required for trim calculation
G	---	750	---	Ω	Required for trim calculation

Where:

F = Rtop
G = Rtrim
Vonom = Vout when Rext is open

Figure 2

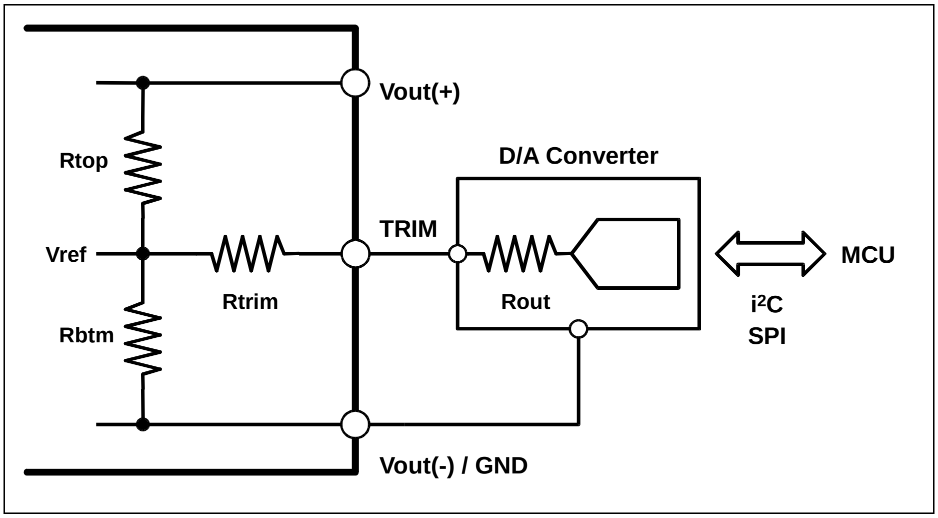
5. Use D/A Converter to Control TRIM

A D/A Converter (DAC) is a component commonly used to control an analog signal with a digital device. There are a wide range of DAC parts available in the market, not all devices are suitable to achieve accurate results. When using a DAC, the output voltage adjustment is being controlled by voltage instead of by a resistor on the TRIM pin. As such, the DAC specifications will become a key consideration in determining the performance of the power module.

DAC Selection Considerations:

- The DAC should have enough resolution. 10bit or higher is recommended.
- The DAC should have low output impedance. Rout should be much lower than Rtrim, and a buffered output is recommended.
- A DAC with nonvolatile memory may be required (store value into EEPROM) to power up in to a controlled condition.

Figure 3 - Typical Application Circuit Using D/A Converter



Step By Step Design Example:

This example shows how to control the output voltage of i7C4W008A120V using MCP4725 device (12bit DAC with buffered output)

<u>STEP1: Check DC/DC Converter datasheet to get output voltage range</u>

The full product specification provides an equation to calculate the external trim resistor "Rext".

$$Rext = \frac{Vref \times F}{Vout - Vonom} - G$$

Rearranging this equation and solving for Vout in terms of Rext.

$$Vout = \frac{Vref \times F}{Rext + G} + Vonom$$

When Rext is not connected or TRIM pin is left open, Rext → ∞, Vout → Vonom = 9.35V (per Figure 2).

In other words, if Rext is not used or left open, the first term in the above equation can be ignored and Vout becomes Vonom as shown above.

Vout goes to maximum, when TRIM pin is pulled to ground [Vout(-)/GND], providing max output adjust voltage as shown below.

Substituting Rext = 0 yields:

$$Vo,max = \frac{1.0\ x\ 30100}{0 + 750} + 9.35 = 49.48V$$

The required value constants for calculation (e.g. Vref, Vnom, F and G) vary by product and can generally be found in the full product specifications on the website similar to Figure 2.

For a linear circuit, we can establish an equation relating VDAC to VOUT using these two data points.

- Point 1: (VDAC, Vout) = (Vref, Vonom) = (1, 9.35)
- Point 2: (VDAC, Vout) = (0, Vo,max) = (0, 49.48)

By calculating the slope, we establish the equation shown:

$$Vout = \frac{(49.48 - 9.35)}{(0 - 1)} VDAC + 49.48$$

Or

$$Vout = 49.48 - 40.13 \times VDAC$$

where VDAC is in range of 0V and 1V.

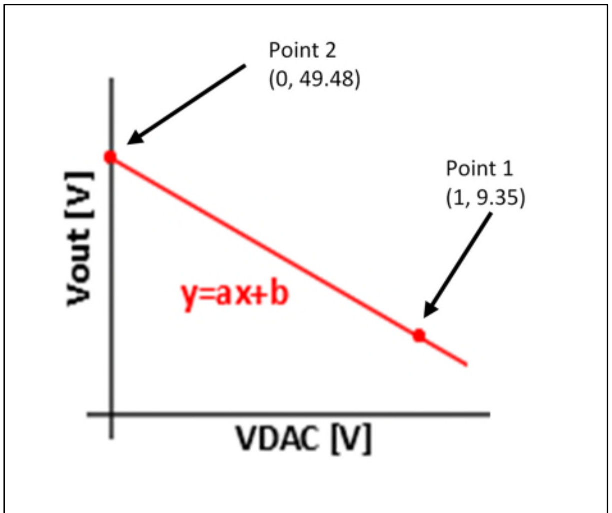
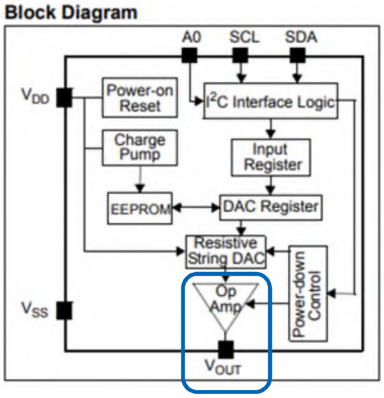


Figure 4

STEP 2: Pick Digital to Analog Converter (DAC)

The DAC voltage range was established in step1. A MCP4725 DAC was selected for this design example. The MCP4725 has twelve bit resolution, buffered output, I²C communication, and EEPROM. When choosing other DAC's, check the device's data sheet to confirm that the DAC output has low output resistance (Rout). Rout appears as a series resistor between the TRIM pin and DAC output and will influence the results if it is not negligible.

Block Diagram



Buffered output

DC Output Impedance	R_{OUT}	—	1	—	Ω	Normal mode (V_{OUT} to V_{SS})
		—	1	—	kΩ	Power-Down Mode 1 (V_{OUT} to V_{SS})
		—	100	—	kΩ	Power-Down Mode 2 (V_{OUT} to V_{SS})
		—	500	—	kΩ	Power-Down Mode 3 (V_{OUT} to V_{SS})

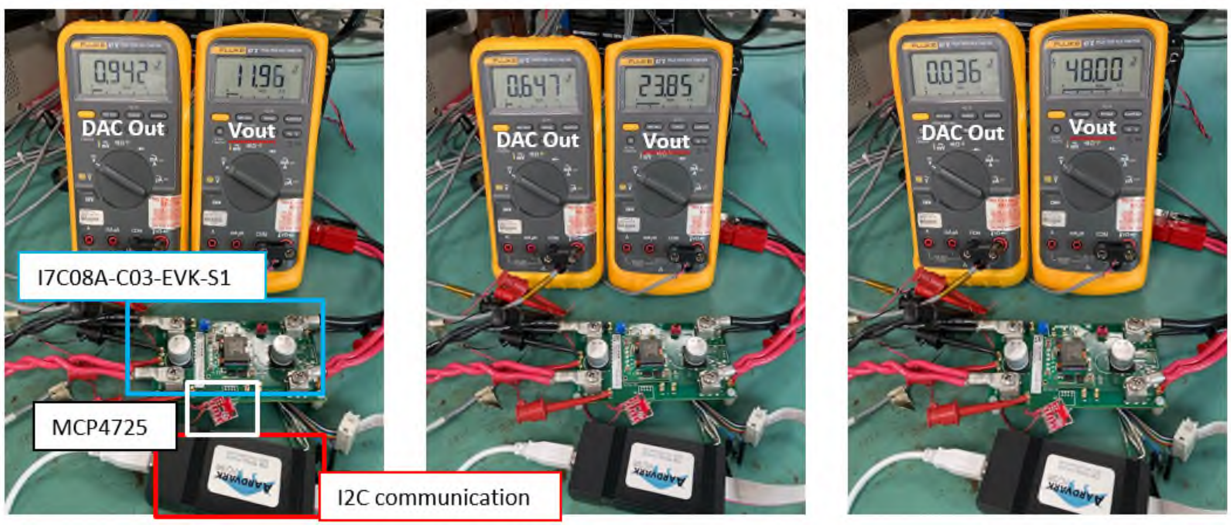
[Ref. MCP4725 datasheet ©Microchip Technology Inc.]

STEP3: PCB design consideration

The DAC output and Gnd (Vss) must be connected with short, direct traces to TRIM and ground [Vout(-)/GND] terminals of the DC-DC converter. To avoid regulation errors from voltage drops, the ground paths need to be kept separate from the power traces carrying load currents. Any noise or voltage drop at the DAC output will cause unexpected output voltage variation.

6. Experimental Results

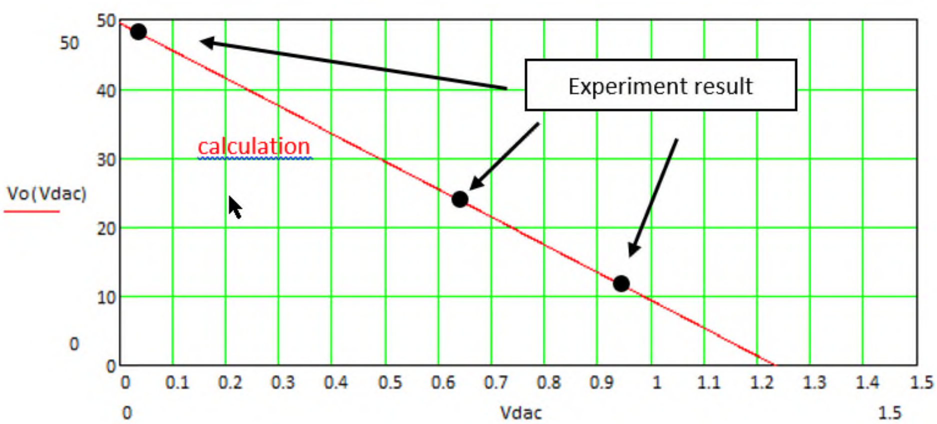
The i7C08A-C03-EVK-S1 has been used with MCP4725 to demonstrate the performance.



The output voltage equation determined previously was verified by experimental test result as shown in the photos.

$$Vout = 49.48 - 40.13 * VDAC$$

The figure below is comparison between calculation result and actual experiment result, showing good correlation between predicted and measured results.



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