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DC-DC Buck Converter Board

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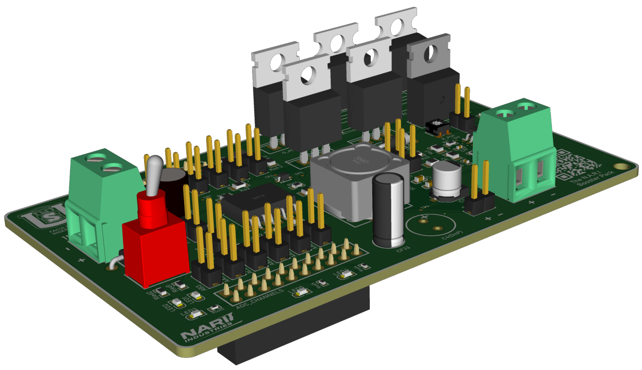
Facultad de Ingenieria

1 Overview

- Compact DC–DC buck converter board designed for educational and experimental applications in power electronics
- Includes current and voltage sensing circuits based on the MCP6004 operational amplifier.
- Equipped with reverse-polarity and overvoltage protection for all signal lines.
- Integrated LED indicators for power status, PWM activity, and system operation.
- Features test points and selection jumpers for diagnostics, calibration, and signal routing.



2 Description

- **Microcontroller Interface and Integration**
  - The board is designed to mechanically and electrically interface with the Texas Instruments LaunchPad F28379D, providing direct GPIO and ADC connectivity. It can also be used with other microcontrollers by connecting the corresponding signals through Dupont cables, enabling flexible integration into various control and monitoring systems.
- **Power Conversion and Operating Conditions**
  - The PWM signal driving the buck converter operates at 145 kHz, stepping down the voltage from 15 V to 5 V through a controlled switching process. These parameters were used as the design and calculation basis for the buck converter components.
  - The board incorporates an LM317 regulator responsible for generating a 6 V supply line required for the proper operation of the MCP6004. This voltage must be precisely adjusted to 6 V using the onboard potentiometer before placing the jumper on J3, which connects the regulator output to the operational amplifier. Correct calibration of this voltage is essential to ensure stable and accurate performance of the circuit.

- **Control Inputs and Signal Routing**
  - The board provides six selectable PWM input channels, three assigned to the high-side and three to the low-side. The user can enable one channel from each group by setting the corresponding jumper. Two additional GPIO lines are available for active load control, of which one can be selected through a jumper according to the desired configuration.
  - The board provides dedicated pin headers for control and feedback signal verification. The available pin header test points are: `PWM-IN(H/L)`, `PWM-OUT(H/L)`, and `VR-SENSE(+/-)`, enabling direct access for oscilloscope probes or Dupont cables, facilitating real-time signal monitoring and analysis. The `VR-SENSE` terminals correspond to the shunt resistor connections, the `PWM-IN(H/L)` lines receive the PWM control signals from the microcontroller, and the `PWM-OUT(H/L)` lines deliver the driver's PWM output signals.
  - The board includes a dedicated `ACTIVE-RES` pin for active load connection or system shutdown control, depending on the application.
  - Note that the driver's PWM output pins are arranged in an interleaved pattern between the High-Side and Low-Side channels. For this reason, you must not connect an output directly to its complementary output, because this will create an internal short circuit and permanently damage the driver channel.

    To ensure proper wiring, refer to the pin assignment table in the datasheet and connect only the designated phase pins in an interleaved manner, for example: (pin P0 – pin P3), avoiding any connection between pins belonging to the same switching side.
- **Signal Conditioning and Measurement**
  - Once the LM317 regulator has been calibrated to 6 V and J3's jumper is placed, the MCP6004 operational amplifier is powered and begins operating in voltage-sensing mode. In this condition, the amplifier continuously measures the system voltage and provides a proportional analog signal to the microcontroller through the ADC input.

    For current measurement, it is essential to ensure that the output voltage does not exceed 5 V to prevent damage to the sensing circuitry. To enable current sensing, jumpers SH1 and SH2 must be placed, connecting the differential input channels to the shunt resistor. The shunt has a resistance of 1 Ω, and the amplifier is configured with a voltage gain of 30. Therefore, the output voltage is related to the current through the shunt by:

    $$V_{\text{out}} = 30 \times I_{\text{shunt}}$$

    which means that 1 V at the amplifier output corresponds to approximately 30 mA of current through the shunt. The amplified signal is then filtered to reduce noise and passed through a buffer stage for impedance matching before being delivered to the microcontroller's ADC input, ensuring stable and accurate current measurement.
  - Fixed voltage dividers are included to adjust the sensed voltage levels to the microcontroller's ADC input range (0–3.3 V). The divider outputs are filtered to reduce noise and are followed by a buffer stage that provides impedance matching and signal stability.
- **Protection and Stability**
  - MOSFET gate networks implement a 10 Ω series gate resistor in parallel with a reverse-oriented Schottky diode to reduce ringing and control switching transients; the diode provides a low-impedance path that shapes the edge and mitigates oscillations. Each gate also includes a 10 kΩ pull-down resistor to discharge the gate when the device is off, ensuring reliable turn-off and preventing unintended conduction.
  - Reverse-polarity protection diodes is implemented at the board's power input stage, preventing damage in case of incorrect supply connection and ensuring safe operation under potential wiring faults.

- **Indicators and Diagnostics**

  – Equipped with LEDs (LED1 and LED2) to display the board's power and operational conditions. LED1 indicates the presence of input power, while LED2 illuminates when the switch is activated, signaling that the power is being distributed to the rest of the PCB.

  – LED3 indicates the 3.3 V power supply provided by the microcontroller, whereas LED4 and LED5 are general-purpose LEDs available for optional use in testing, debugging, or user-defined applications.

- **Optional Components and Design Flexibility**

  – The board includes several components marked as DNP (Do Not Populate), which provide flexibility for advanced testing or customization. In particular, capacitor C4 and diode D5 directly affect the buck converter's behavior. Capacitor C4 can be added in parallel with the LC filter to further reduce output voltage ripple, improving stability under high dynamic load conditions. Diode D5, a Schottky diode placed in parallel with the low-side MOSFET, allows operation in asynchronous mode when the user prefers to disable synchronous rectification, or serves as an additional safety path to prevent cross-conduction between the high-side and low-side MOSFETs.

  – Additional unpopulated filtering capacitors, such as CF33 and CF15, are also available on the PCB. These positions allow the user to solder extra decoupling or filtering capacitors to improve power supply stability, depending on specific application requirements.

- **Operating Recommendations**

  – The board includes two power load resistors in TO-220 packages, each rated for a maximum dissipation of 35 W according to the manufacturer's specifications. One of them functions as a **passive load**, which remains permanently connected to the output, while the other operates as an **active load**, controlled by the active-load MOSFET. These loads are not interchangeable or configurable, as each one serves a specific role within the circuit.

  During operation with only the passive load, heat is mainly dissipated by the passive resistor due to continuous current conduction. However, when the active load is enabled, both the active and passive resistors conduct simultaneously, resulting in increased power dissipation and significant temperature rise. To ensure safe operation and prevent thermal damage, it is strongly recommended to mount proper heatsinks on both resistors for adequate heat dissipation and long-term reliability.

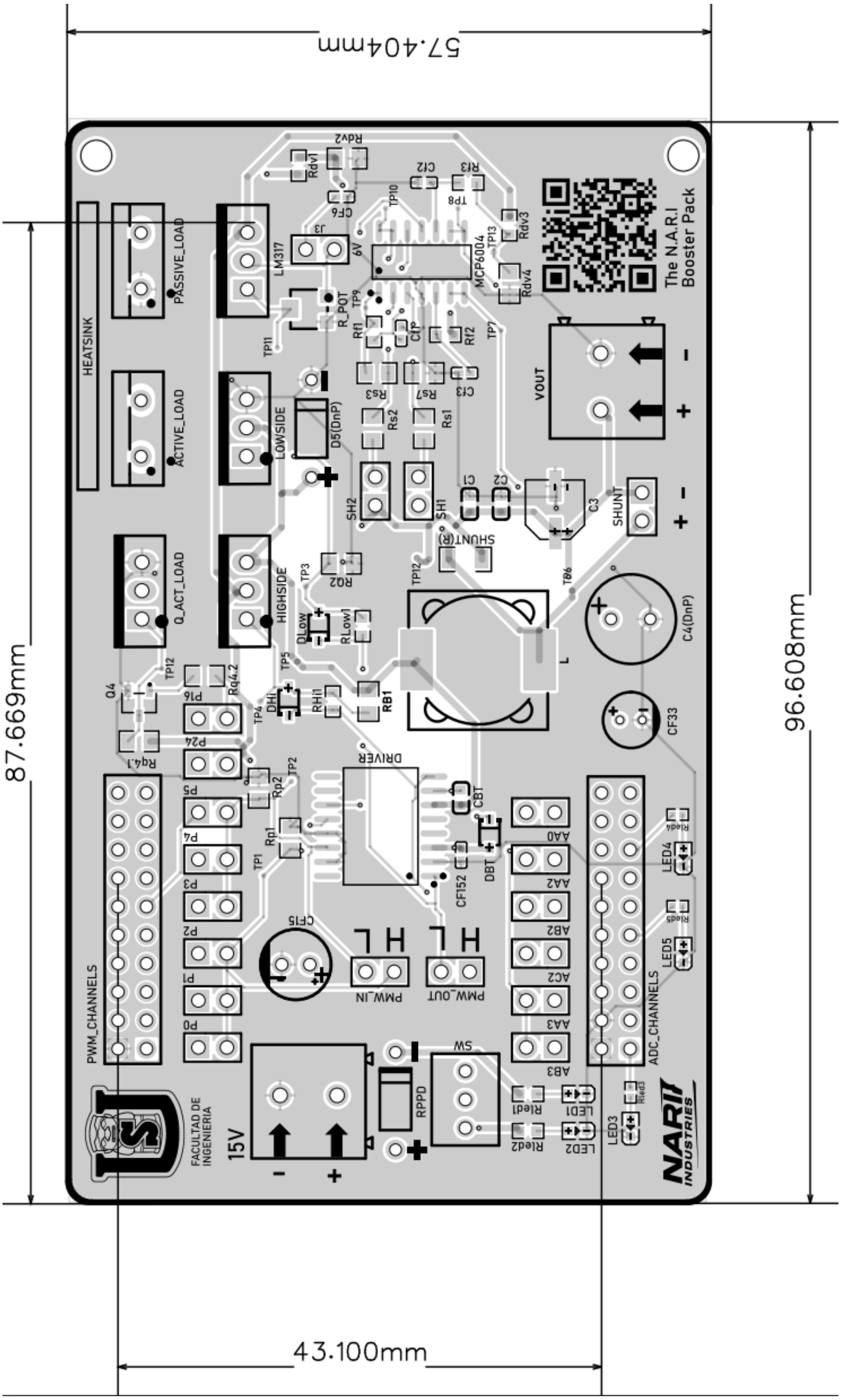
3 Technical specification

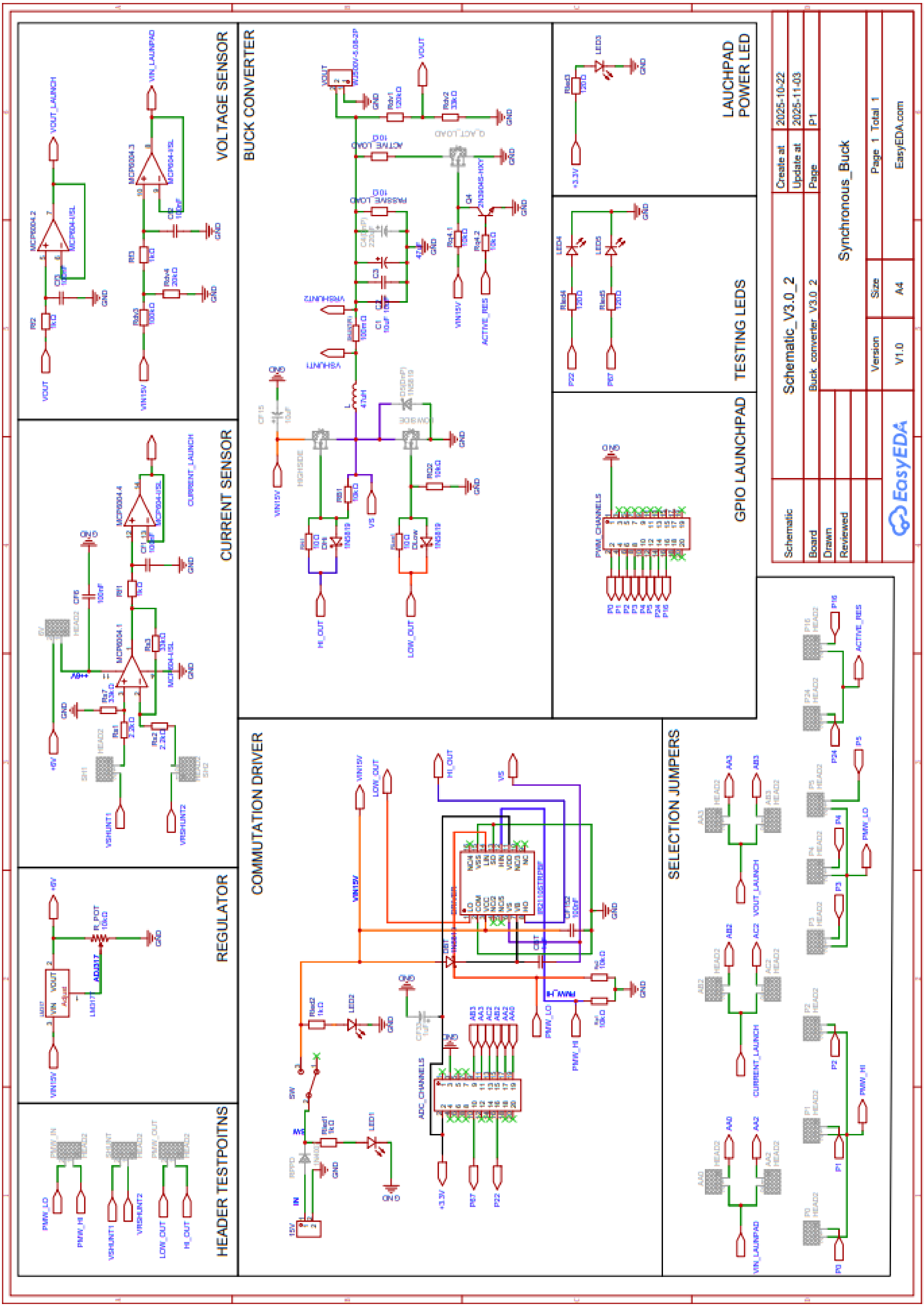
	Unit	Value
MAX Power voltage	V	15
Maximum current through SC	A	2
Dimensions	mm	96.60x57.40
Weight	g	70
Temperature range	C	-20 ÷ 60
n° PWM of inputs	−−	6
n° Vin of inputs	−−	2
Voltage range signal input	V	0 - 5

4 Pinout

Pin	Signal
P0	Input Channel PWM High
P1	Input Channel PWM Low
P2	Input Channel PWM High
P3	Input Channel PWM Low
P4	Input Channel PWM High
P5	Input Channel PWM Low
P24	Input Active Load
P16	Input Active Load
AB3	ADC Channels Voltage Output
AA3	ADC Channels Voltage Output
AC2	ADC Channels Current
AB2	ADC Channels Current
AA2	ADC Channels Voltage Input
AA0	ADC Channels Voltage Input
SH1	Activation Current Sensor
SH2	Activation Current Sensor
J3	Activation Regulator Voltage 6V
SHUNT	Resistor Shunt Voltage Measure
VOUT	Voltage Output Measure
VI	Voltage Input Measure
PWM IN	Signal Input PWM Measure
PWM OUT	Signal Output PWM Measure

5 Measures


57.404mm
87.669mm
96.608mm
43.100mm
The N.A.R.I
Booster Pack
HEATSINK
PASSIVE_LOAD
ACTIVE_LOAD
Q_ACT_LOAD
LM317
LOWSIDE
HIGHSIDE
MCP6004
VOUT
SHUNT
DRIVER
PWM_CHANNELS
ADC_CHANNELS
PWM_IN
PWM_OUT
15V
FACULTAD DE
INGENIERIA
NARI
INDUSTRIES


VOLTAGE SENSOR
BUCK CONVERTER
LAUCHPAD POWER LED
TESTING LEDS
GPIO LAUNCHPAD
CURRENT SENSOR
REGULATOR
COMMUTATION DRIVER
SELECTION JUMPERS
HEADER TESTPOITNS
Schematic_V3.0_2
Buck converter V3.0 2
Synchronous_Buck
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