C2000 PGA-Type 2

Design Use Cases

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PGA : Overview

What is PGA?

- An operational amplifier module with programmable gain
- Operation modes:
  - Type2 : Non-inverting, Buffer, Subtractor, and Standalone
- Application : Voltage and current sensing for signal conditioning, fault protection, and real-time control

What are Requirements for different applications?

Amplifiers with a precisely matched resistive gain network with the following characteristics:

- Accurate and precise measurements
- Response speed

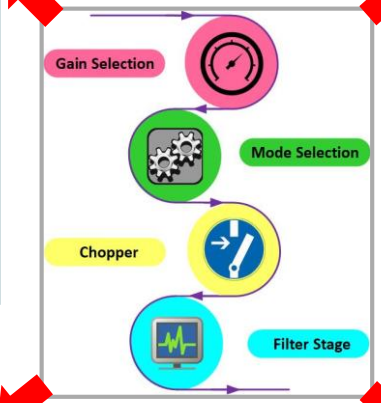
System Benefits of Using Integrated PGA

- Saving board space
- Reducing BOM costs
- Decreasing the design complexity due to compatibility with downstream ADC and comparator modules

PGA : Module Components

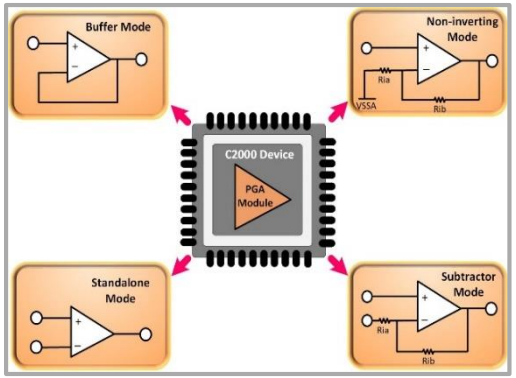
- Gain Selection
  - Non-inverting : 2X, 4X, 8X to 64X
  - Inverting: -1X, -3X, -7X to -63X

- Chopper
  - Reduces 1/f noise to a minimum
  - Ensures stability across a wide range of temperatures and throughout its lifetime



PGA Module Components

- Operation Modes



- Filter Stage
  - Low-pass filter using R_{FILT}
  - Low-pass filter using gain resistor R_{ib}

Buffer Mode for High-Impedance Source

Application

- To sense a high voltage bus
  - Using a resistor voltage divider
  - The value of resistors should be large enough to minimize the power loss

Problem

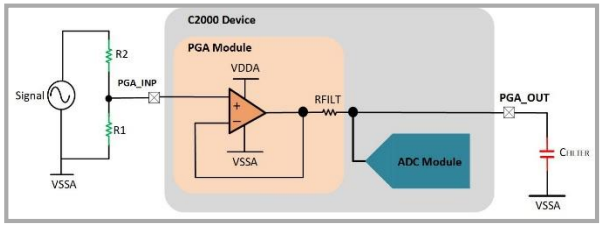
- Long time constant due to the ADC input capacitance combined with the large resistors of the voltage divider

Solutions

- Choosing a long Sample+Hold duration to achieve acceptable settling performance
  - it limits the sampling rate, which affects the performance of the control system
- A buffer (unity-gain op-amp) with low output impedance

Implementation Using Type-2 PGA

- Users can use an embedded filter resistor array and external capacitor to form a low-pass filter.



System Benefits

- Reduced BOM
- Compatibility with downstream ADC and CMPSS

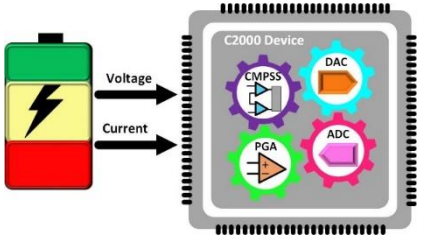
Battery Voltage and Current Monitoring

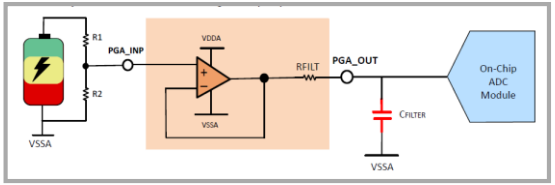
Application

- Measuring battery voltage and current is essential to determine when the battery needs to be charged or replaced.
  - Un-interruptible Power Supply (UPS)
  - Motor drive control

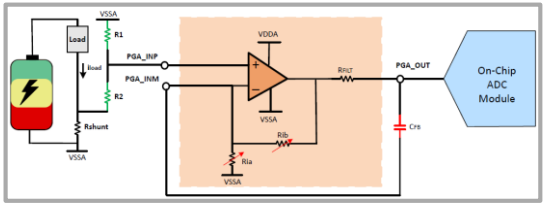
System Benefits

- Simplifies design
- Saves space
- Optimized tracking of battery status and health





Voltage measurement using PGA

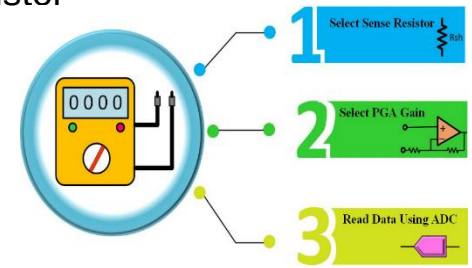


Low-side current measurement using PGA

Low-Side Current Measurement

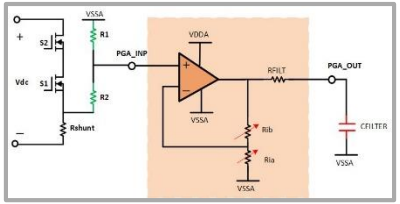
Application

- Accurately and quickly detecting load current through a low-side shunt resistor
  - over-current protection
  - faster feedback control loops
  - power supply monitoring



System Benefits

- Using less number of pins due to internal connection to VSSA
- Reduces BOM costs
- Saves space
- Reduces gain error and improves common mode rejection



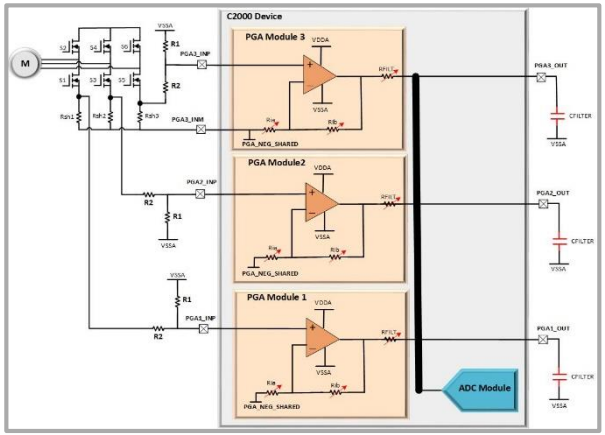
Three-Phase Low-Side Current Sensing

Application

- Precise current measurement plays an important role in motor drive applications
  - minimizes torque ripple
  - increases speed and torque accuracy
  - improves efficiency

System Benefits

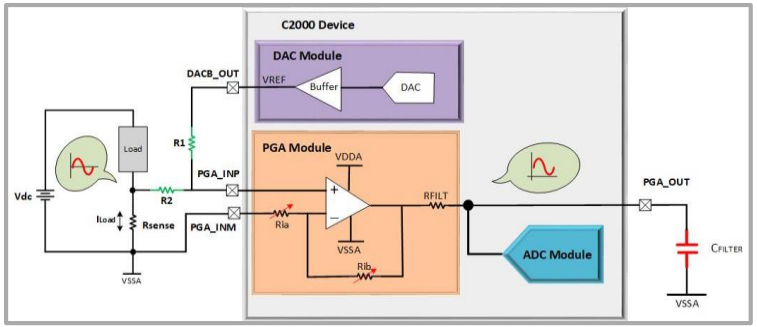
- Saves two pins for alternative functions
  - By sharing a common negative sense point across modules
- Reduces BOM costs
- Saves space



Bidirectional Current Sensing

Application

- The PGA, in combination with DAC and ADC modules, senses the current in either direction.
  - Battery packs
  - Autonomous vehicles
  - Motor control
  - Server power management



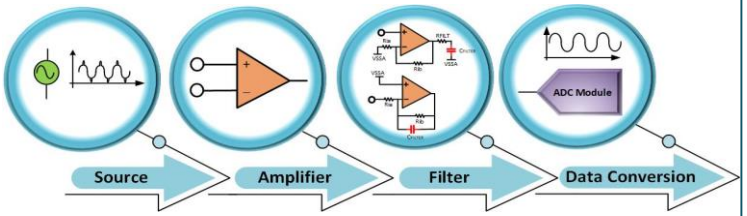
System Benefits

- Reduces BOM costs
- Compatibility with downstream ADC and DAC

Embedded Low-Pass Filter

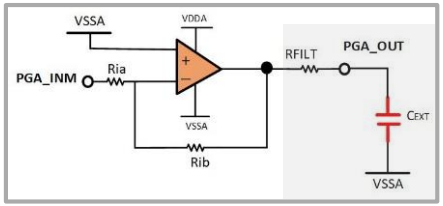
System Benefits

- Mitigates the impact of the switching artifacts to reduce the amount of output error
  - false trips and shutdowns
- Optimum settling time and stability

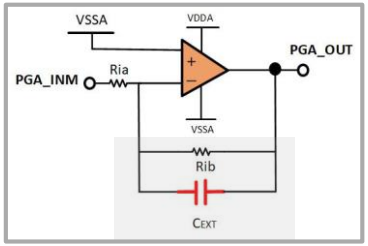


Filter Types

- RC post filter using RFILT
- Filter using gain resistor Rib
  - The feedback capacitor compensates for the zero created by the feedback network impedance and the input capacitance of the PGA and any parasitic layout capacitance



RC post filter using RFILT



Filter using gain resistor Rib

Additional Resources

- C2000 Real-Time Control MCU Peripherals reference guide
- PGA Module in C2000 Academy
- PGA Application Note
- Sensing and signal conditioning Application Reports
  - Sensor to ADC—analog interface design
  - Selecting amplifiers for shunt-based current sensing in 3-phase motor drives
  - An engineer's guide to current sensing