DTCP Weekly meeting slides

EMG Design: ADS1299 Specs and Example Applications

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Objective

- Determine whether ADS1299 is suitable for EMG recording and whether the specs are adequate in the context of a battery-powered system

Methods

- ADS1299 datasheet
- Literature Review:
    1. B. Rodríguez-Tapia, I. Soto, D. M. Martínez and N. C. Arballo, ”Myoelectric Interfaces and Related Applications: Current State of EMG Signal Processing–A Systematic Review,” in IEEE Access
- EMG system stages: Sensing -> Amplifying -> Filtering -> ADC

Results (General characteristics)

- Two power supplies:
  1. Analog: from 4.75 V to 5.25 V (will need to add a 5V boost converter)
  2. Digital: from 1.8 V to 3.6 V (we have 3.3 V power for the MCU)
- Internal clock frequency (can use external clock of up to 2.25 MHz): 2.048 MHz
- Assuming AVDD - AVSS = 5V, DVDD = 3.3V, data rate of 250 SPS and 6 channels (there are options for 4, 6, or 8 channels):
  1. Passive power (power-down mode) consumption: 10 μW
  2. Active power (normal mode) consumption: 30-33 mW

Results (SPI, PGA)

- SPI:
  1. Can setup and control the device with SPI (commands include: WAKEUP, STANDBY, START, STOP)
  2. Serial CLK: minimum period of 50 ns (maximum frequency of 20 MHz; MCU can generate 12 MHz SCLK at most)
- Programmable Gain Amplifier:
  1. Gain of up to 24x
  2. EMG signals are in range of 0 - 10 mV [1]

Results (Filtering)

- Filtering:
  1. Frequency of EMG signal is 0 - 500 Hz [1]
  2. For the EMG systems of ”muscular activation monitoring”, filters used includes band-pass of 500 Hz and low-pass filters [1]

Results (ADC)

- ADC:
    1. Resolution: 24 bits (Assuming reference of 4.5V, (4.5V / $2\hat{2}4$) = 0.268 µV)
    2. Sampling (data) rate: from 250 SPS to 16 kSPS
    3. ”21 papers reported sampling frequency values ranging from 1000 to 1500 samples per second; for the remaining 3 papers, the sampling frequency ranges from 2000 to 23434 samples per second” [1]

Observation / Conclusion

- Power Consumption
  1. Meets the constraints?
- Gain
  1. We probably want the gain to be far more than the maximum of 24x provided by the ADS chip
  2. For the application of ”muscular activation monitoring”: there are work examples of gains of 600, of 1000, of 4000, and of low noise and variable gain amplifier [1].

Results: Gain

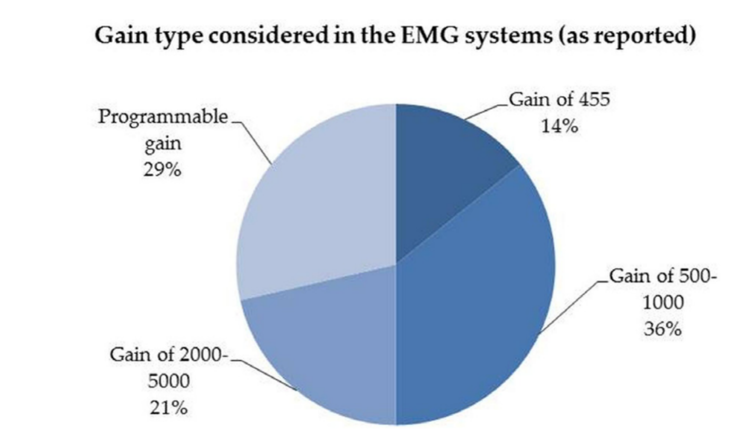

Figure 1: Distribution of the gains used in EMG systems (overall) [1]

Next Steps

Next Steps

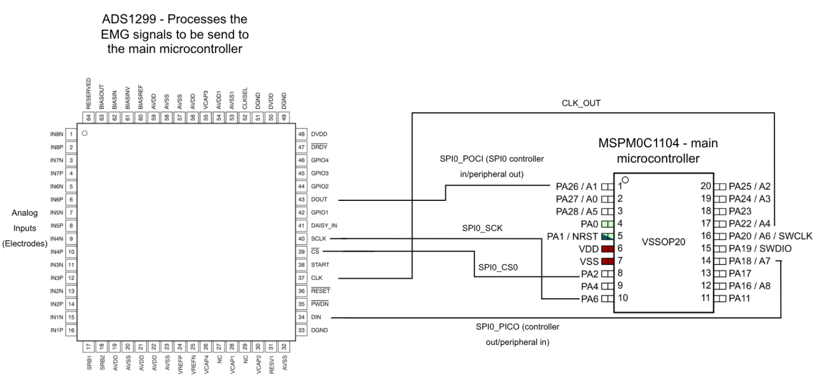

Figure 2: SPI Pins

Next Steps

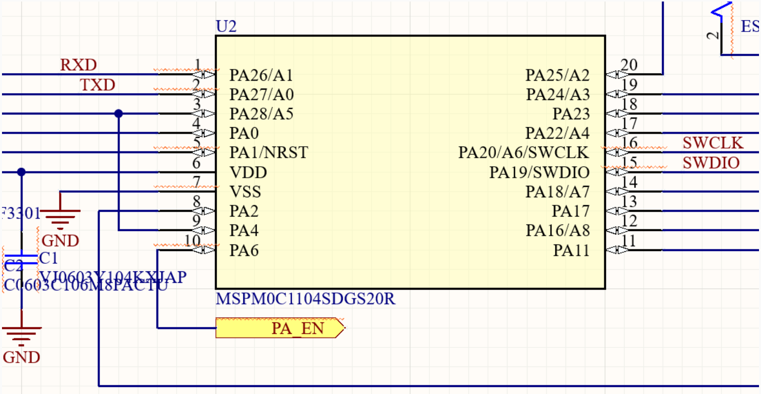

Figure 3: Most, if not all, of the current MCU pins are already in use

References

[1] Bernabe Rodríguez-Tapia et al. **“Myoelectric Interfaces and Related Applications: Current State of EMG Signal Processing–A Systematic Review”.** In: *IEEE Access* 8 (2020), pp. 7792–7805. DOI: *10.1109/ACCESS.2019.2963881*.

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EMG Recording System

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Objective

- Preliminary design of the EMG recording system using ADS1299-4
- Firmware dataflow

Methods

- Altium
- Recommendations from the ADS1299 datasheet
- Existing Works

Results: System

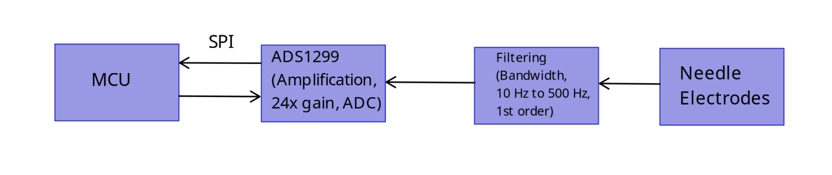

Figure 4: System Diagram

Results: Schematic

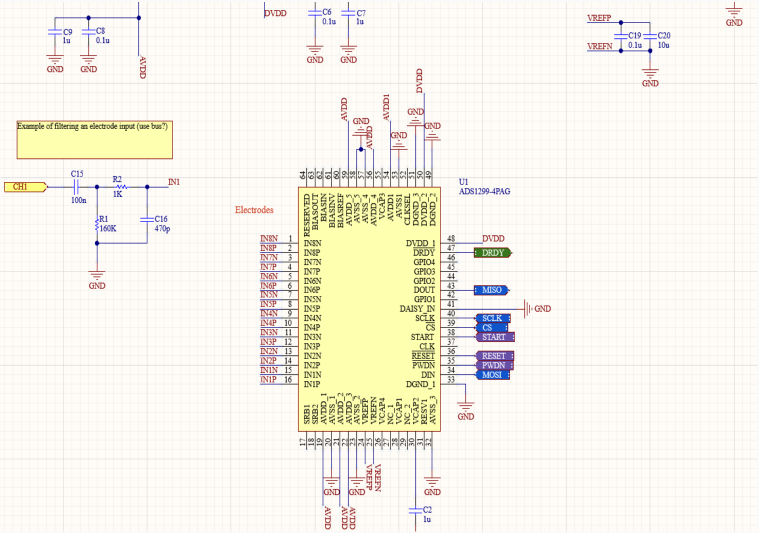

Figure 5: Altium Schematic

Results: Firmware

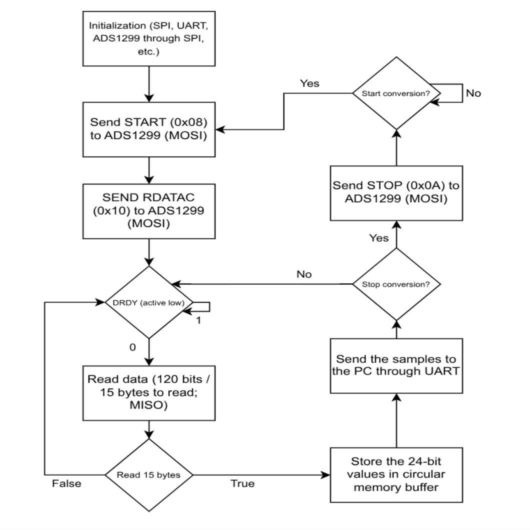

Figure 6: Flowchart between ADS1299 and the MCU

Observation / Conclusion

- Schematic Mismatch
  1. Schematic and the footprint uses 8 channels
- Electrodes and analog inputs
  1. Positive and negative terminals?
  2. Bi-polar power supplies?
  3. Full wave rectification?

Full Wave Rectification

Full wave rectification

In a first step all negative amplitudes are converted to positive amplitudes, the negative spikes are “moved up” to plus or reflected by the baseline (Fig. 37). Besides easier reading the main effect is that standard amplitude parameters like mean, peak/max value and area can be applied to the curve (raw EMG has a mean value of zero).

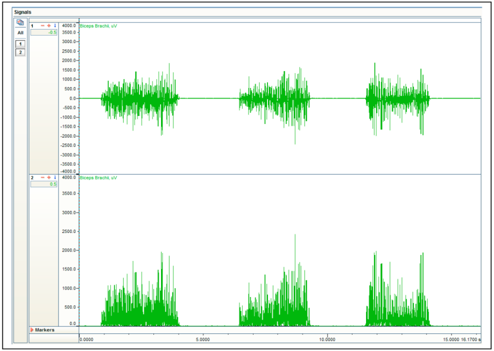

Fig. 37: EMG raw recording with ECG spikes

Figure 7: Full Wave Rectification example

Next Steps