Daisy-Chaining Embedded Processors for Enhanced Capacitive Sensor Array Resolution

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Introduction

- Capacitive sensors
  - Low power consumption
  - Can be mutually coupled to form an array (CSAs)
  - Useful in ubiquitous sensing and Industry 4.0 applications (e.g., industrial robotics, farming)[1]
- Problem: limited capacitive channels give insufficient spatial data
- Daisy-chained architecture supports higher resolution

Approach

- TI MSP430FR2676 MCU
  - 16 channels - most capacitive channels on the market [2]
- Inter-Integrated Circuit (I2C) protocol
  - Connects MCUs together to send/receive data.
  - Controller/Peripheral; ACK-based
- Analyze slack time and packet send time

Preliminary Results

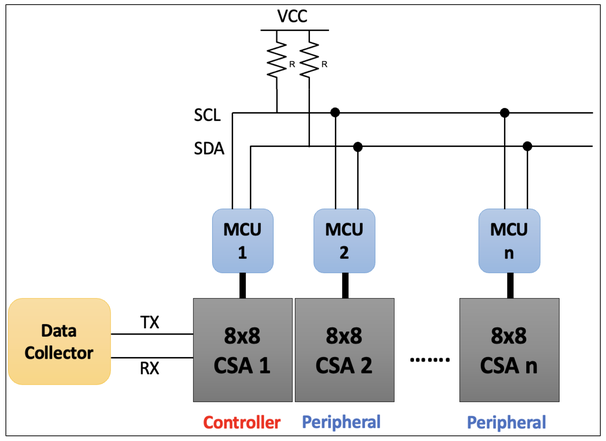

Figure 1. Daisy-chain architecture

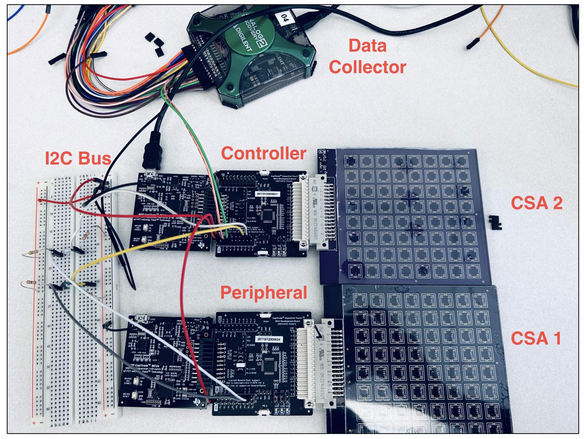

Figure 2. Rapid prototyping implementation

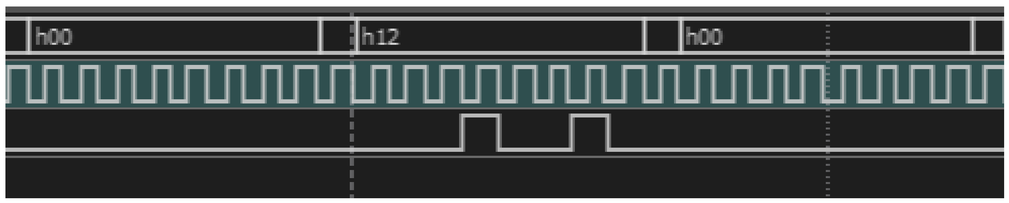

Figure 3. 3-byte snippet sent from peripheral and being accepted by controller. Send time is 627.8 microseconds.

Update Frequency (Hz)	Est. Packet Time (ms)	Est. No. of Devices (Touch)	Est. No. of Devices (Prox.)
30	33.33	52	6
60	16.67	26	3
120	8.33	13	1

Table 1. Estimated additional supported devices for each update frequency for touch (8 bytes) and proximity (64 bytes).

- Touch represents ON/OFF state of each capacitor packaged in 8 bytes.
- Proximity represents ON/OFF and proximal capacitances packaged in 64 bytes.

Conclusion

- 8 bytes can send in **627.8 microseconds**, proving that this method can have high data transfer and update frequency while also increasing CSA resolution to 128 sensors.

Future Work

- Custom Printed Circuit Board (PCB)
- Faster data processing with Field Programmable Gate Arrays (FPGAs)
- Flexible and portable CSA material integration (e.g., Indium Tin Oxide (ITO))

Acknowledgements

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References

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[2] H. Liu, J. P. Parkerson, and A. Nelson, "Connected capacitive sensor array for upper-extremity motor rehabilitation," in Proceedings of the 2018 IEEE/ACM International Conference on Connected Health: Applications, Systems and Engineering Technologies. ACM, pp. 17–18

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