University of Colorado Boulder

OPTICAL COMMUNICATION BETWEEN MSP432 AND AT89C51 BOARD

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ECEN 5613 EMBEDDED SYSTEM DESIGN

FINAL PROJECT

SPRING 2018

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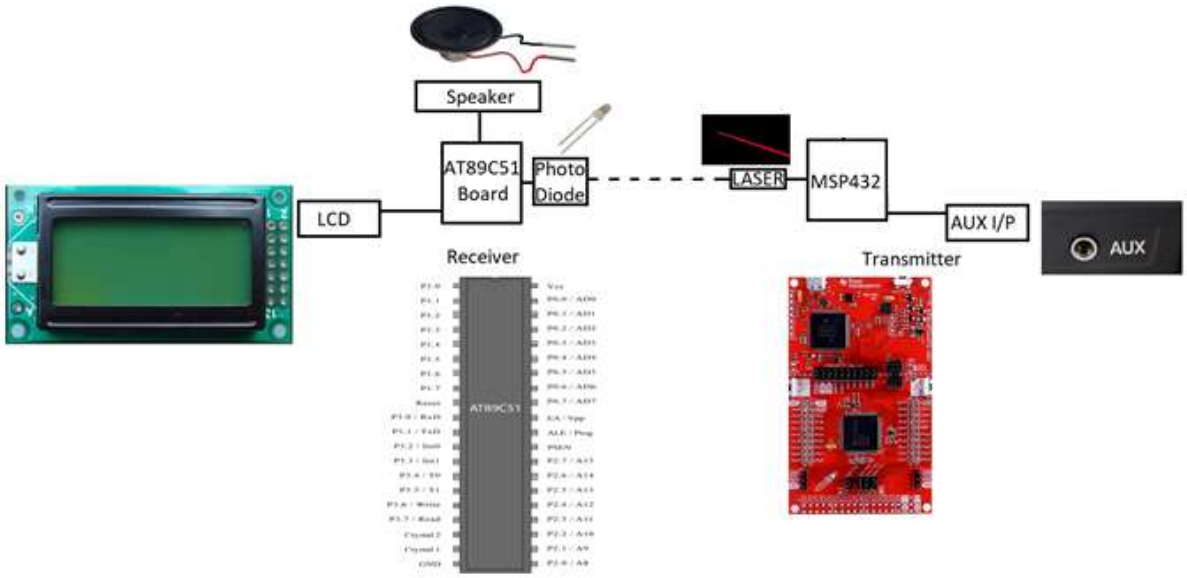
Introduction

Optical Communication between TI MSP432p401r (Transmitter) and AT89C51 Board (Receiver). Laser and Photodiode used for the optical link.



Technical Description

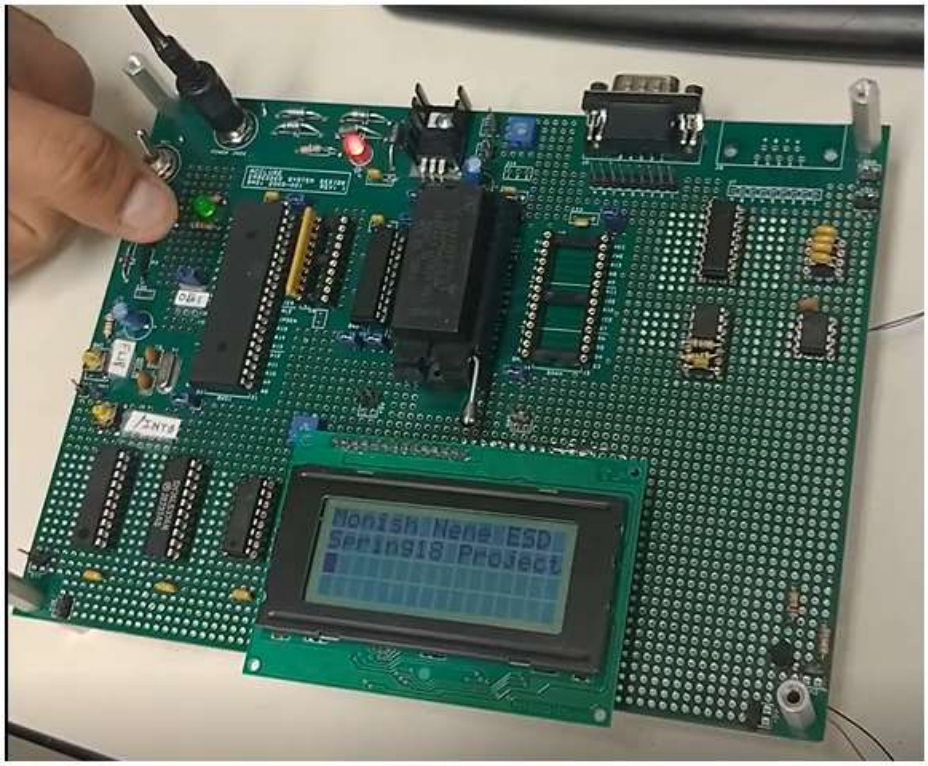
Working:

- Inbuilt ADC of MSP432 converts signal from AUX cord into digital equivalent.
- The Digital data is sent over LASER to a photodiode.
- The Analog signal at the photodiode is converted into a digital signal.
- The Digital signal is bit banged by the AT89C51 and converted to data byte.
- The data byte is sent to DAC with SPI interface.
- The Signal from DAC is sent to the speaker.

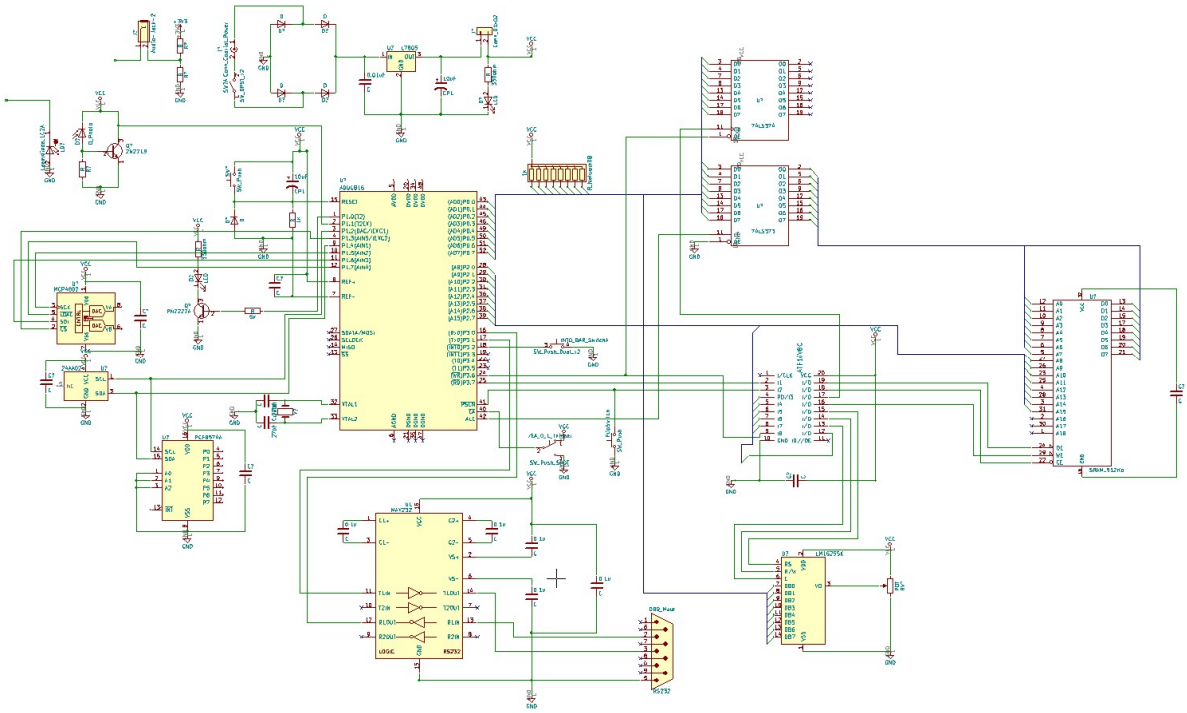
Problems addressed:

- Wireless communication.
- Synchronizing 2 devices with different clocks and different clock frequencies.
- Custom communication Protocol.
- Converting Analog photodiode signal to digital signal.
- Analog to digital conversion for AUX input.
- Digital to Analog conversion for the speaker.
- Optimizing code to reduce execution time.

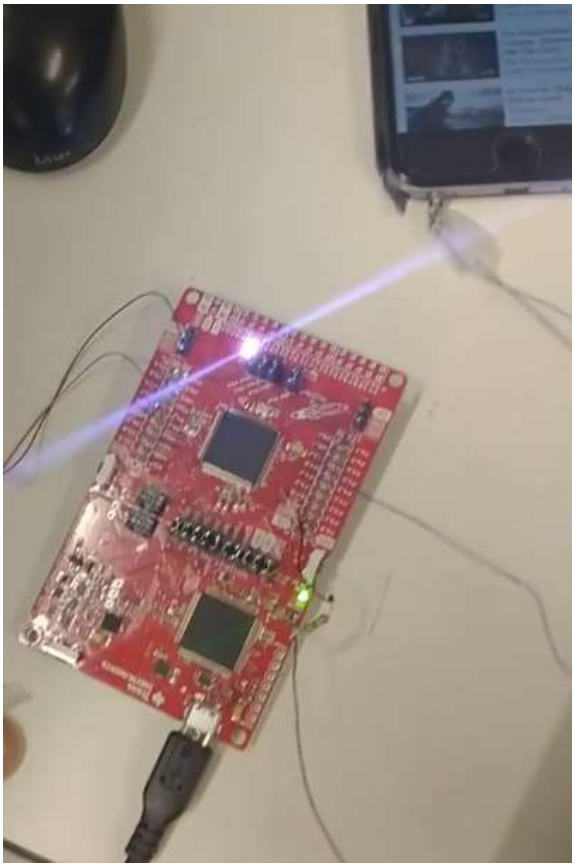
Board Design

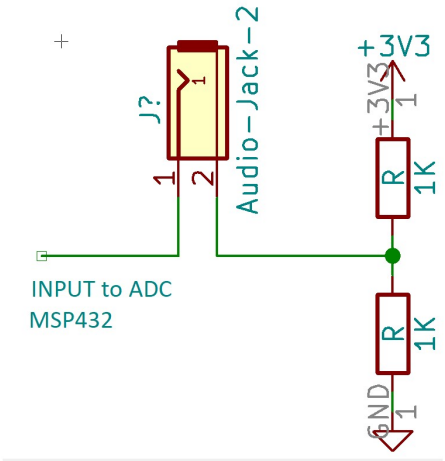


Schematic



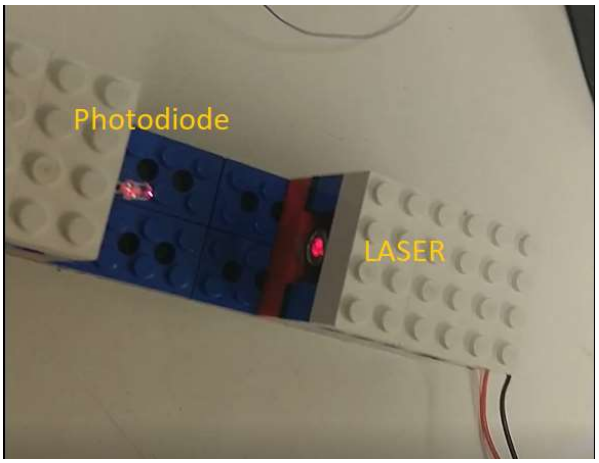
AUX input to MSP432 ADC

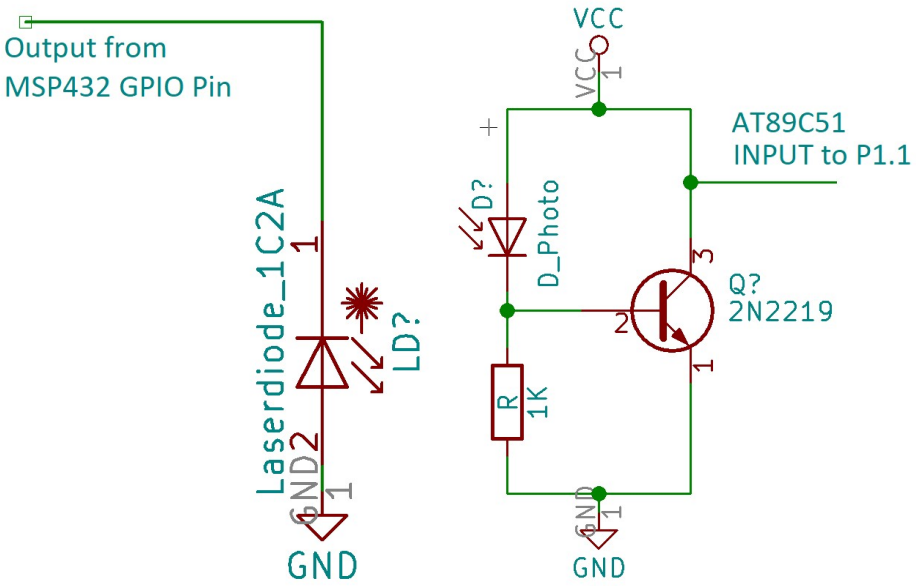




- Audio Jack is connected to AUX port on a cellphone or Laptop.
- The ADC reads a sample every 8uS.
- The 16 bit ADC Value is converted to a 8 bit value with a changed linear scale.
- This 8 bit value is further transmitted on the laser.

LASER and Photodiode





- The 8 bit data is transmitted by the MSP432 by a push pull gpio pin connected to the LASER.
- The Photodiode detects the LASER.
- When there is no light falling on the photodiode, the base of the NPN BJT is at low voltage and thus the BJT is off. The voltage at P1.1 is equal to VCC.
- When Light falls on the photodiode, it works as a diode and the base of NPN BJT goes to high voltage. The BJT is turned on. The Voltage at P1.1 becomes equal to GND as the BJT conducts.
- Thus, when the input to LASER is high we get a low voltage at P1.1 and vice versa.

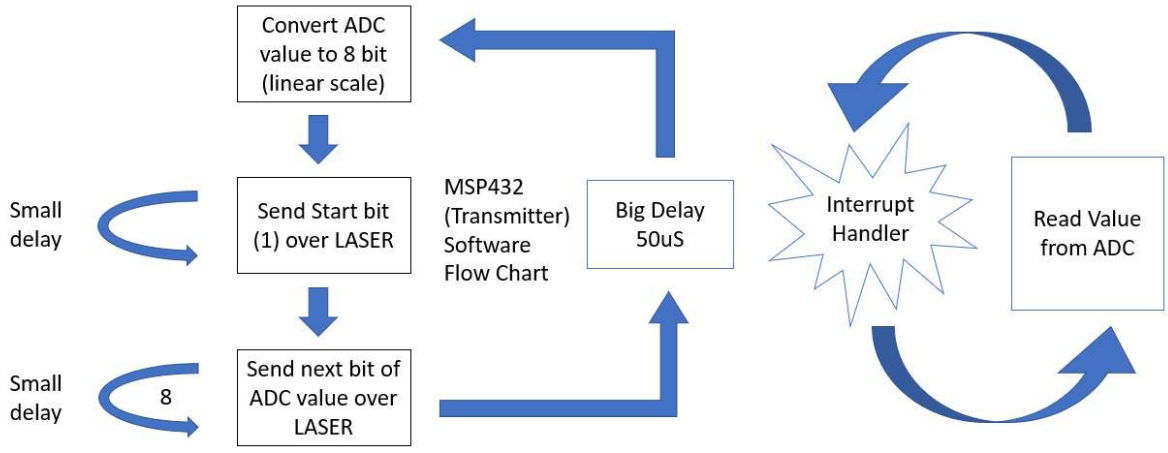
Data transmission

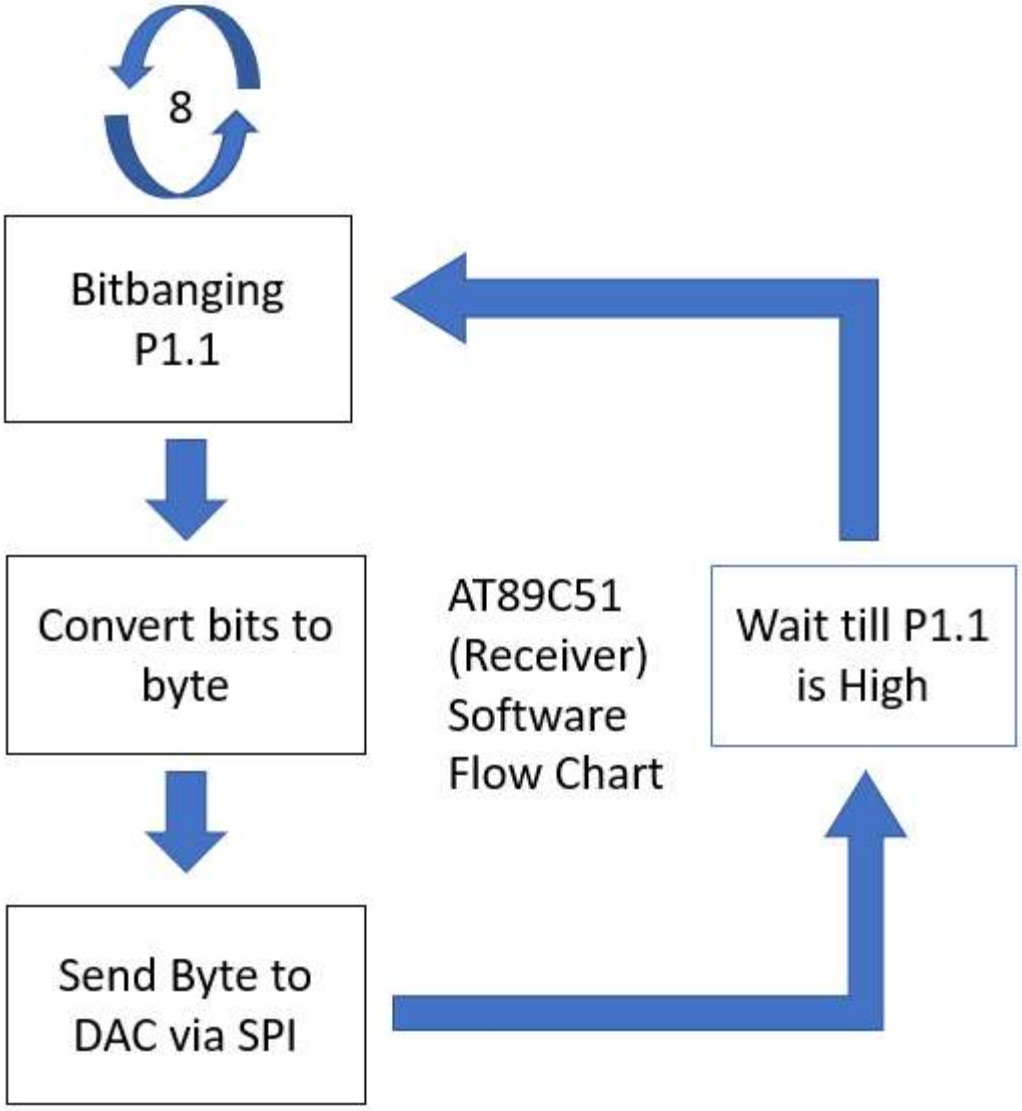
- 1 start bit (high) followed by 8bit data.
- Every sample (one byte) sent after a 50 us delay. (20kHz)
- 9 x 20khz = 180k bits per second transmitted over optical medium.
- 160kbps music bitrate. (Recommended 96 to 320 kbps).
- Transmission rate limited by processing speed of AT89C51. It takes 50us to update the DAC with SPI interface.
- If the delay is less than that synchronization is lost and noise increases.

Bit Banging

- The AT89C51 Checks for a low signal at P1.1 i.e. the Start bit.
- When it receives the start bit it checks the value at P1.1 8 times as fast as it can and saves in a variable as a byte.
- The delay is adjusted on MSP432 such that the byte is read properly while bit banging.
- The byte is sent to DAC (MCP4802) with SPI protocol

Software Flowchart





Testing Process

- Connect the audio jack at the MSP432 (transmitter) to AUX port of a Phone, Laptop or MP3 Player.
- Connect the audio jack at the AT89C51 (receiver) to AUX port of a speaker.
- Play Music on the Device connected at transmitter end.
- You can listen to the music coming from the speaker.
- You can obstruct the data transmission by putting some opaque object between the LASER and Photodiode and observe that the music stops.

Results and Error Analysis

- No error check or feedback for data lost during transmission.
- The audio jack absorbs a lot of external noise due to bad quality hardware.

Conclusion

- It is possible to transmit audio signals via optical medium.
- Songs can be sent at bitrate that qualify the standards.
- External noise difficult to remove once introduced as the music transmitted may contain harmonics of any frequency so analog and digital filtering will cause loss of data and unpleasant music.

Future Development Ideas

- Use better quality hardware.
- Run the LCD screen with another micro-controller and display changing wave patterns with custom characters animation.

References

- MSP432 coding examples for inbuilt ADC, GPIO pins control and IRQ handler.
- DAC MCP4802 and AT89C51 Datasheet.

Bill of Materials

Part Description	Source	Cost
Photodiode	Digi-Key www.digikey.com	$1
LASER	Digi-Key www.digikey.com	$5
BJT	ECEN Electronics shop	$1
Audio Jack	Reused from scrap	$0
Resistors	ITLL	$0
TOTAL		$7

Video Link of Project

https://www.linkedin.com/feed/update/urn:li:activity:6396109419922411520