LUGGAGE LINK

Group 15

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Project Overview

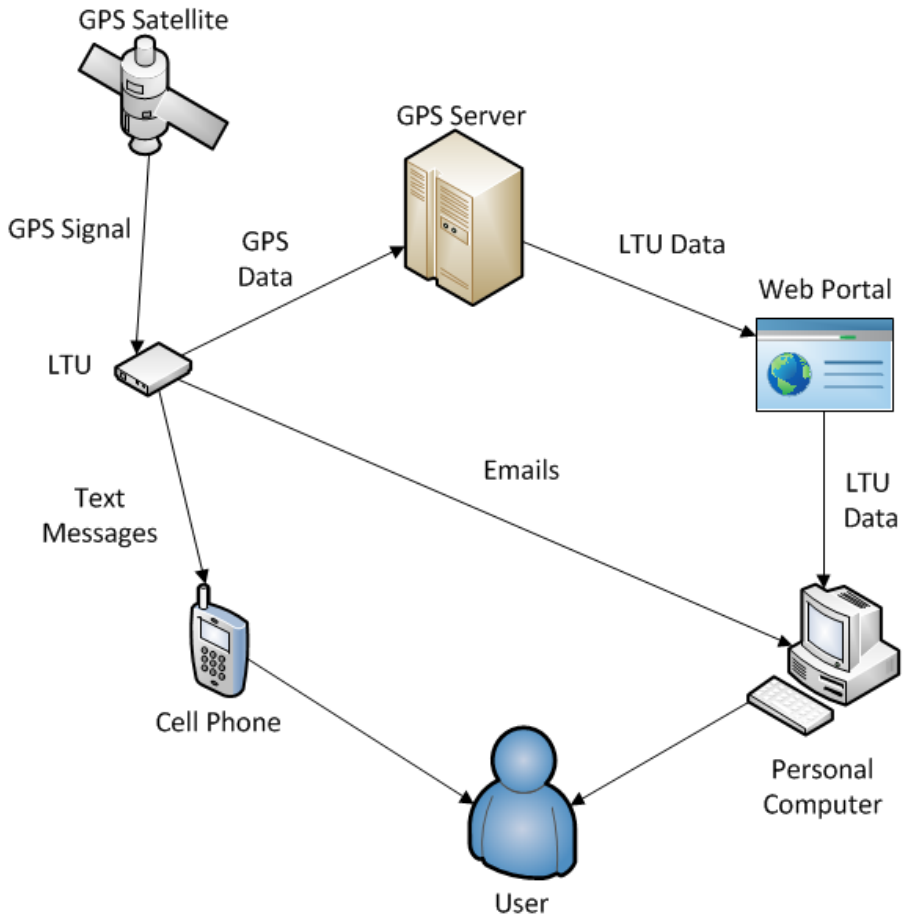
- Luggage Tracking Unit
  - GPS
  - GSM
  - Microcontroller
- Light sensor
- Pressure sensor
- GPS Server

Motivation

- Provide a reliable way to track luggage anywhere in the world
- Decrease reliance upon airlines to handle luggage
- Less stress and fewer headaches!

System Concept Diagram

- User receives data from 3 sources
  - Text Message
  - Email
  - Web Portal



Development Strategy

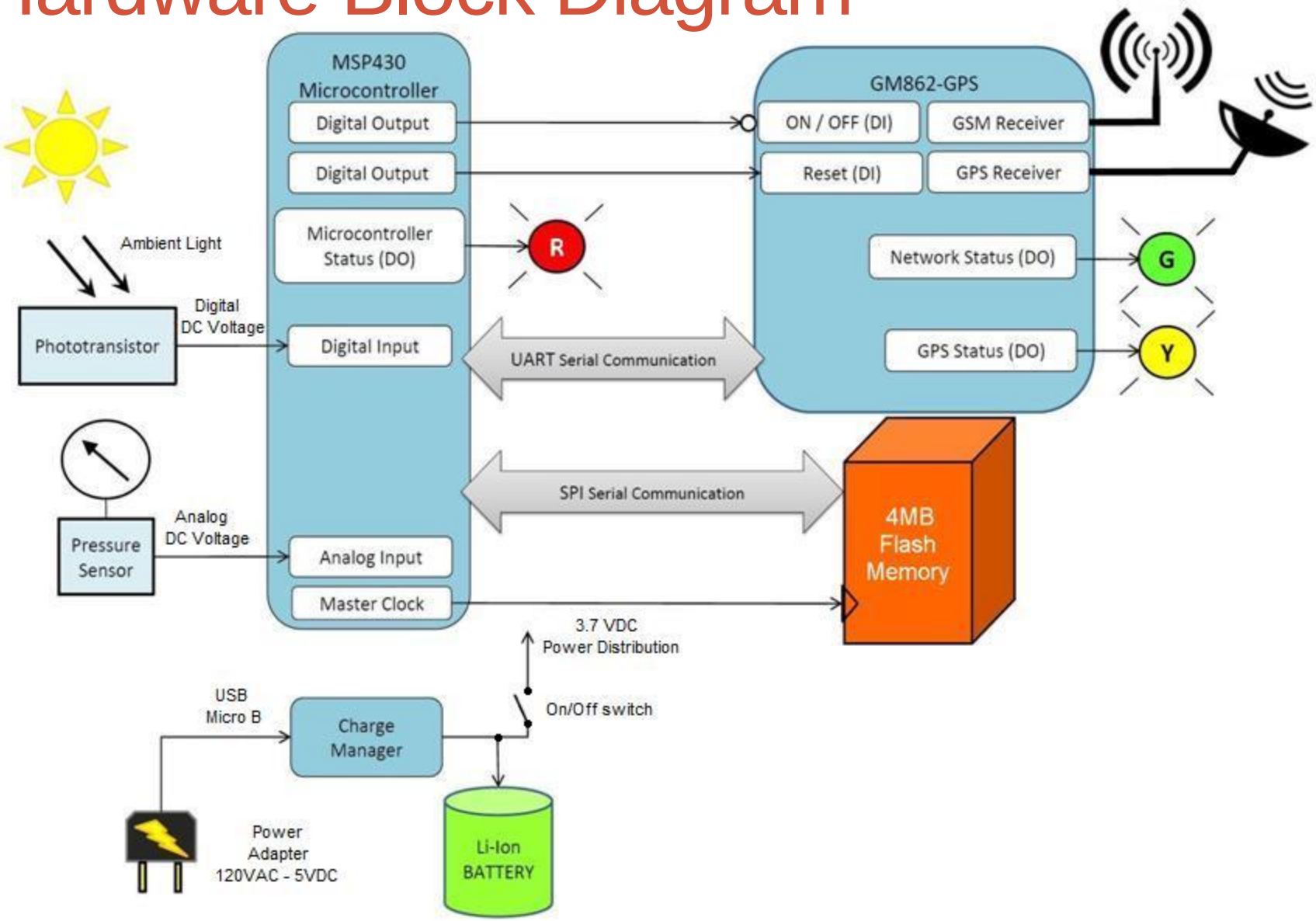
- Phased development to mitigate risk
- Ensures a working product that will be ready well in advance of the final demonstration

Phase	Capabilities and Features
A	Ability to receive GPS signal and send GPS coordinates via SMS text message and email
B	All capabilities of Phase A plus a GPS server interface which receives data from one or more tracking units

Demonstrations

- Pressure Sensor
- Light Sensor
- User interface
- GPS Fix (outside)

Hardware Block Diagram



Microcontroller

- Functions as the brain of the system
- “Hobbyist” microcontrollers not allowed

MSP430G2553

Texas Instruments

•Supply voltage 1.8 V to 3.6 V

•16 I/O pins

•Universal Serial Communication Interface (USCI)

•UART with Auto Baud rate Detection

•Synchronous SPI

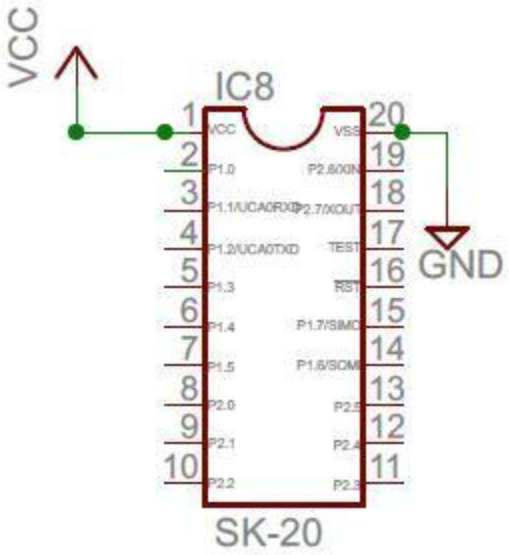
•Supports Analog-to-Digital Conversion (ADC10)

•16 KB Flash

•512 B Ram

Microcontroller

Pros	Cons
Low cost	Code written in C
Widely used	Steep learning curve
Low power consumption	Code and RAM size limitations
Online tech support forums and sample code readily available	Must deal with low level controls (i.e. interrupts)



GSM / GPRS

- Provides uplink to the server, SMS and GPS receiver

GM862-GPS

•Supply voltage 3.2 V to 4.5 V

•13 I/O pins

•Serial link through UART (RS-232)

•Quad-band GSM/GPRS modem

• -107 dBm @ 850/900 MHz

•SMS cell broadcast

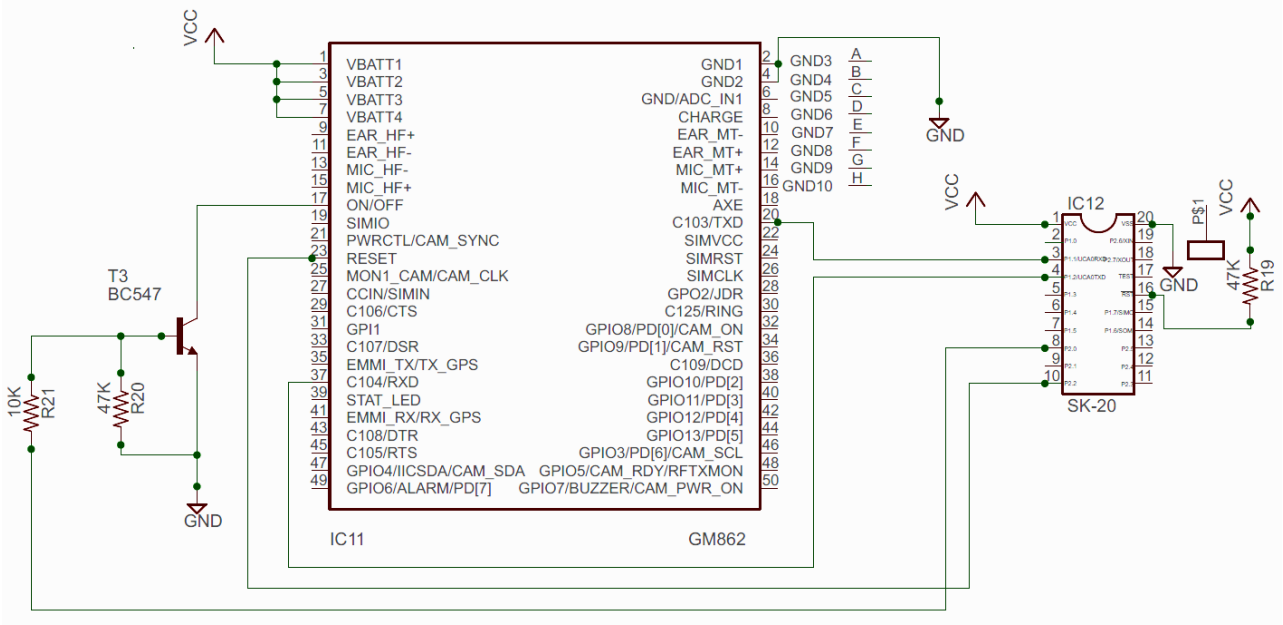
•GPS receiver up to 20-channels

•Accuracy: 2.5 m position resolution

•High sensitivity for indoor reception, up to -159 dBm with active antenna

Telit

GSM / GPRS



Pros	Cons
Relative small foot print to features ratio	High cost
Integrated GSM and GPS antenna connectors	Online tech support not readily available
Integrated SIM card holder	
Low power consumption	

GSM and GPS Antenna

- Antennas for Cellular and GPS reception

FXP07.09.0100A

Taoglas

- Flexible GSM antenna
- Efficiency: 83% GSM

GPS3620

EAD

- Compact internal GPS patch
- LNA gain 20dB
- Active antenna
- 2.5 V to 5 V

Memory

- Functions as temporary storage until network connection is available

AT45DB041D

Atmel

•Supply voltage 2.5V to 3.6V

• 4-megabit data flash

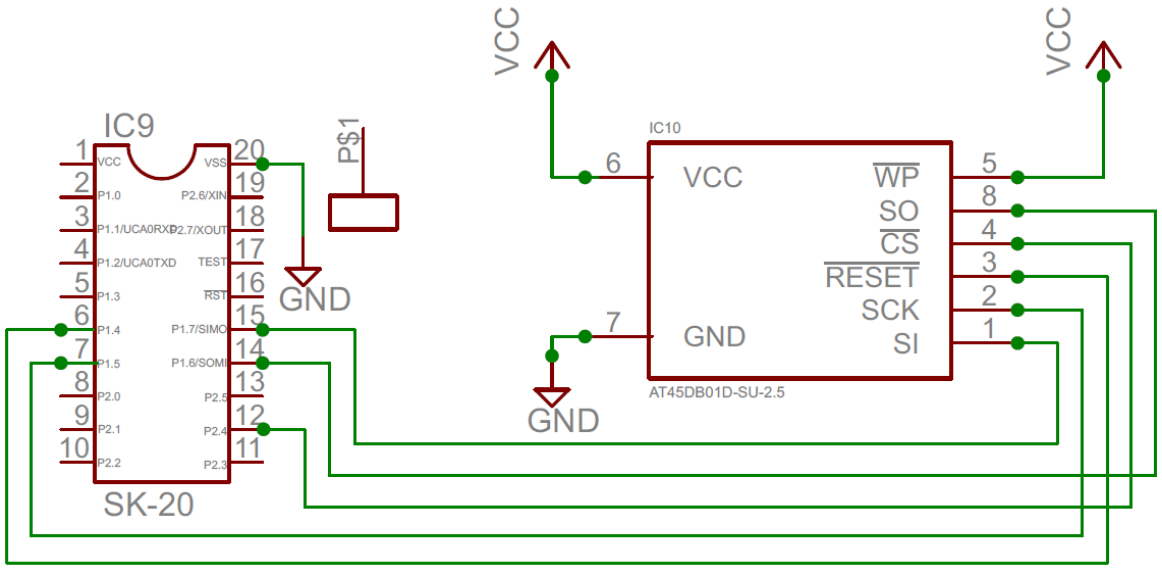
• RapidS Serial Interface SPI Compatible up to 66 MHz

•Two SRAM Data Buffers (256/264 Bytes)

• Low-power dissipation

• Hardware and software data protection features

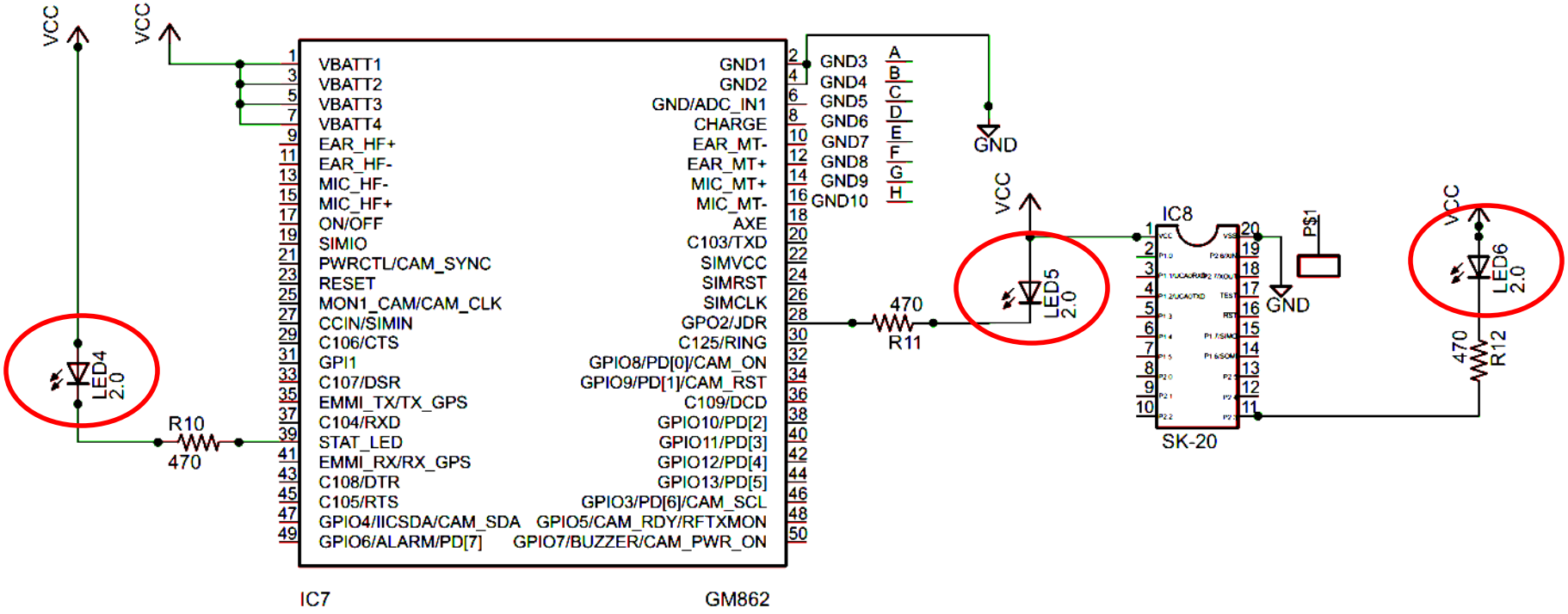
Memory



Pros	Cons
Low cost	Difficult to solder to PCB.
Widely used	Pin width: 0.51 mm Pin separation: 1.27 mm
Low power consumption	Steep learning curve

LEDs

Network Status = Green LED
GPS Status = Yellow LED
Microcontroller Status = Red LED



Pressure Sensor

- Functions as an altimeter for Air Plane mode
- Barometric sensor

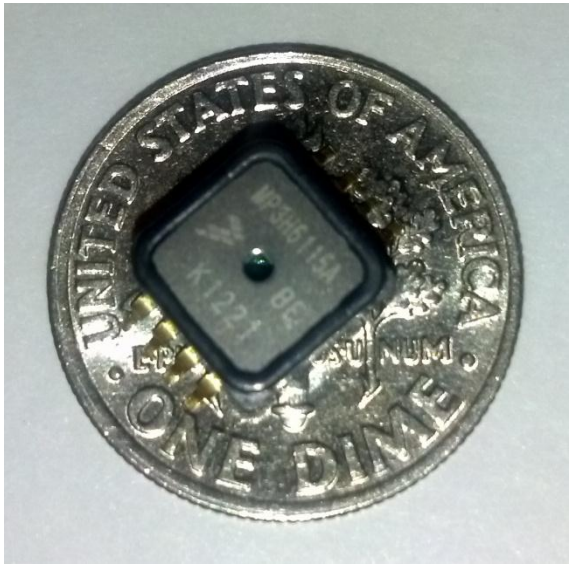
MP3H6115A

- Supply voltage 2.7 V to 3.3 V
- Measures absolute pressure
  150 to 115kPA (2.2 to 16.7 psi)

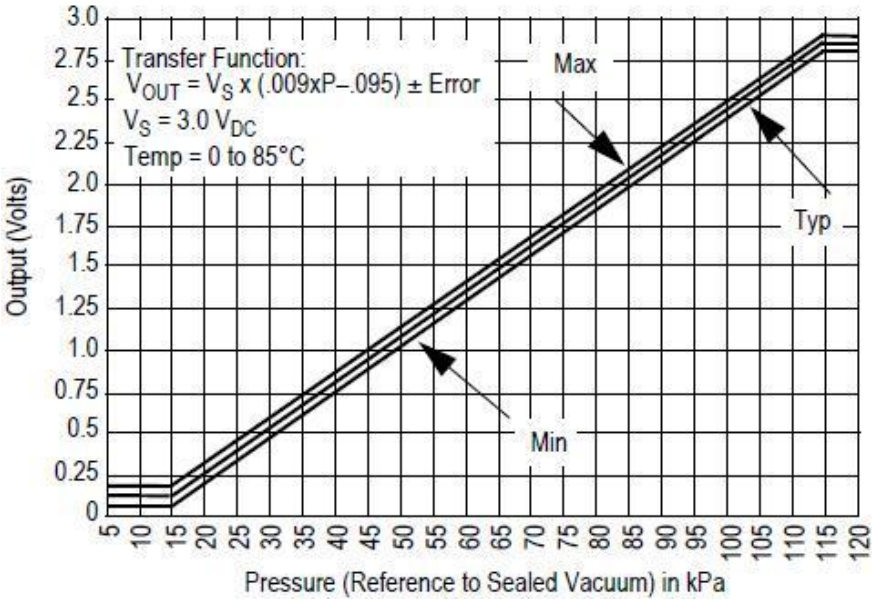
$V_{out} = V_{cc} \times (0.009 \times P - 0.095)$

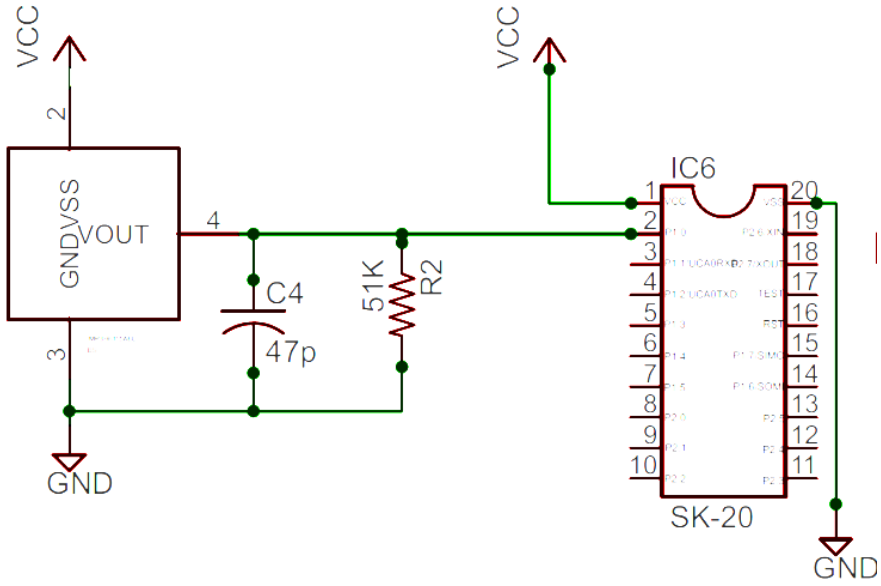
- Temperature compensated
- Fast response time 1.0 ms
- Accuracy 1.5% V_{FSS}

Freescale Semiconductors



Pressure Sensor





Pros	Cons
Low cost	Relatively large footprint
Temperature compensated	Always on, constant use of power
High accuracy, fast response < 1.0 ms	

Pressure Sensor Demo

Phototransistor

- Functions as detection of luggage being opened
- High sensitivity to ambient light

BPW85A

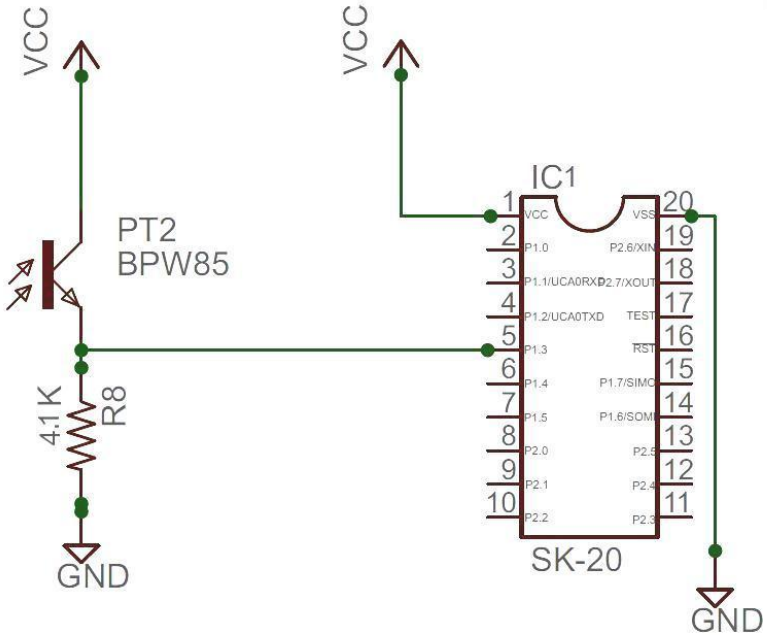
VISHAY

- Wavelength = 450 to 1080 nm
- Collector light current (min) = 0.55 mA
- Digital input threshold (High) = 2.2 V_{DC}
- Gain Equation:

$R_8 > 2.2 / 0.55 = 4\ K\Omega$

- Collector dark current = 0.20 mA

$Vin = 4.1\ K\Omega \times 0.20\ mA = 0.82\ V_{DC}$



Light Sensor Demo

Battery

- Rechargeable Li-Ion battery provides power to the LTU

UBP002

- Voltage range 3.0 V to 4.2 V, 3.7 V average
- Capacity 900 mAh
- Rated for 2.1 A Hold Current
- Energy 3.4 Wh
- Cycle Life > 500 cycles
- No memory effect

Ultralife

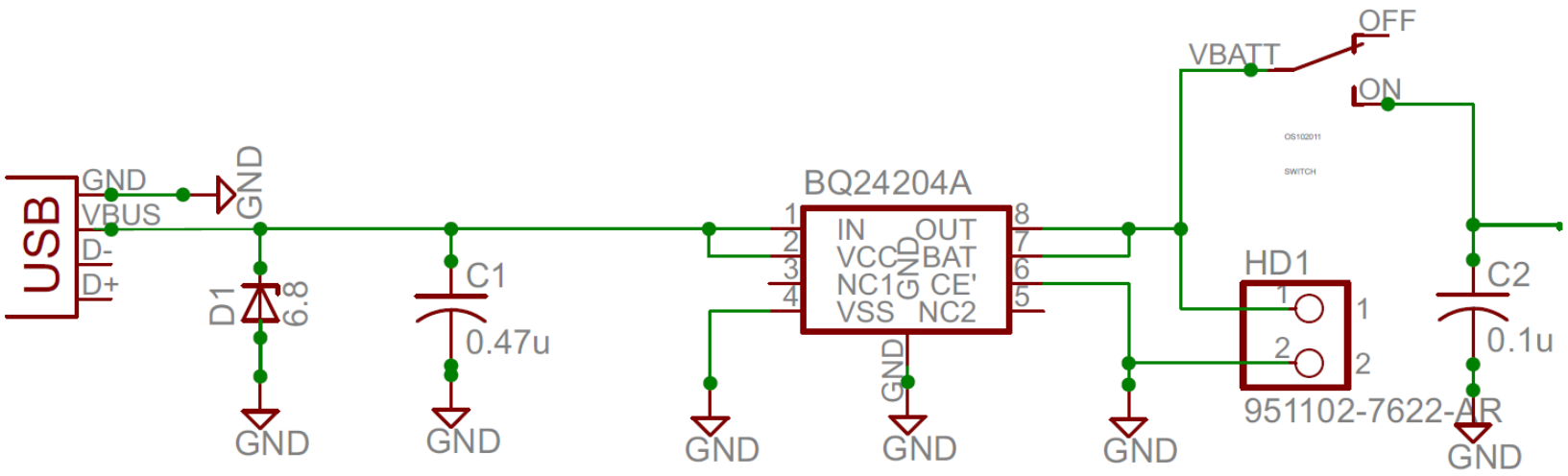
Charge Manager

- Functions as the charge manager for Li-Ion battery

BQ24204 **Texas Instruments**

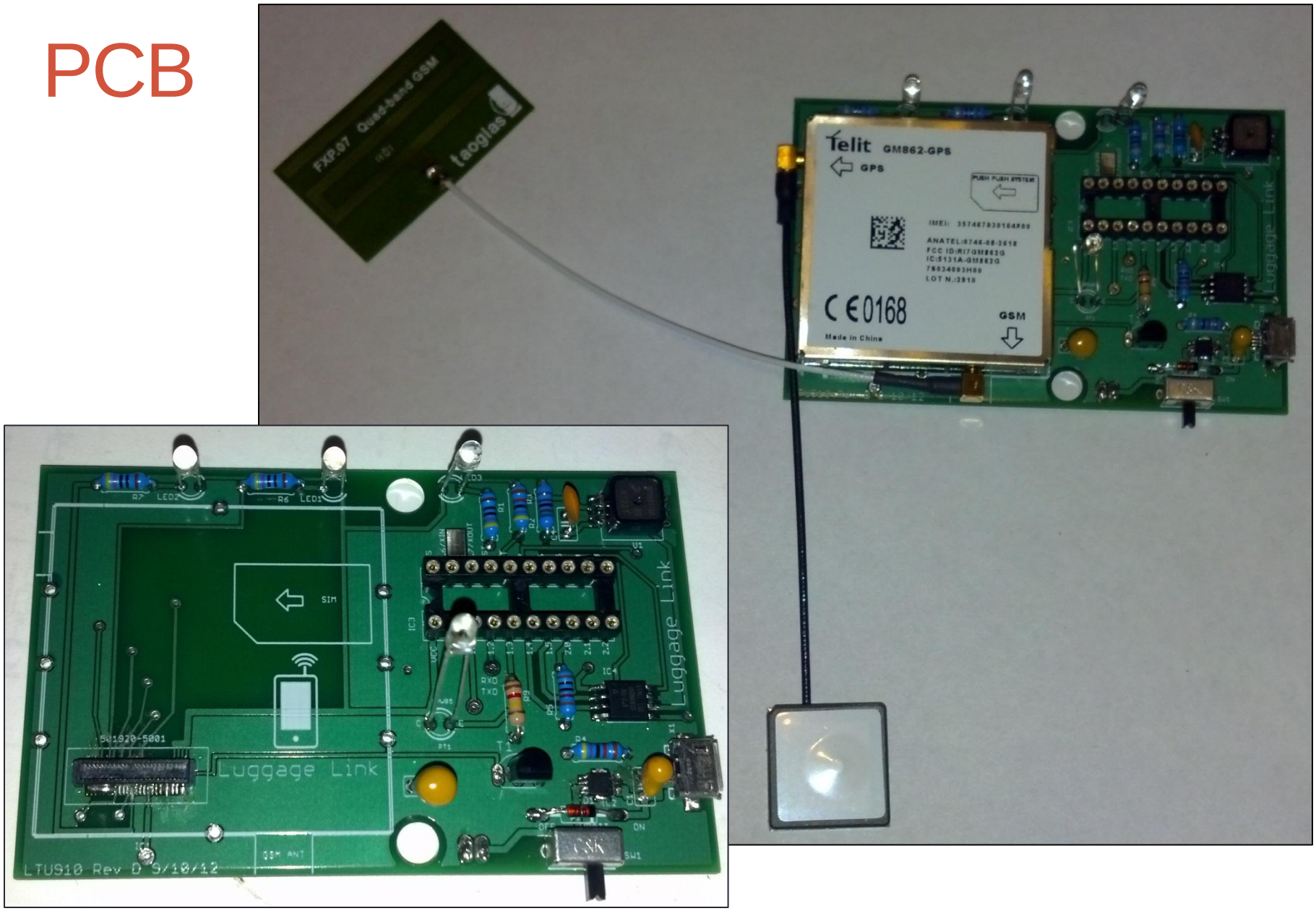
- Designed to work with current-limited wall supplies
- Ideal for Low Dropout Charger Design Single-Cell Li-Ion Packs
- Charge regulation voltage of 4.2 V
- Battery detection
- Pre-Charge conditioning
- Charge termination
- Sleep Mode for low-power consumption

Charge Manager



Pros	Cons
Low cost	Difficult to solder to PCB
Widely used	Pin width: 0.35 mm
Low power consumption	Pin separation: 0.65 mm
Will allow the use of the same wall adapter as the users cell phone	

PCB


FXP.07 Quad-band GSM
taoglas
Telit GM862-GPS
GPS
GSM
Made in China
Luggage Link
SIM
LTUS10 Rev D 9/10/12

Development Boards

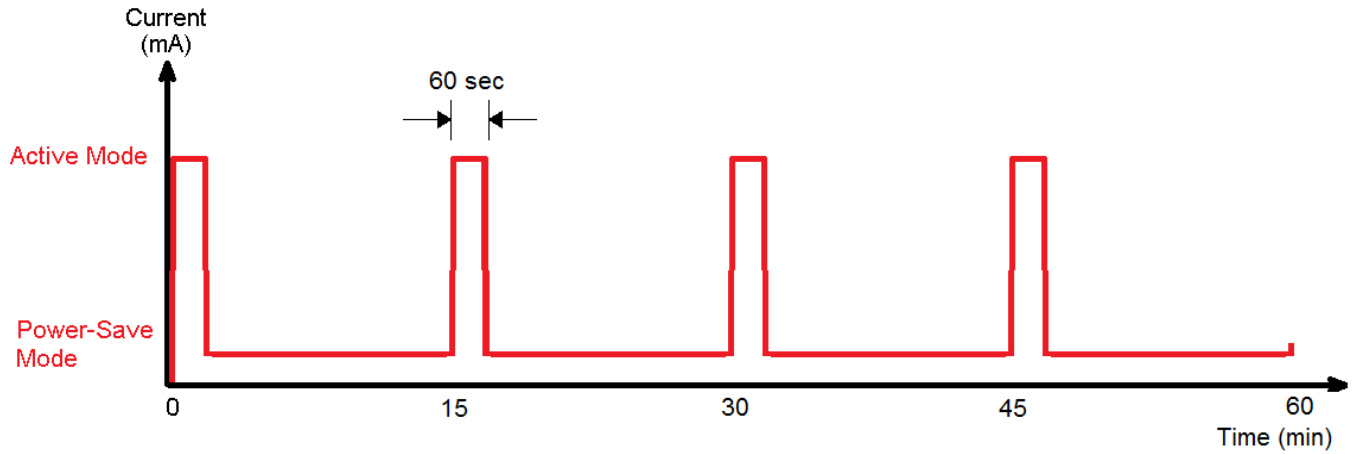
- GM862 Cellular Evaluation Board - USB

- MSP-EXP430G2 LaunchPad Value Line Development kit

Power Consumption

Component	Power-Saving Mode	Active Mode
Microcontroller	11 μW	506 μW
GSM / GPRS	96 μW	1369 mW
GPS Antenna	96 μW	259 mW
Memory	54 μW	26 mW
Pressure Sensor	14.8 mW	14.8 mW
Phototransistor	2.96 mW	100 mW
Total	**18.02 mW**	**1769.31 mW**
Current @ 3.7 V	4.87 mA	478.2 mA

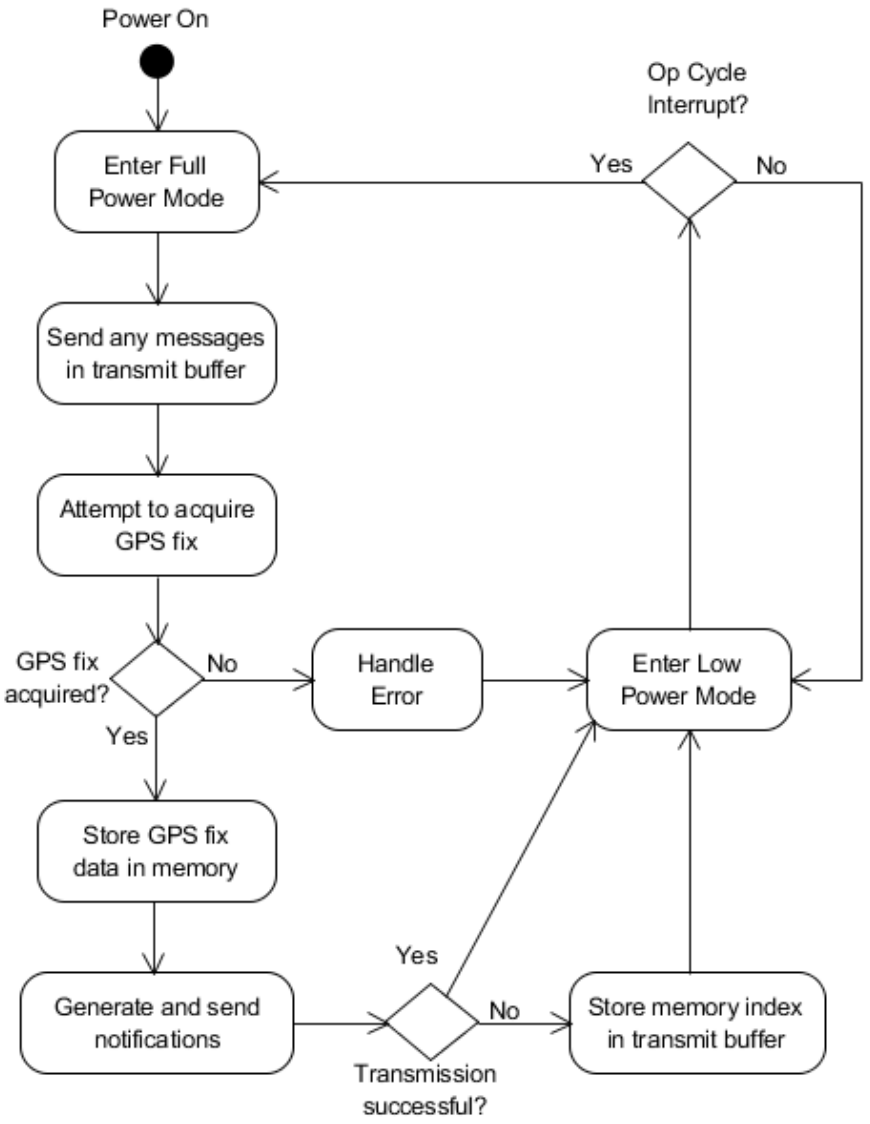
Battery Life



Battery Capacity	900 mAh
Current consumption during Power-Saving Mode	4.87 mA
Current consumption during Active Mode	478.2 mA
Number of wakes per hour	4
Duration wakes	60 seconds
Self discharge per month	<10%
Estimated Battery Life	**5.91 days**

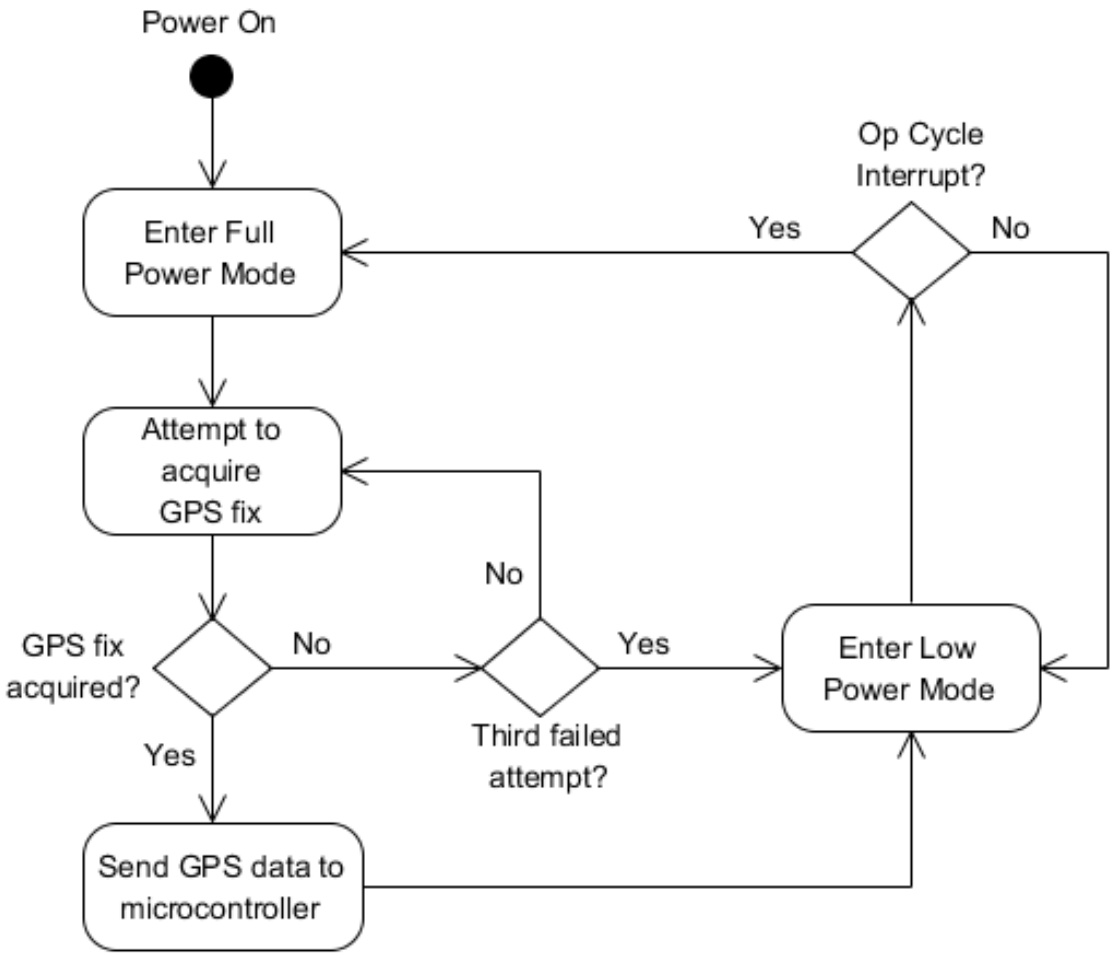
Software Architecture

- LTU Operation Cycle Activity Diagram

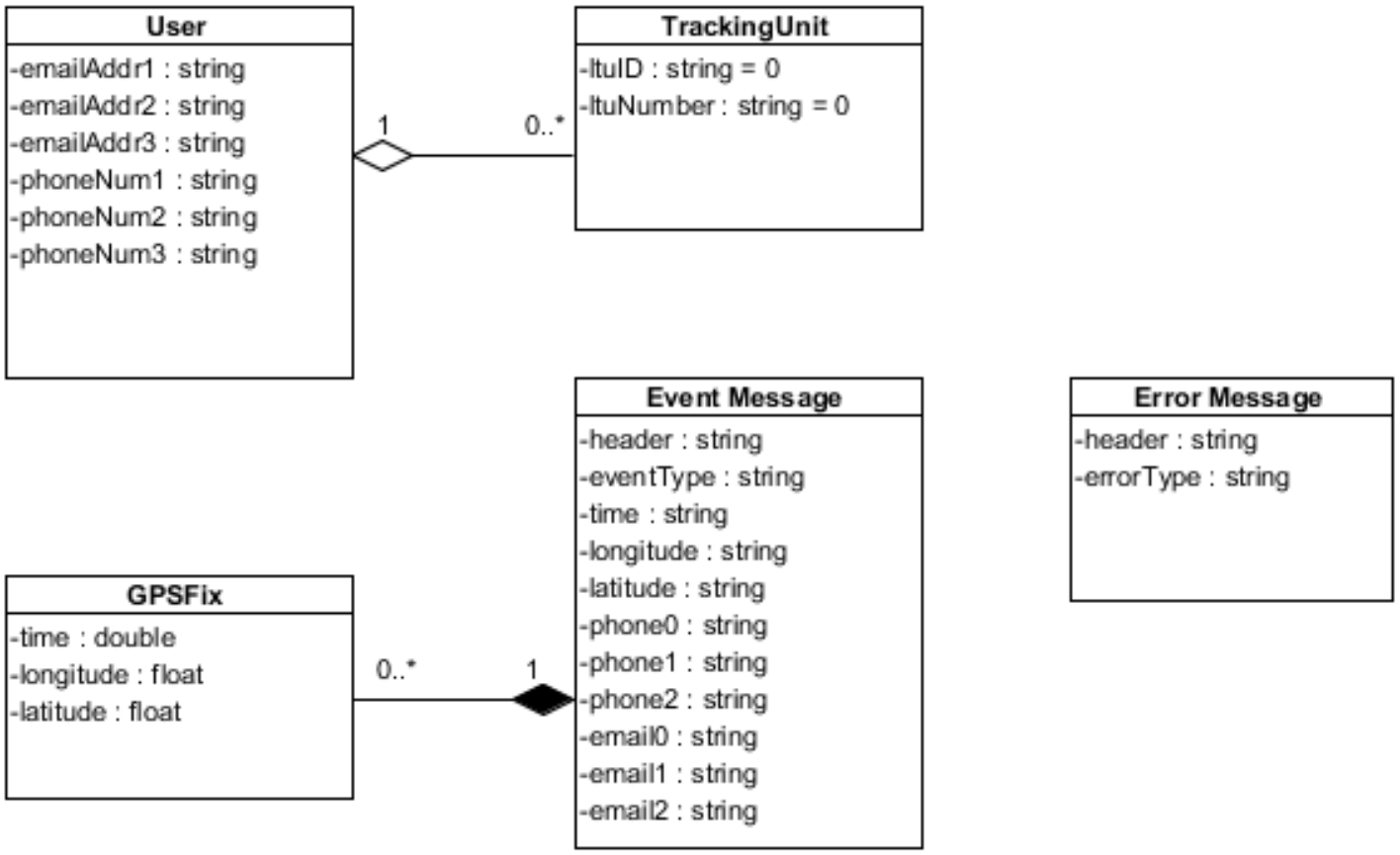


Software Architecture

- GPS Module Activity Diagram



Class Diagram



GPS Data Processing

- Receive all data in one string
- Format
  - $GPSACP: <UTC>,<latitude>,<longitude>,<hdop>,<altitude>,<fix>,<cog>,<spkm>,<spkn>,<date>,<nsat>
  - UTC – Universal Time Coordinated time (hhmmss.sss)
  - latitude - latitude (ddmm.mmmm)
  - longitude - longitude (dddmm.mmmm)
  - hdop - horizontal dilution of precision (X.X)
  - altitude - altitude in meters (X.X)
  - fix: 0 = invalid fix; 2 = 2D fix; 3 = 3D fix
  - cog – course over ground (ddd.mm)
  - spkm - speed over ground (in km/hr) (X.X)
  - spkn - speed over ground (knots) (X.X)
  - date - date of fix (ddmmyy)
  - nsat - number of satellites in use (00-12)

GPS Data Processing

- Receives all data in RxBuffer
- $GPSACP:
  213839.000,2830.6272N,08121.8487W,2.0,50.2,3,203.07,1.00,0.54,211012,04
- Only certain data is relevant
  - UTC time, longitude, latitude, date
- Parse Relevant Data
  - utcBuffer
  - latitudeBuffer
  - longitudeBuffer

GPS Data Notifications

- Attempts to send GPS Fix in SMS text message
- Sample:

  LTU 001 notification:

  A GPS fix has been acquired.

  Time: 13:26:50

  Latitude: 28 36.0438N

  Longitude: 081 11.8344W

- Attempts to send GPS Fix in an email
- Sample:

  Subject: LTU 001 Notification

  GPS fix obtained at 22:47:58

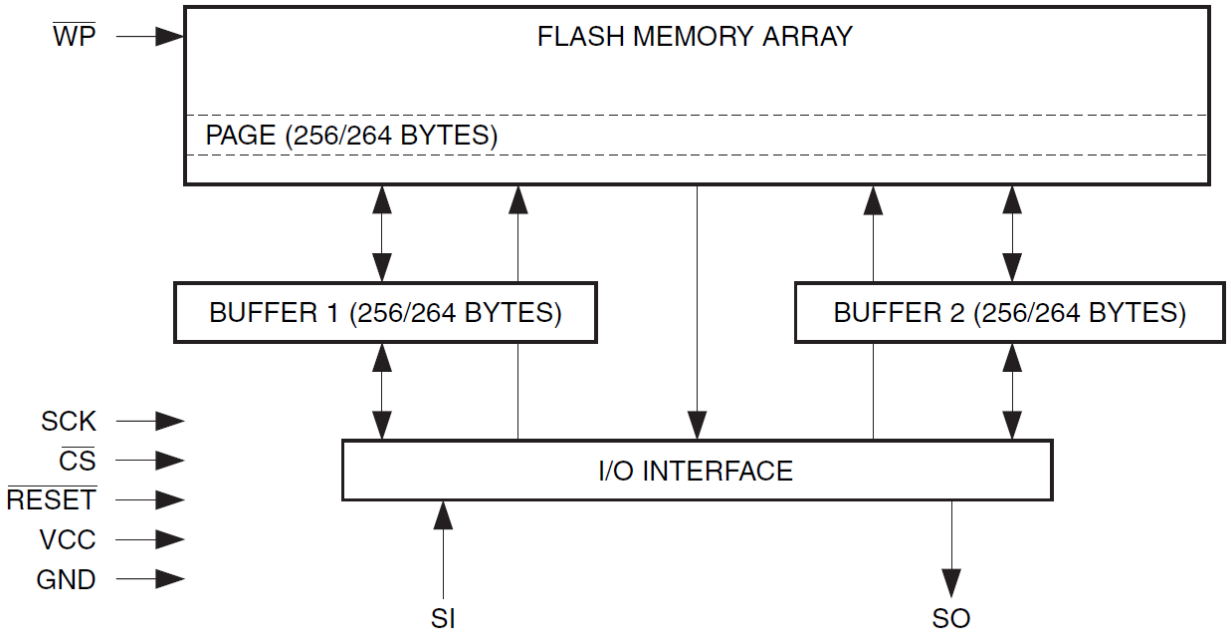
  Click here for map:
  https://maps.google.com/maps?q=28%2050.7912N,081%2036.9070W

Memory Log

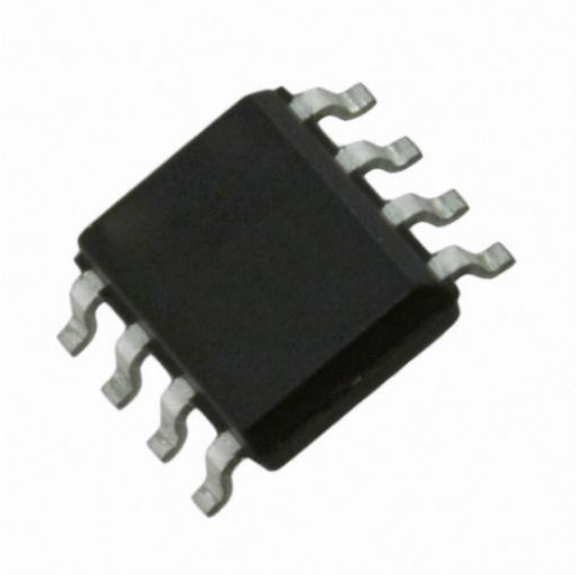
- Failure in Message Transmission
- Log event in memory
  - Time
  - Other relevant information based on event (GPS coorindates)
- Store Data Sequentially
- Attempt retransmission every operation cycle
  - Success – Transmits
  - Failure – Remains in memory

Memory Architecture

- Serial Peripheral Interface (SPI)
- Large Capacity for LTU
  - 4,325,376 total bits of memory
  - 2,048 pages



Memory Architecture



- High capacity allows for:
  - Better organization
  - Ease of use
- Each event is allocated its own page
  - Allows for 2,048 events, 264 Bytes each
    - Sufficient for detailed events
  - Sequential storage of events
  - Avoids parsing numerous events stored in a single page
  - Easy to recall and send individual events
    - Memory Dump
    - Resend Notifications

User Interface

- Only external connector is mini-USB port for recharging
- LTU settings cannot be modified by user via mini-USB
- Implemented text message user interface
  - Power down tracking unit
    - User Input: ‘O’
    - Next op cycle:
      - Event Notification
      - Power down GM862

User Interface Demo

GPS Server

- No server experience, so open source server must be implemented
- OpenGTS Server
  - Web portal
  - Map plotting
  - Geozones
  - Tracking unit data

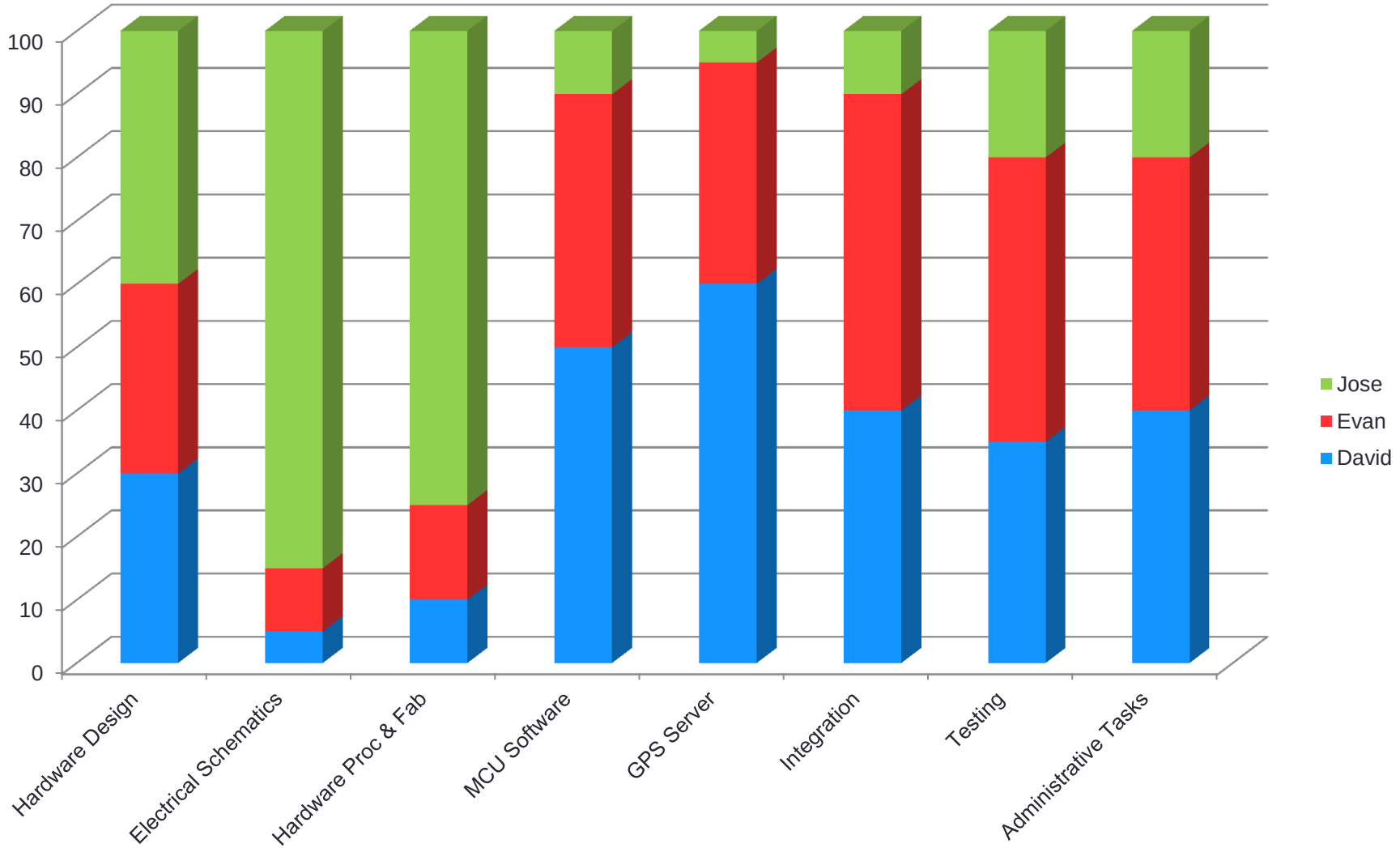
Budget & Financing

decimal.
Outsourced Accounting Services

- $500 donation from project sponsor
- Total expenditure goal: $1,000 or less

Project Budget					
Part	**Estimate**	**Qty**	**Estimated Total**	**Actual Total**	**Balance**
GM862 Module	120.00	2	240.00	241.29	(1.29)
GM862 Evaluation Board	100.00	1	100.00	84.71	15.29
GSM Antenna	20.00	2	40.00	29.64	10.36
GPS Antenna	15.00	2	30.00	33.91	(3.91)
Mini USB port	5.00	2	10.00	2.16	7.84
Battery	45.00	2	90.00	20.16	69.84
Memory	10.00	2	20.00	2.00	18.00
Pressure sensor	10.00	2	20.00	21.32	(1.32)
Phototransistor	1.00	2	2.00	1.84	0.16
50-pin connector	10.00	2	20.00	21.78	(1.78)
Minor electrical components	20.00	1	20.00	47.87	(27.87)
Microcontroller	5.00	2	10.00	9.68	0.32
Printed Circuit Board	35.00	4	140.00	150.45	(10.45)
Enclosure	15.00	2	30.00	7.68	22.32
AT&T Cellular Service	16.25	6	97.50	166.96	(69.46)
Total			**$ 869.50**	**$ 841.45**	**$ 28.05**

Work Distribution



Total Distribution ~ 33.3% per person

Issues & Challenges

- Manpower and availability
  - Only 3 group members
  - Little availability outside of school and work
- GPS/GSM to MCU communication
  - Poorly designed/documented evaluation board was root cause
  - Delayed development by ~2 weeks
- MSP430 learning curve
  - Cryptic code slows development significantly
- Inexperience in numerous areas
  - Communication protocols (i.e. UART, SPI)
  - Server setup/integration

GPS Demo

Questions?