A new Telemetry System for the Automatic Geophysical Observatories using Iridium SBD Messaging

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The AGOs

- 5 remote sites on the high plateau
- Run year-round
- Wind and solar power
- Iridium comms for data transfer (appx 20 MB/day)
- Need a separate telemetry channel

Existing Telemetry using ARGOS

- Argos ST-5 and ST-20 PTTs (transmitters) running since late 90’s
- Driven by a 8252 micro-processor
- 32-byte data packet
- Transmit at 401.65 MHz

An Alternative using Iridium SBD

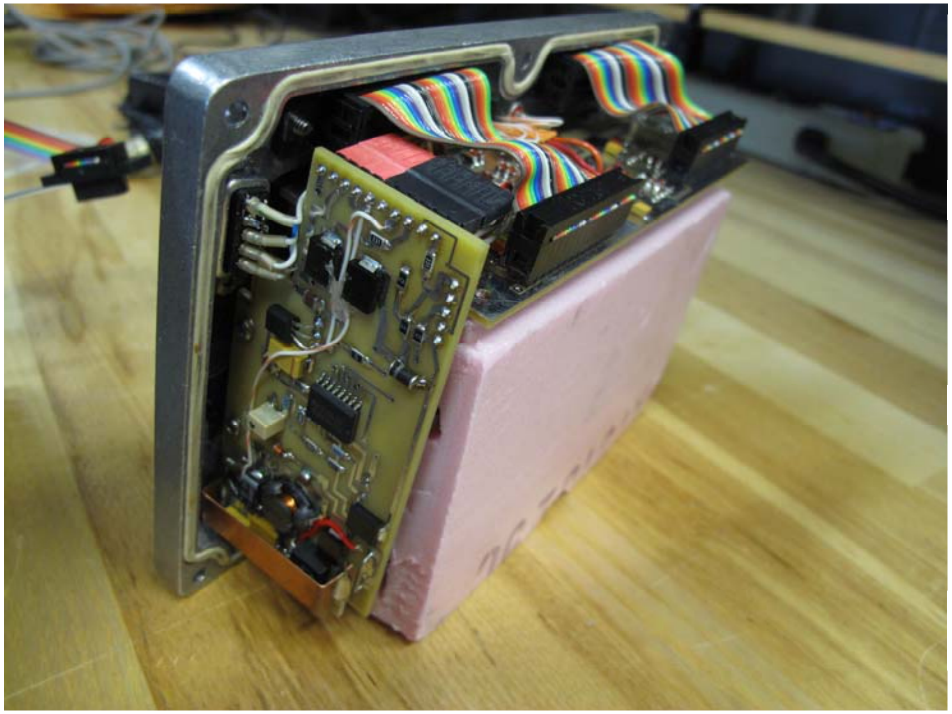
- Designed (in something of a rush!) prior to 2010 field season
- Based on 9601 SBD modem
- Two units deployed in Dec 2010
- One failed in early March 2011, one is still running

Main design issues -- general

- Communicate with modem via a serial link
- Modem must be warmer than -30 C for reliable transmissions
- Modem operates in burst-mode; it requires approximately 30 seconds to connect to the network and send a packet
- Transmissions have error-checking and modem receives an ack/nak for each packet
- User receives an e-mail with data packet as an attachment
- Telemetry module runs off of station power when available; if station power drops, module coasts off of an internal rechargeable battery as long as it can
- SBD allows two-way communications; module provides two latching relays whose state can be controlled by a stateside command

Electronic design

- Charging circuit based on TI BQ24450
- Sealed lead-acid, 7Ah at 18 V
- Internal heater with dual set-points – keep it substantially warmer when station power is available
- ADuC843 uP provides eight 12-bit analog channels; use 4 of them for self-monitoring
- Provide additional measurement options for user: 4 analog channels, I2C and two digital channels
- Used bipolar op-amps (33272) for signal conditioning
- Isolate inputs – opto-couplers for digital input, buffers for analog signals



Idea for the TI BQ24450

- User must solve coupled non-linear equations to get resistor values
- Do this with a symbolic solver like Macsyma
- It works great and allows easy experimentation with different vales

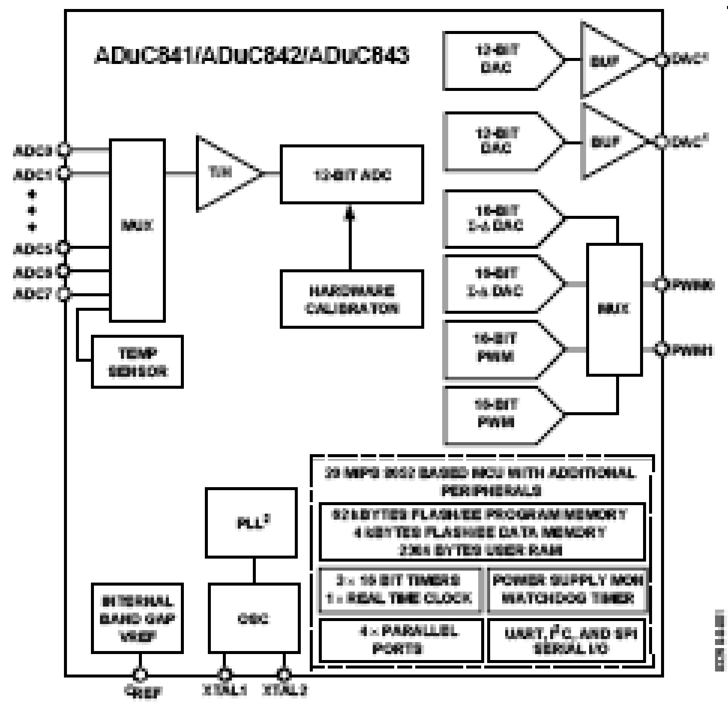
```
par(x,y):=(x*y)/(x+y);

solve([rc=46.4e3,vth=26.25,vfloat=34.50,
vboost=36.75,
vref=2.3,vfloat=vref*(ra+rb+rc)/rc,
vboost=vref*(ra+rb+par(rc,rd))/par(rc,rd),
vth=vref*(ra+rb+par(rc,rd))/(rb+par(rc,rd)
)],
[ra,rb,rc,rd,vth,vfloat,vboost,vref]);
```

ra 354k
rb 17.3k
rc 46.4k
rd 632.4k

The ADuC843

- Uses 8051 instruction set
- 8-channel, 12-bit ADC
- Serial port
- Low-power sleep mode
- Easy to program via serial link



Programming issues

- Code is 2300 lines of assembly
- Does not use interrupt capability
- Assembly language was ideal for manipulating data obtained from various I2C sensors
- Re-use code from www.8052.com
- Randomize transmit times by masking off last three bits from the check-sum of the most recent data packet and adding to transmit interval
- Serial access to both modem and uP via a jumper cable – a simple but extremely effective debugging aid
- uP implements a simple monitor program for debugging via a serial terminal program
- Manufacturer should provide an emulator program!

Mechanical design

- Electronics in a die-cast box; very easy to work with
- Electronics insulated with pink-board inside of a surplus military transit case obtained form Hardigg
- Tested in a home-made cold chamber at -30 C

Sample transmission

- Programmed to send a packet every 6 hours
- Include communications statistics (very useful)
- Include status code with each channel

P4 Engineering Data File: P4_February_28_2011.eng
Time of Session (UTC): Mon Feb 28 14:19:02 2011
======= Analog Channels =========

Chan	Hex Value	Engineering Value	
00:	7308	26.87	input voltage
01:	0130	-1.00	turbine current
02:	9f08	37.15	PV voltage
03:	0635	-1.00	PV current
04:	6268	22.99	battery voltage
05:	fb03	-0.25	battery current
06:	feed	-1.00	vreg current
07:	ea00	-22.00	rack temperature
08:	Invalid		
09:	e1c0	-30.25	hut temperature
10:	0d05	30.51	primary voltage
11:	0d0e	22.45	internal battery voltage
12:	066f	17.38	internal battery temperature
13:	0671	17.48	modem temperature
14:	039c	11.28	wind speed
15:	0fff	365.00	wind direction
16:	031f	617.07	barometric pressure
17:	0bbd	3005.00	compact flash progress

==== End of Analog Channels ====
Digital Status A: f
Digital Status B: 0
Comm Attempts: 22
Modem Not Reg Attempts: 00
Poor Signal Reports: 00
Bad Return Code: 00
Successful Comms: 22
Sum of Signal over last 8 Xmissions: 40
Average of Last 8 Signal Strengths: 5.00

Good and bad

- 9601 can draw large transient currents – caused uP to glitch!
- Small puck antenna just as effective as a larger antenna
- Plastic shell connectors are entirely adequate for indoor use; but USB connectors for I2C did not work out
- I2C itself was a disaster – not sure what is wrong

Second generation

- Use 9602 instead of 9601
- Same uP, same code
- Simplify power system – station power and a Lithium *primary* pack
- Use only linear regulators – excess heat goes for warming electronics
- Electronics package in a Dewar flask
- All analog inputs differential

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- Pf. Noel Petit (Augsburg college) implemented the state-side data processing
- Andy Stillinger built the cold-chamber in his garage!