

A Radio Relay System for Remote Sensors in the Antarctic

Final Seminar

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Motivation

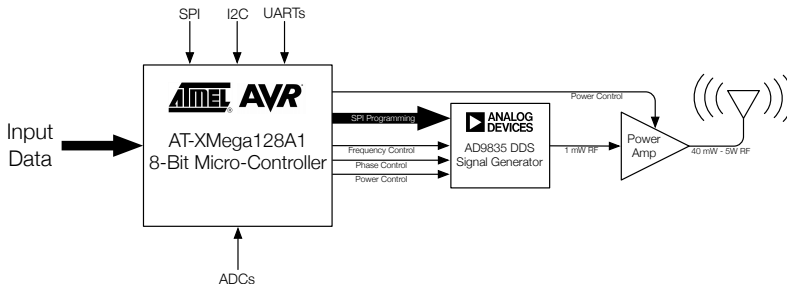
Aim - Design and build a low power HF data transmitter for use in an antarctic remote sensor application.

- ▶ Project scope expanded mid-year to include other applications.
- ▶ Initial Constraints still used.
 - ▶ Low Temperature Operation
 - ▶ Low Power Consumption
- ▶ Can be used in a huge amount of applications!

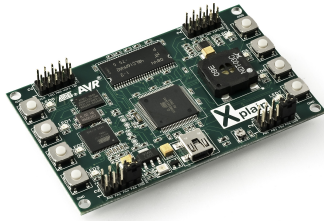
Hardware & Software Overview

- ▶ Modular Design & Construction

Hardware & Software Overview



CPU - Atmel ATXmega128A1

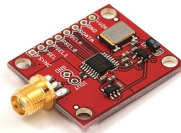


Atmel XPlain Development Board

- ▶ Atmel ATXmega128A1 Micro-Controller, clocked at 32MHz
- ▶ 8MB SDRAM
- ▶ 8MB NAND Flash Memory
- ▶ Low Power Consumption - 18mA @ 32MHz, 1.4mA @ 2MHz, 1.16 μ A Power-Save

Signal Generator - Analog Devices AD9835

- ▶ Original intention was to use an AD9834
- ▶ AD9835 Board ended up having the same power requirements!



Analog Devices AD9835

- ▶ Can generate Sine-waves between 1Hz - 25MHz.
- ▶ 2 programmable (via SPI) frequency registers.
- ▶ Dedicated pins for switching between registers.
- ▶ Using 16MHz SPI clock, can reprogram at 7500Hz.

Power Amplifier

- ▶ Op-Amp based pre-amplifier - 40mW output.
- ▶ Class C NPN Transistor Amplifier - 1W output.
- ▶ Class E MOSFET Power Amplifier - 5W output.

Power Supply

Supply Requirements

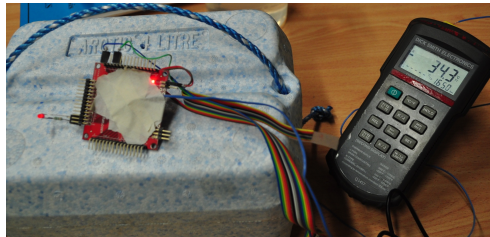
- ▶ 12v, 5v and 3.3v rails are required.
- ▶ Linear Regulators are very in-efficient.
- ▶ Switch-mode Regulators used instead.

Battery Power

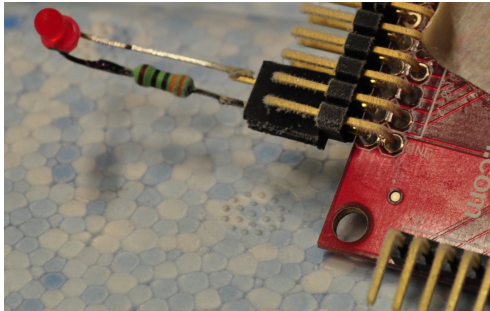
- ▶ Powered from a 12V SLA for testing.
- ▶ For sub-zero use, Lithium-iron primary cells can be used.
- ▶ Lithium-thionyl chloride secondary cells can operate down to -60°C .

Low Temperature Testing

- ▶ All major components rated to either -40°C or -55°C .
- ▶ Doesn't hurt to check!
- ▶ Dry Ice used to cool components below rated limits.



Low Temperature Testing



- ▶ AT-XMega's internal RC 32MHz oscillator drifts up to 33MHz at -55°C .
- ▶ AD9835's output only drifts up by $\sim 300\text{Hz}$ at -40°C !

Software Overview

- ▶ Coded in C and C++.
- ▶ Libraries built first, more complex applications later.
- ▶ Morse, RTTY (FSK) and DominoEX modulation implemented.
- ▶ Data acquisition from onboard ADCs, UARTs, or I²C Devices.

Morse Code & QRSS

- ▶ Morse Code at very slow speeds can be received over very long distances.
- ▶ Signals are pulled out of the noise floor with DSP techniques.
- ▶ Very low signal bandwidth.
- ▶ Not very useful for transmitting lots of data.
- ▶ Good for beaconing.

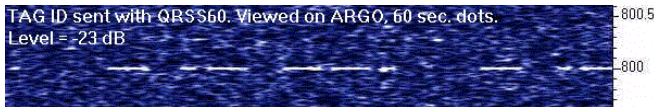


Figure: QRSS Morse Broadcast, signal level -23dB below the noise floor.

RTTY (FSK)

- ▶ FSK Modulation, with start and stop bits.
- ▶ Implemented to operate between 50 and 300 baud (symbols/sec).
- ▶ Carrier Shift programmable from 170 to 425Hz.
- ▶ Plenty of existing software to decode RTTY (i.e. fldigi)

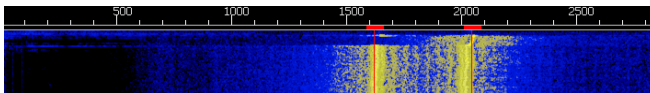


Figure: 300 Baud RTTY, with 425Hz Carrier Shift

DominoEX (MFSK)

- ▶ The first MFSK-based mode implemented - utilises Incremental Frequency Shift Keying.
- ▶ Resistant to multi-path and doppler effects.
- ▶ 6 variations available, each with different symbol rates (3.9 to 29.5Hz) and bandwidths (173 to 524Hz).
- ▶ Data rates varying from 2 to 14 *characters* per second.

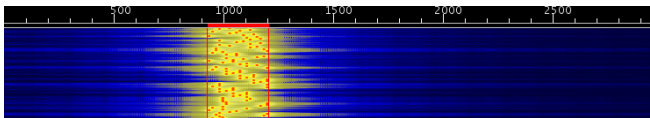


Figure: DominoEX8 - 7.8125 baud, 346Hz Bandwidth

Testing Procedures

- ▶ Checking of library operation once coded.

Example Application - HAB Telemetry Transmitter

Amateur High Altitude Ballooning (HAB)

- ▶ Aims to set height / distance records for balloon flights.
- ▶ Some form of telemetry system used to track balloon in flight.
- ▶ 433MHz Single-Sideband Transmissions commonly used.



A wide-angle view of Earth from space, showing a dense layer of white clouds over a blue ocean, with the blackness of space above the horizon.

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Prototype

- ▶ System 'Motherboard'
 - ▶ XMEGA
 - ▶ AD9835 DDS VFO
 - ▶ UBlox5 GPS Module
 - ▶ I²C Temperature Sensors
- ▶ Amplifier Module

References

Saft *Lithium-thionyl chloride (Li-SOCl₂) Cell Range*

http://www.saftbatteries.com/Produit_LSH_cell_range_303_8/Default.aspx