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A Radio Relay System for Remote Sensors in the Antarctic
Final Seminar

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Introduction
Hardware
Software
Example Application & Prototype

Motivation
Hardware & Software Overview

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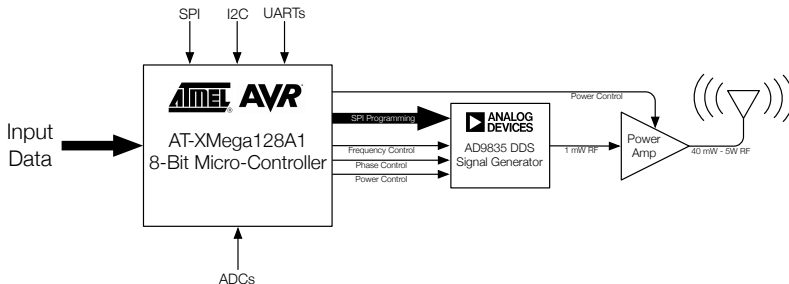AUSTRALIA

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
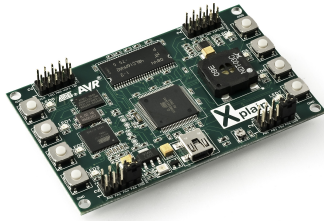- Can be used in a huge amount of applications!

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Hardware & Software Overview

- Modular Design & Construction

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Hardware & Software Overview

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Signal Generator
Power Amplifier
Power Supply
Hardware Testing

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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, $1.16\mu A$ Power-Save

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Signal Generator - Analog Devices AD9835

▶ Original intention was to use an AD9834

▶ AD9835 Board ended up having the same power requirements!
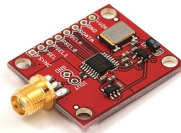
Analog Devices AD9835

▶ 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.

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Power Amplifier

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

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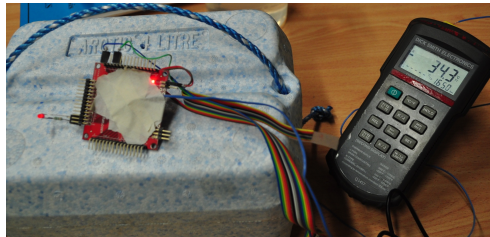OF ADELAIDE
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Power Supply

Supply Requirements

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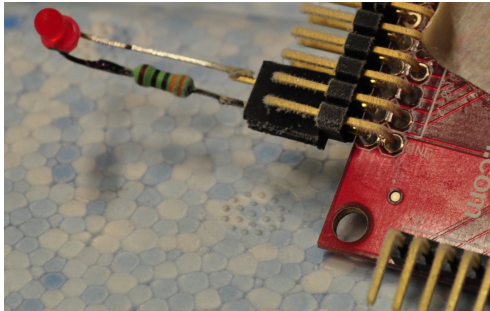- Switch-mode Regulators used instead.

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.

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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.

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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$300Hz at -40°C!

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DominoEX
Testing Procedures

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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 I^2C Devices.

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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.
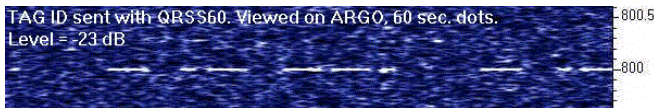- ▶ Good for beaconing.

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

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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.
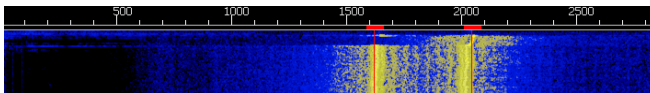- ▶ Plenty of existing software to decode RTTY (i.e. fldigi)

Figure: 300 Baud RTTY, with 425Hz Carrier Shift

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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).
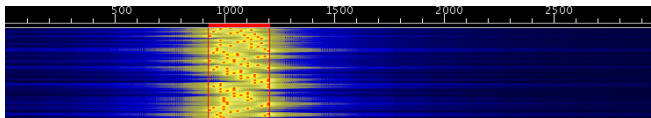- ▶ Data rates varying from 2 to 14 *characters* per second.

Figure: DominoEX8 - 7.8125 baud, 346Hz Bandwidth

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Testing Procedures

- ▶ Checking of library operation once coded.

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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.

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Example Application - HAB Telemetry Transmitter

- ▶ Local Amateur HAB group - **Project Horus**
- ▶ Have offered to fly a prototype transmitter, with modifications.
  - ▶ GPS Receiever, for positioning information
  - ▶ Temperature Sensors

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Prototype

- System 'Motherboard'
    - XMega
    - AD9835 DDS VFO
    - UBlox5 GPS Module
    - I^{2}C 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`