# A Radio Relay System for Remote Sensors in the Antarctic

## Proposal Seminar

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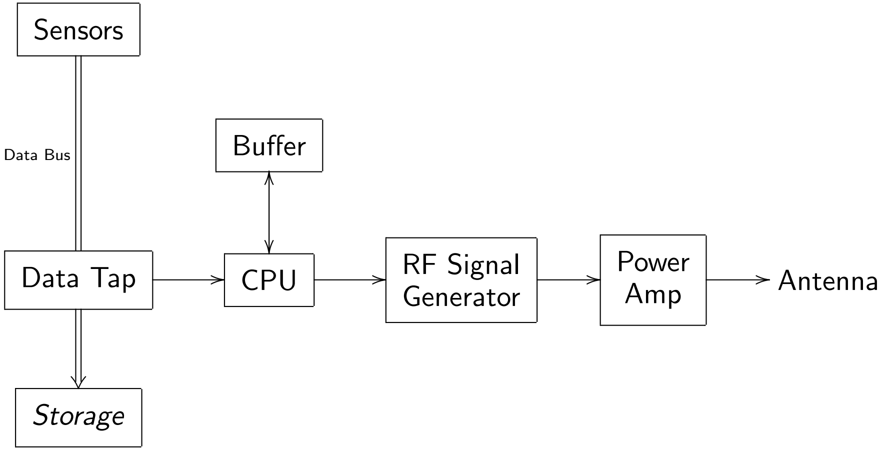
# Project Background

- Research team operating ionospheric measurement equipment in Antarctica.
- Equipment left in the field for many months at a time.
- Results are obtained only when the equipment is retrieved.
- Not much can be accomplished while the equipment is in the field.
- Need some way to gain access to the data!

# Project Aim

- Design and build a low power short wave data transmitter that can translate low rate data into a modulated short wave output with sufficient power to transmit the data over several hundred kilometres on an Antarctic communication path.

# Block Overview



# Limitations & Challenges

- Low power budget
- Extremely cold temperatures
- Ionospheric absorption loss

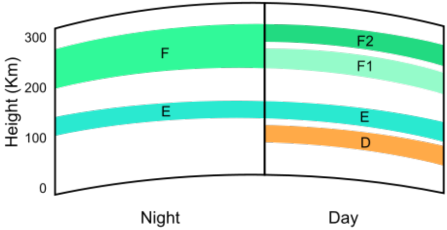



Figure: Layers of the Ionosphere

# Power Budget

- Equipment operates from battery power for many months at a time.
- Efficiency is extremely important.
- Components will need to be carefully selected for minimal power consumption.
- Transmission frequency may need to be lowered to keep within constraints.

# Preliminary Sizing Calculations

If we make a few assumptions, we can use the Friis transmission equation and the Shannon-Hartley Theorem to calculate the theoretical maximum bit rate of a radio link.
Assume:

- 200km Distance between TX and RX (on ground)
- 400km radio path (via near-vertical skywave)
- 5MHz Transmission frequency ($\lambda = 60$m)
- No ionospheric absorption loss (Not Realistic!)
- Dipole antennas one each end ($G_t = G_r = 1.5$)
- 10dB SNR required
- -114dB[2] background noise at 5MHz

# Preliminary Sizing Calculations - SNR

Using 1W transmission power, we can calculate the power at the receiving antenna:

$$
\begin{aligned}
P_r &= \frac{P_t G_t G_r}{(4\pi R/\lambda)^2} \\
&= \frac{1 \times 1.5 \times 1.5}{(4\pi \times 400000/60)^2} = 0.3206nW = -94.94dB
\end{aligned}
$$

$$SNR = 114 - 94.94 = 19.06dB = 80.54$$

# Preliminary Sizing Calculations - Capacity

We can use the Shannon-Hartley theorem to calculate the theoretical maximum channel capacity of the link:

$$C = B \log_2(1 + SNR)$$

Where $C$ is the channel capacity (in bits/s) and B is the signal bandwidth. Assuming Binary FSK modulation is used with a 600Hz frequency shift, we calculate the maximum channel capacity as:

$$C = 600 \log_2(1 + 80.54) = 3809.66 \text{ bits/s}$$

To ensure reliability, a much lower bit-rate ($\sim$ 600 bits/s) would be used.

## Preliminary Sizing Calculations - Power Usage

To get a rough idea of the power usage, let us assume we are transmitting at 600 bit/s for one hour (263.67 kB of data). The power usage of some devices that could be used are as follows:

- Microcontroller - 75mW in active mode [3]
- Signal Generator - 40mW when active [4]
- Power Amplifier - 1W (idealised)

So under these ideal conditions, the transmitter will draw 1.115W when transmitting, which is 4014 Joules of energy for one hour of transmission.

# Temperature

- Mean annual temperature for Antarctica's interior is $-57°C$.
- Standard industry specification is $-55°C$ to $+125°C$.
- Not all devices conform to this spec, and many will be unreliable at these limits!

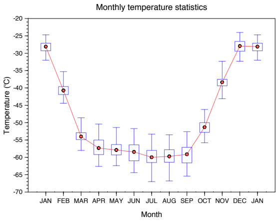



Figure: Monthly Temperature Statistics for the Amundsen Scott Research Station [1]

# Budget

Maximum cost = \$250

- Devices for stress testing (i.e. micro-controllers) - \$50
- RF System - \$50
- Control System - \$50
- PCB Construction - \$50

# Timeline

| **Task** | **Expected Completion** |
|---|---|
| Background Research | S1 Week 3 |
| Simulation & Component Research | S1 Week 5 |
| High-level design | S1 Week 7 |
| Software Design & Coding | End of S1 |
| Hardware Design | End of S1 |
| Data-Tap | |
| Controller | |
| RF System | |
| Prototype construction | Early S2 |
| Testing & Optimisation | Mid S2 |

# Deliverables

- Proposal Seminar (Now!)
- Stage 1 Design Document (S1 Week 5)
- Progress report (S1 Week 11)
- Interim Performance Report (S1 Week 12)
- Final Seminar (S2 Mid-semester break)
- Final Report (S2 Week 11)
- Final Performance Report (S2 Week 12)
- Project Exhibition (S2 Week 12)

# Risks & Dependencies

- No life-threatening risks involved with this project.
- Minor risks involving electrical/RF safety.
- Minor risks involving hardware damage, shipping problems, etc.
- Medium-level risk involved if project leader becomes ill.

# References

[1] G. Marshall. "Monthly mean surface temperature at Amundsen-Scott station" *http://www.nerc-bas.ac.uk/icd/gjma/pole.temps.html* Mar. 9, 2010 [Mar. 11, 2010]
[2] S.K. Datta. "Radio Noise Measurement in HF/VHF Band at Antarctica" *http://dspace.ncaor.org:8080/dspace/bitstream/123456789/707/1/115-119.pdf* (Google Cache), 1995 [Mar. 15, 2010]
[3] Atmel, "ATMega168PA Electrical Characteristics", ATMega168PA Datasheet, Dec. 2009

[4] Analog Devices, "AD9834 Specifications", AD9834 Datasheet, Feb. 2003

Any Questions?