Ausroc III Telemetry System

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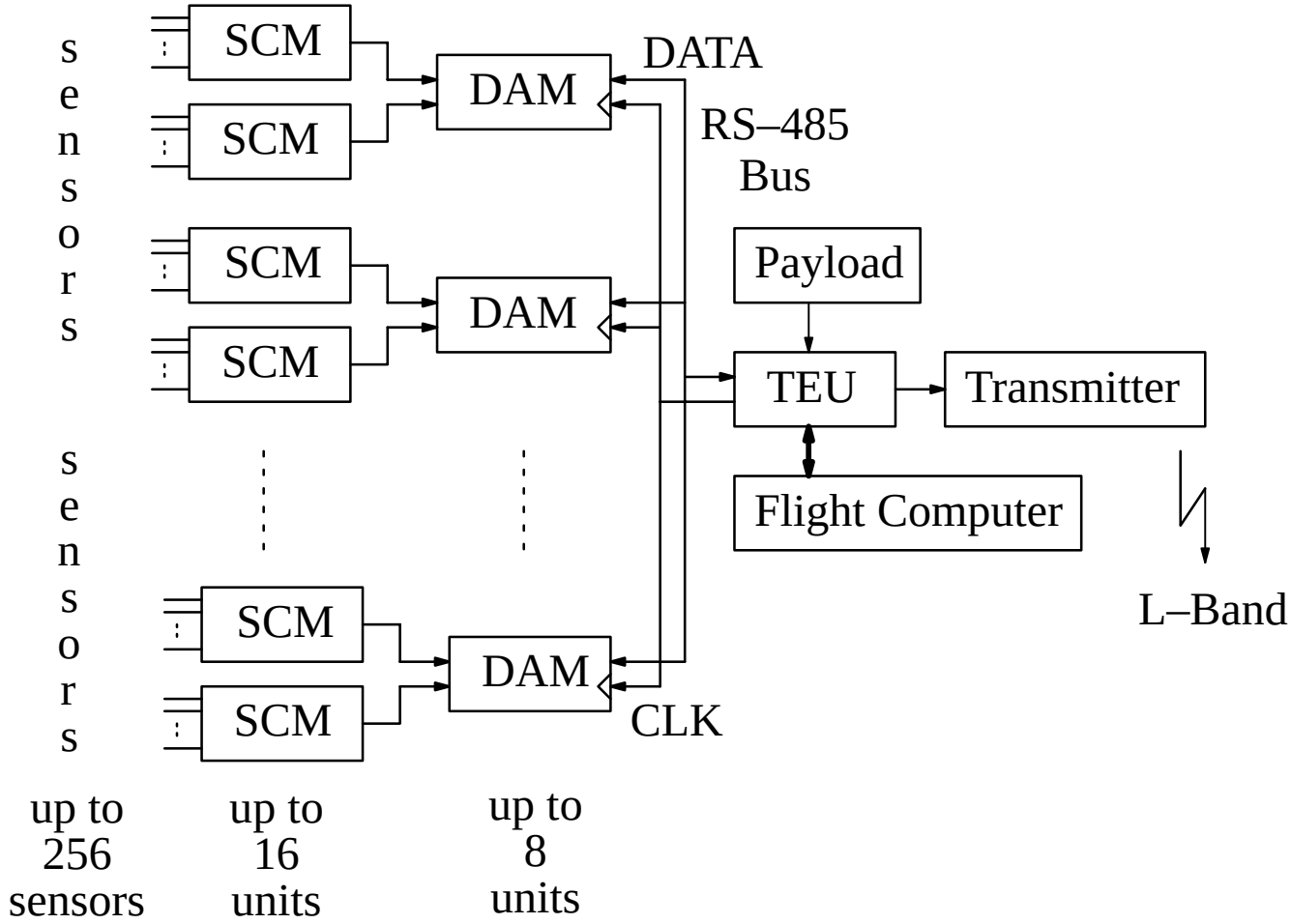
Introduction

- The Ausroc III Telemetry System is designed to transmit information of the state of the Ausroc III sounding rocket before and during launch. On payload separation, the system transmits data from the payload.
- The information includes pressures, temperatures, actuator positions, valve positions, flow rates, strains, propellant levels, flight computer data and experimental data from the payload.
- The transmitted data is received on the ground where it is simultaneously stored and displayed on PCs for use in the launch control centre.
- The system was started as a student project at the University of South Australia in 1989, culminating in 1994 with students Vince Rose (sensor conditioning module), Troy Ziersch (data acquisition module), and David Mullins (telemetry encoder unit).

The Original System

- The original Ausroc III Telemetry System consists of three separate modules:
- *Sensor Conditioning Module (SCM)*: Collects analog sensor data and converts it to a standard –5 to +5 V signal. Each SCM can condition up to eight sensors on a 3U 160 mm eurocard with a small daughter board for temperature conditioning.
- *Data Acquisition Module (DAM)*: Converts standard signal data from up to two SCMs and/or 12 on/off signals into 12 bit samples on a 3U 160 mm eurocard.
- *Telemetry Encoder Unit (TEU)*: The TEU commands up to 16 DAMs to convert and transmit sampled data to the TEU which combines it into a 250 kbit/s stream. The TEU also collects and sends data to the Flight Computer and transmits payload data after payload separation. A 3U 160 mm eurocard was used.

System Block Diagram

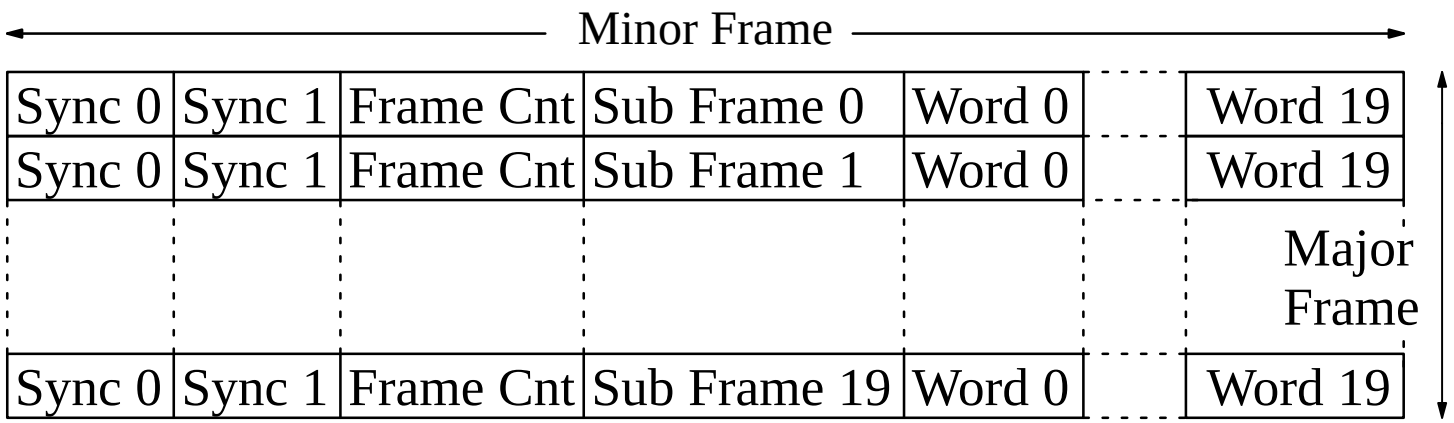


Telemetry Format

- The telemetry format that is transmitted to the ground follows standard techniques with frames and sub–frames.
- Each sub–frame consists of 24 words (originally 54 words) with 13 bits in each word. The first two words are synchronisation words, followed a frame count, sub–frame count, and 20 data words. There are 20 (originally 16) sub–frames per frame.
- Synch Word 0 = 1111 1010 0110 1
  Synch Word 1 = 0110 0110 0000 0
  Frame Count = 0–4095 (12 bits) with 1 odd parity bit
  Sub–Frame Count = 0–19 (12 bits) with 1 odd parity bit
  Data Word = 12 bits per sample with 1 odd parity bit
- Frame Frequency = 5 Hz (22.258 Hz originally)
  Sub Frame Frequency = 100 Hz (356.13 Hz originally)
  Word Frequency = 2400 Hz (19,230.7 Hz originally)
  Bit Frequency = 31,200 Hz (250,000 Hz originally)

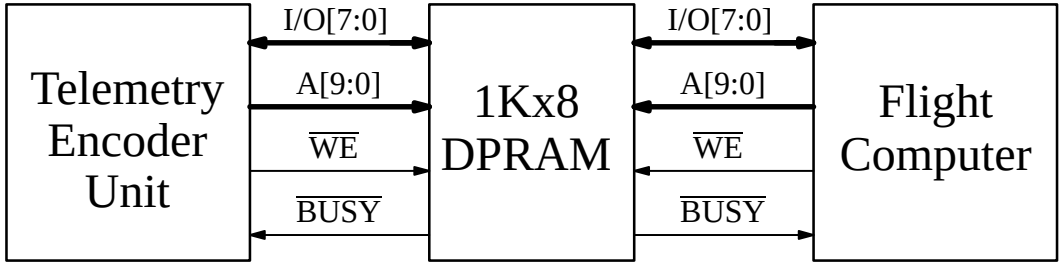
Telemetry Format (cont'd)

- The word rates and frame sizes were changed so as to have sampling rates of 10 and 100 Hz. Each Ausroc III is expected to have 8 sensors at 100 Hz for the motor and 62 sensors at 10 Hz for the rest of the vehicle. This allowed the data rate to be greatly reduced.
- Original design with Xilinx XC3064, three 2Kx8 EPROMs, and two dual–port RAMs (for FC) redesigned with Xilinx XCS05, one EPROM, and one 1Kx8 dual–port RAM.



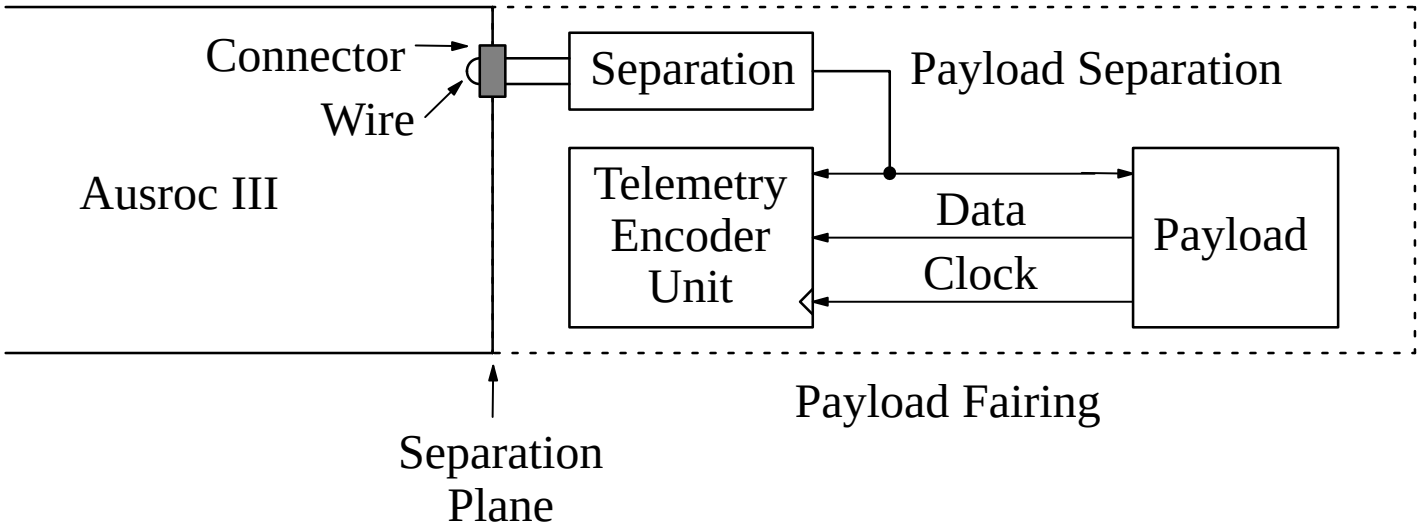
Flight Computer Interface

- The interface from the TEU to the Flight Computer (FC) is via a 1Kx8 dual–port RAM. Each sensor word requires two address locations (for the low and high bytes). With up to 256 sensors the first 512 bytes are for sending sensor data to the FC. The remaining 512 bytes are for sending FC data to the TEU.
- The $\overline{\text{BUSY}}$ signal is used by the TEU to check if the FC is writing data to the location that is being read. If so, the TEU inverts the parity bit to indicate that the data could be corrupted.



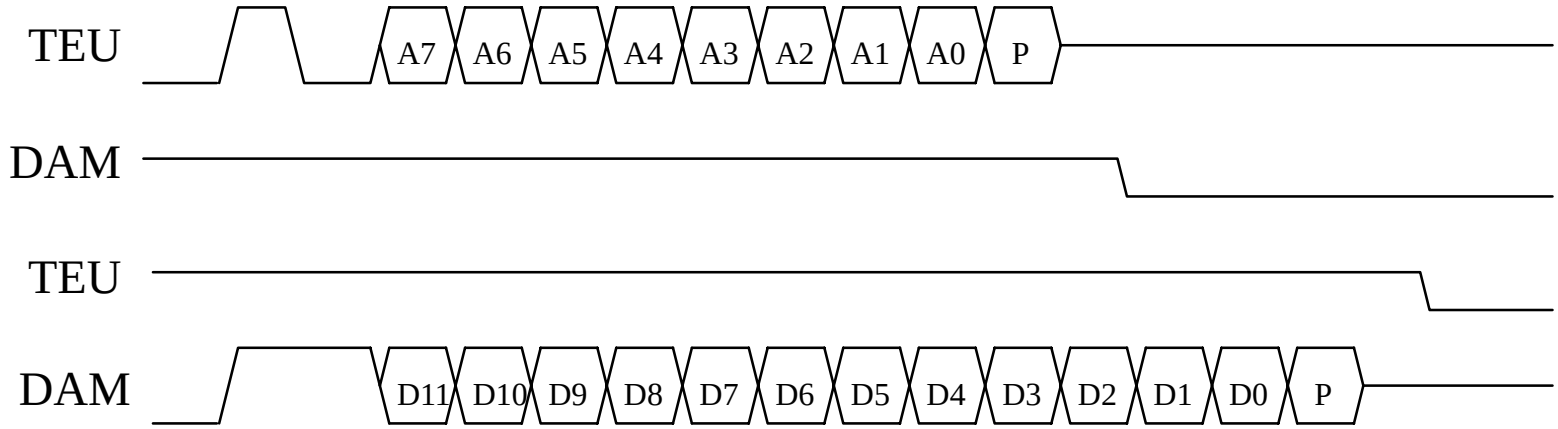
Payload Interface

- On payload separation, a wire path is broken to indicate that sensor data is to be replaced by payload data. If separation is not detected, then a timer signal is used to indicate start of payload operations.
- The payload provides its own stream and clock to the TEU. This allows the payload to transmit data to the ground at its own data rate.



RS–485 Bus Protocol

- During each word period (416.7 μs) the TEU serially sends an eight bit address to the data bus. The first four bits select the DAM and the next four bits selects the sensor for that DAM. Sensor address 0 can also be used to select the 12 on/off signals.
- Once selected, the DAM converts the analog data to digital and serially sends the 12 bit sample and odd–parity bit to the data bus. A separate clock signal from the TEU keeps the signals synchronised.



Implementation Issues

- The original DAM used a Xilinx XC3030, a 16 to 1 analog multiplexer and a 12–bit MAX122 analog to digital (A/D) converter. Currently, the XC3030 has been replaced with an XCS05.
- To reduce power (from 230 to 66 mW) and cost (from $60 to $30) the multiplexer and A/D will be replaced with two A/D converters with eight analog inputs. The input voltage range will change from –5 to +5 V to 0 to 4.096 V (with 1 mV per division).
- Each Ausroc III will have five SCM/DAM units (Boattail, Intertank 1, Intertank 2, Payload Fairing, and Nose Cone). Four of these have 16 sensors with the Nose Cone having 8 sensors.
- Thus, to reduce size and mass, two SCMs will be implemented on a 6U 160 mm eurocard, with up to eight temperature sensors.
- The DAM, TEU and power supply will also be implemented on a 6U 160 mm eurocard (only one unit will have the TEU loaded).

Conclusions

- A telemetry system for Ausroc III has been designed that allows sensor, flight computer, and payload data to be transmitted to the ground.
- This system is currently being redesigned for flight using industrial grade components. Improvements have been made to reduce component count, cost and power.
- Hardware and software to store and display the received telemetry on the ground still needs to be performed.
- The telemetry system can also be used in other vehicles (such as Ausroc IV) due to its flexibility and programmability.