

A Cubesat Beacon for the Correction of Ionospheric Faraday Rotation in Low-frequency Radio Signals

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Investigators Background / Experience

David Herne

Measurement and modelling of TEC at the MRO since 2007.

Member of the MWA Solar Heliosphere Ionosphere [SHI] Team since 2004.

John Kennewell

Author of the ionospheric case for the Australian bid for the SKA.

Formerly Chief Officer, Learmonth IPS facility.

Merv Lynch

Formerly Co-chair, MWA SHI Project.

Project: Characterising the Ionosphere over the SKA-Lo Site Calibration of MWA Antennas



Antennas of the 1T expedition MWA prototype tile. These were the first placed on the Murchison Radio Observatory site.

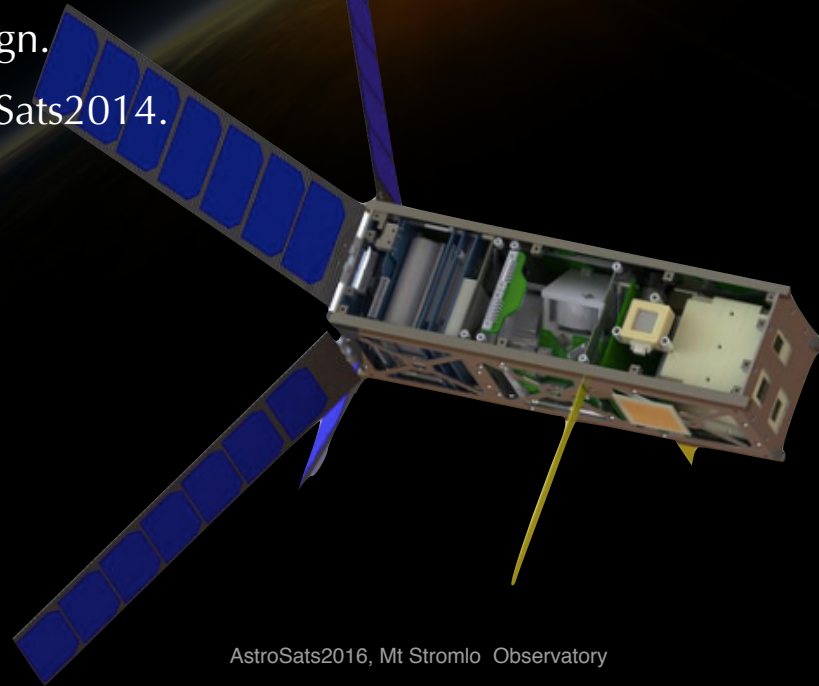
Motivation, Need and Impact

- Growth of major low frequency radio telescopes.
- Ionospheric turbulent structure in the electron density plays the parallel role in radio astronomy that atmospheric turbulence does in degrading optical astronomy.
- 4 major new LF radio telescopes on 4 continents [LOFAR, MWA, SKA, LWA].

Previous Research Proposals

Low frequency radio beacons on satellites have been proposed previously. In Australia:

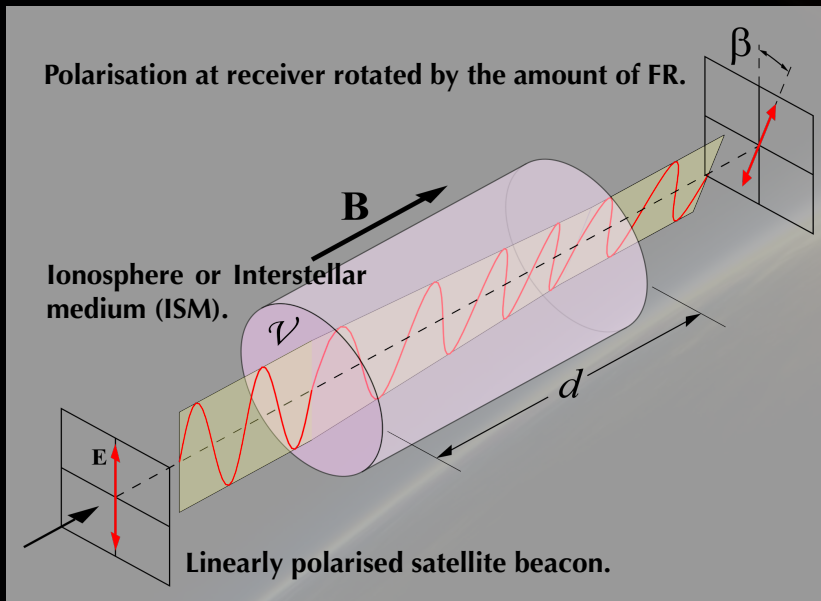
1. The AUSSAT initiative stimulated interest in such facilities being placed on orbit (Essex 1987; Kennewell 1987). Cousins (2010) proposed a 3 frequency CubeSat radio beacon design.
2. Lynch et. al, AstroSats2014.



AstroSats2016, Mt Stromlo Observatory

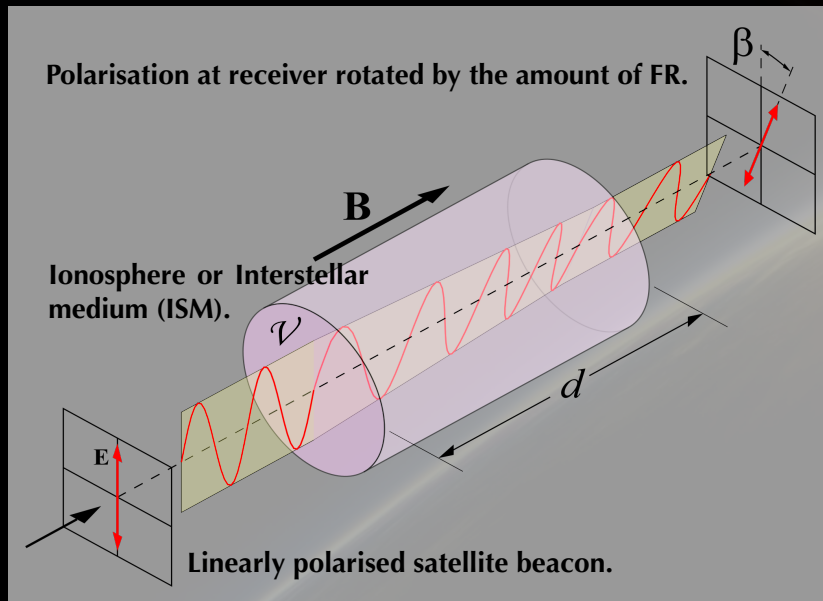


Faraday Rotation



In radio astronomy, **Faraday rotation** (β) describes the rotation of the plane of polarisation of a linearly polarised radio wave in the ionosphere or other dielectric such as the interstellar medium (ISM) under the influence of a magnetic field.

Faraday Rotation



The overall strength of the rotation is determined by the rotation measure (RM), which is a function of the number density of free electrons along a line-of-sight and the strength of the corresponding magnetic field ($\mathbf{B}$), found as

$$RM = \frac{e^3}{8\pi^2 \epsilon_0 m^2 c^3} \int N_e \mathbf{B} \cdot d\mathbf{s}$$

Faraday rotation is proportional to the square of the observation wavelength and RM and found as

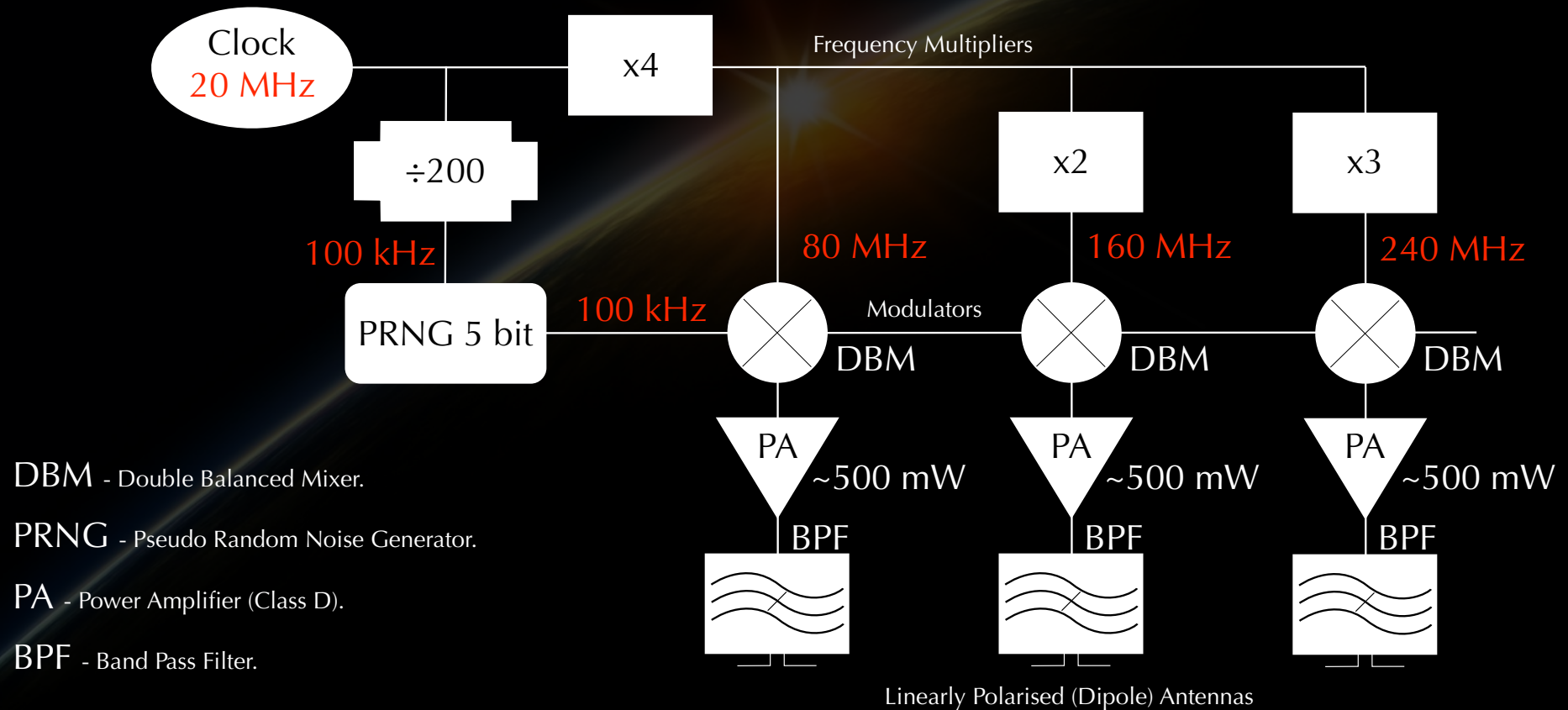
$$\beta = RM \times \lambda^2$$

Faraday Rotation in the Ionosphere

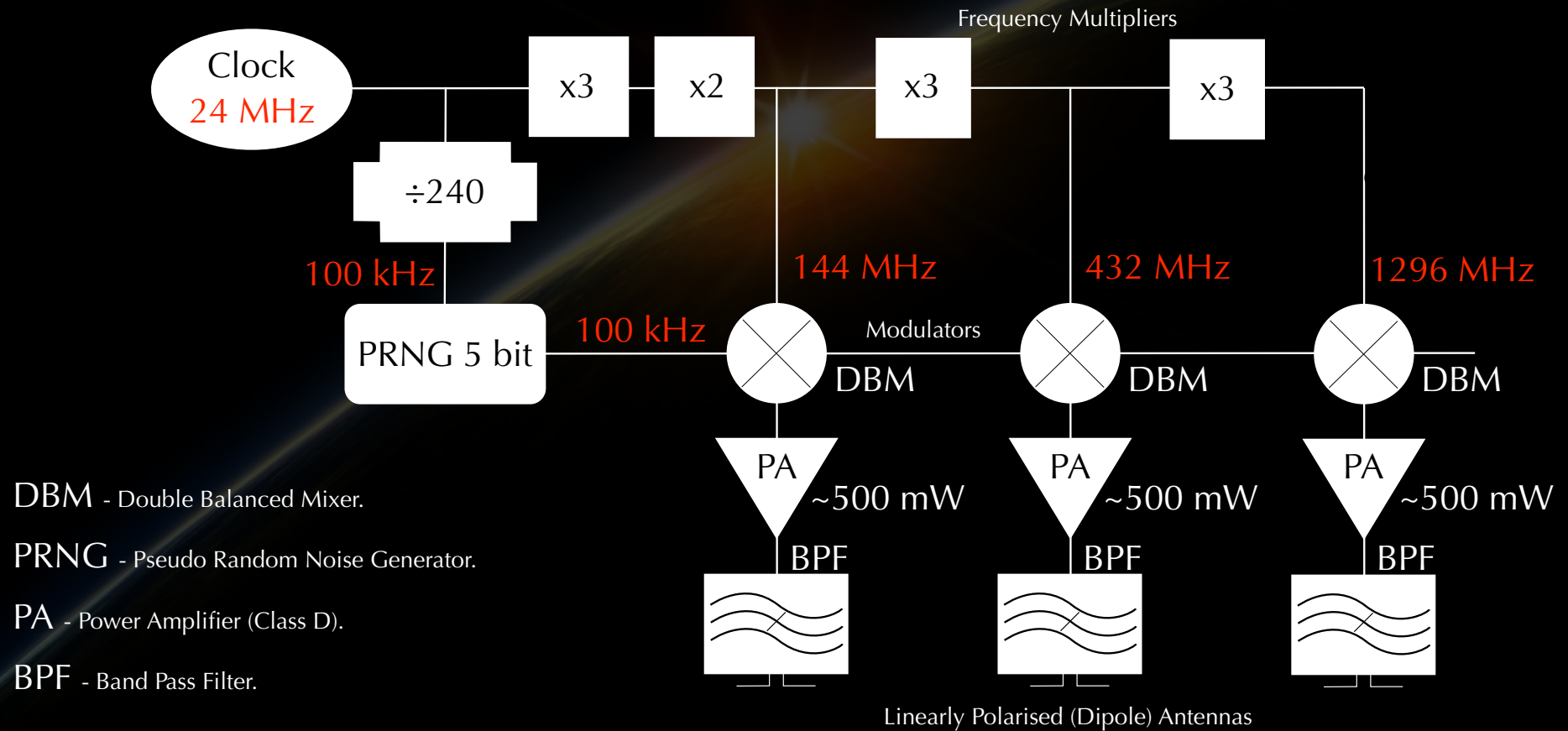
FR for 1 TECU	Observation Frequency (MHz)				
Observation Elevation (°)	50	80	160	240	300
30	3.9917 π	1.5593 π	0.3898 π	0.1732 π	0.1109 π
45	2.5758 π	1.0062 π	0.2515 π	0.1118 π	0.0716 π
60	1.8763 π	0.7329 π	0.1832 π	0.0814 π	0.0521 π
75	1.4893 π	0.5818 π	0.1454 π	0.0646 π	0.0414 π
90	1.2535 π	0.4896 π	0.1224 π	0.0544 π	0.0348 π

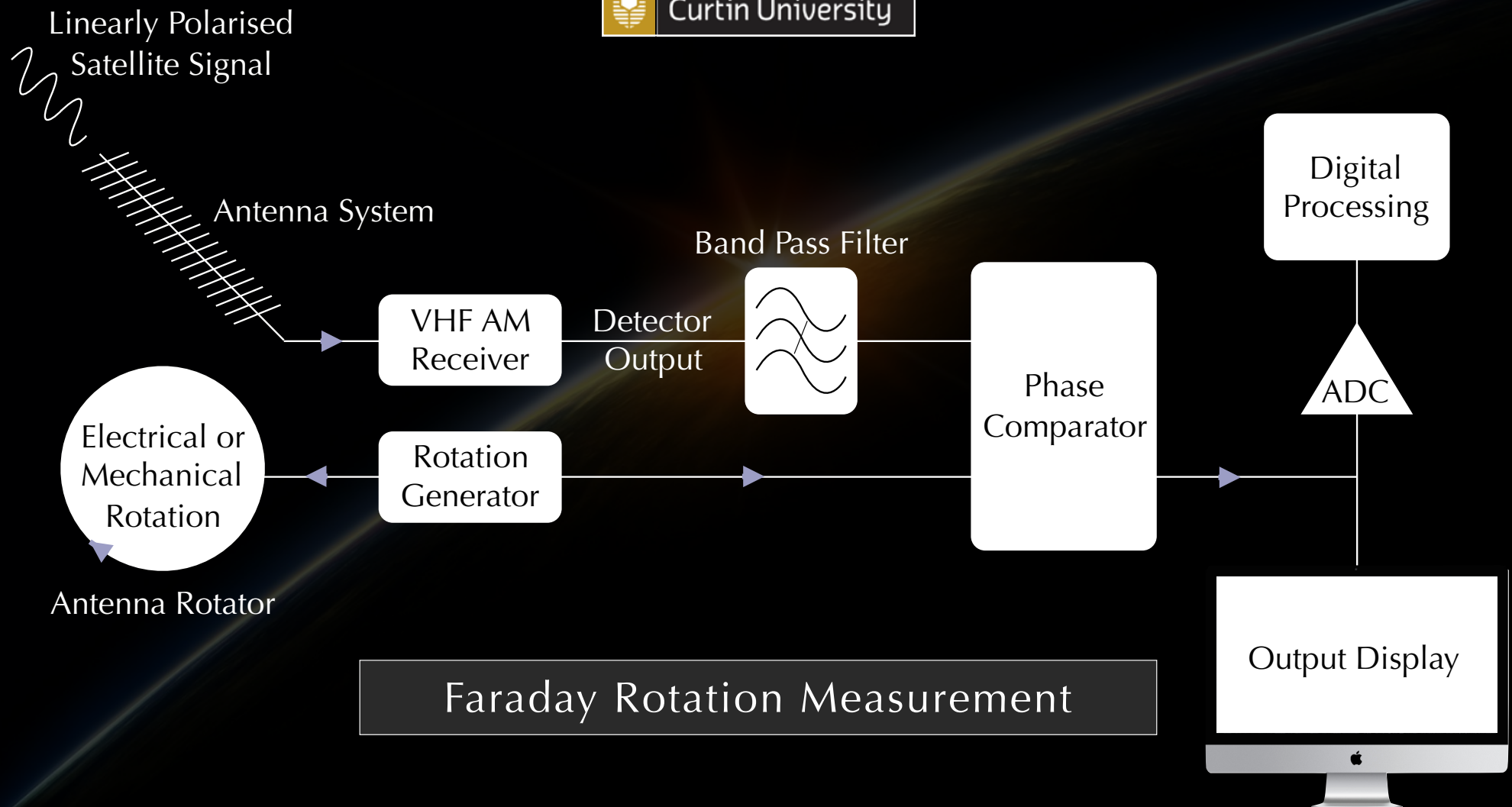
FR is the ionospheric Faraday rotation in radians.

Proposed Three Frequency Satellite Radio Beacon

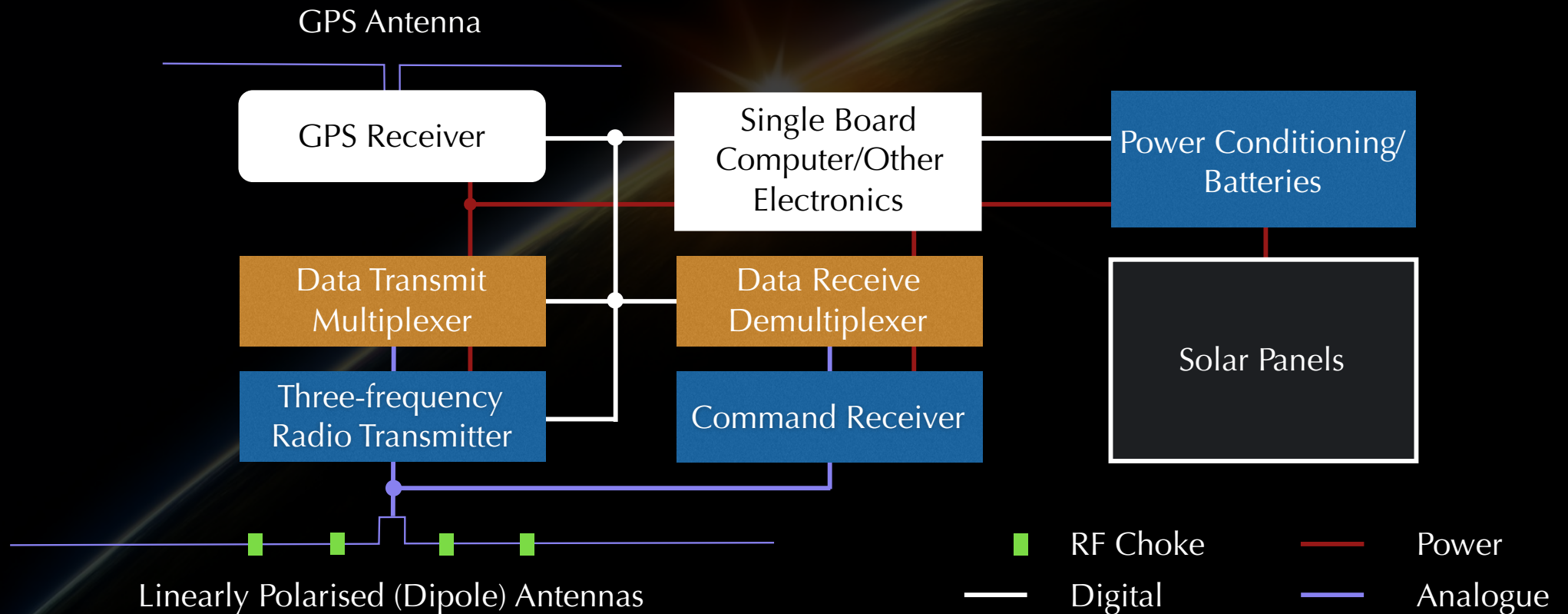


Alternate Beacon in the Amateur Radio Band

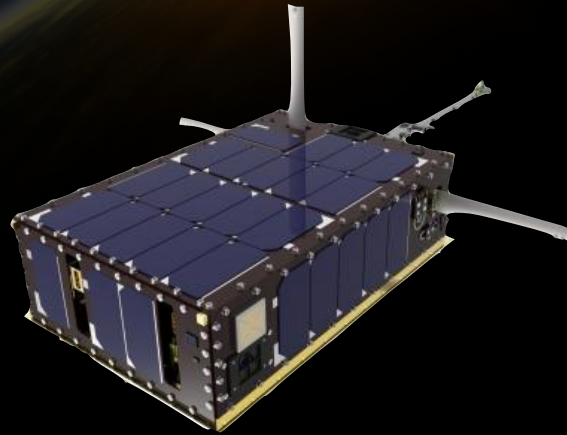




Possible Systems Architecture



The case for low-frequency radio astronomy
finds a parallel in the case for space weather
studies.



References

Essex, E. A. (1987). On Monitoring the State of the Ionosphere Using a Multifrequency Beacon on the Next generation of AUSSAT Satellites. Third National Space Engineering Symposium. Canberra, 30 June - 2 July.

Cousins, M. (2010). A CubeSat Radio Beacon Experiment: CUBECON – A Beacon Test of Designs for the Future. CubeSat Developers Workshop. San Luis Obispo. California, April 23.

Kennewell, J. A. (1987). An Australian Geosynchronous Satellite Radio Beacon. Third National Space Engineering Symposium. Canberra, 30 June - 2 July.

Herne D. E. (2016). The Australian Mid-latitude Continental Ionosphere with Respect to Low-frequency Radio Astronomy. Thesis for the Degree of Doctor of Philosophy of Curtin University.

Thank you

