32T System Specification

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1 Introduction

The Murchison Widefield Array (MWA) is a dipole-based aperture array synthesis telescope designed to operate in the 80-300 MHz frequency range. It is capable of a wide range of science investigations, but is initially focused on three key science projects. These are detection and characterization of 3-dimensional brightness temperature fluctuations in the 21cm line of neutral hydrogen during the Epoch of Reionization (EoR) at redshifts from 6 to 10; solar imaging and remote sensing of the inner helliosphere via propagation effects on signals from distant background sources; and high-sensitivity exploration fo the variable radio sky.

The complete array design features 8192 dual-polarization brad-band active dipoles, arranged into 512 "tiles" comprising 16 dipoles each. The tiles are quad-randomly distributed over an aperture 1.5Km in diameter, with a small number of outliers extending to 3Km. All tile-tile baselines are correlated in custom FPGA-based hardware, yielding a Nyquist-sampled instantaneous monochromatic uv coverage and unprecedented point spread function quality The correlated data are calibrated in real time using novel position-dependent self-calibration algorithms. The array is to be located in the Murchison Shire of Western Australia. This region is characterized by extremely low population density and a superbly radio-quiet environment, allowing full exploitation of the instrumental capabilities.

A pathfinder telescope comprised of 32 tiles (32T) allows us to validate the design of the basic engineering building blocks necessary for the later deployment of the full 512 tile (512T) system as well as gathering some operating experience in the implementation of embedded signal processing algorithms.

2 References

3 512T System

For reference purposes we provide here a summary of the 512T design

3.1 Performance Specification

Frequency range	80-300 MHz
Number of receptors	8192 dual-polarization dipoles
Number of antenna tiles	512
Number of baselines	130,816
Collecting area	~8000 m^2 (at 200 MHz)
Field of View	~15^o – 50^o (1000 deg^2 at 200 MHz)
Configuration	Core array ~1.5 Km diameter (97% of area); Extended array ~3 Km diameter (3% of area)
Bandwidth	230 MHz (Sampled); 30.72 MHz (Processed)
Spectral channels	1024 (30 KHz spectral resolution)
Temporal resolution	0.5 sec uncalibrated; 8 sec calibrated
Polarization	Full Stokes
Continuum point source sens.	20 mJy in 1 sec (at 200 MHz full bandwith); 0.34 mJy in 1 hour
Array voltage-beams	32, single polarization

3.2 Implementation

3.2.1 Tiles

16 dual-polarization dipoles are distributed over a ground screen in a 4 x 4 array. Each dipole contains 2 Low Noise Amplifiers, one for each polarization. The 16 X and 16 Y signals are the combined in a beamformer that uses analog delay lines to produce a 15 – 50 degree frequency-dependent beam that can be steered to elevations above 30 degrees. The resulting single analog X and Y signals, which at this point cover then entire 80 – 300 MHz frequency range of interest are transmitted to a Receiver.

3.2.2 Receivers

In the Receiver the tile X and Y signals are converted to 5-bit digital quantities and digitally filtered into coarse a selectable set of 24 1.29 MHz channels. As a matter of convenience, the signals from 8 tiles are thus processed in a single receiver assembly; we now have 16 x 24 separate data streams that are fed to the Central Hardware Data Processor.

3.2.3 Central Hardware Data Processor

In the first pass a Polyphase Filter Board splits each 1.29MHz data streams into 128 10KHz data streams and reorders the data for presentation to the Correlator Board which performs the actual cross- and auto-correlation functions.

3.2.4 Real Time Computer/Software

Visibility binner, mapper, foreground predictor, ionospheric calibration, and instrumental calibration

3.2.5 Monitor & Control

The Monitor & Control software package, running on a machine separate from the RTC, is needed to control the operation of the beamformer, receivers, and central hardware data processor, coordinating all this with the operation of the Real Time Software. It is also responsible for archiving the state of the instrument during observations.

4 32T System

As a pathfinder system, the 32T instrument has a reduced set of basic design requirements as well as certain demonstrations of feasibility that the 512T will meet its scientific goals.

4.1 Design Requirements

Req. ID	Requirement	Value
4.1.1	Frequency Range	80-300 MHz
4.1.2	Number of Receptors	512 dual-polarization dipoles
4.1.3	Number of Antenna Tiles	32
4.1.4	Number of Baselines	496
4.1.5	Collecting Area	~560 m^2 at 200 MHz
4.1.6	Field of view	~15 x 50 deg at 200 MHz
4.1.7	Configuration	Array covers ~300 m diameter circle
4.1.8	Bandwidth	230 MHz (Sampled); 30.72 MHz processed
4.1.9	Spectral Channels	1024 (30 KHz spectral resolution)
4.1.10	Temporal Resolution	0.5 sec uncalibrated; 8 sec calibrated
4.1.11	Polarization	Full Stokes
4.1.12	Point Source Sensitivity	320 mJy in 1 sec (at 200 MHz)
4.1.13	Array voltage-beams	Not implemented

4.2 Demonstrations

Req. ID	Test	Requirement
4.2.1	Orbsomm beam maps (137MHz)	Tile beams respond smoothly with angle and match a simple analytic model
4.2.2	RFI Excicision	Demonstrate efficacy of algorithms
4.2.3	Diurnal power variation	Variations consistent with sky over several days of observation
4.2.4	Antenna position via Interferometry	Show consistency with GPS measurements
4.2.5	FFT Imaging at 3 frequencies	Make images in real time
4.2.6	FFT Imaging at 3 frequencies	Show consistency with modeling over track
4.2.7	Produce All-Sky Map with 3 frequencies and 3 Pointings	Demonstrate end-to-end ability to produce all-sky maps over full FOV
4.2.8	Repeat All-Sky Map	Demonstrate consistent day-to-day results
4.2.9	Track and Image a Field over s period >6 hr	Generate calibrated, integrated images at multiple frequencies on multiple days
4.2.10	Observe DMSP F15 satelllite	Measure polarization of a known source
4.2.11	Coordinated Operation	Demonstrate a useful Monitor & Control environment for telescope operations

Revision History

Rev Ltr	Date	Author	Description
01	2010-03-03	RFG	Initial Draft