

*MASTR V: A Software Defined Base Station for
Public Safety*

R. Menon, P. Grissom & R. Taylor
Harris Corporation
RF Communications Division

- Introduction to MASTR V
- Features
- Hardware Architecture
- Software Architecture
- Summary

- SDR base station for Land Mobile Radio Systems
- SDR design methodologies
 - Direct Digital Synthesis
 - FPGA designed using Simulink-based tools
 - Digital transmit power control
 - Digital automatic gain control
 - Polar feedback based PA linearizer
 - Digital calibration
- Software reconfigurable for multiple, potentially arbitrary waveforms
 - P25 Phase I and II
 - Opensky®
 - High speed data EDACS
 - WCQPSK linear simulcast
 - QAM

- IP communication framework (including IP backplane)
- Modular software and hardware architecture
- Advantages
 - Flexible and scalable
 - Supports remote code-loads and configuration
 - Remote IP-addressable modular testing capability
 - Easily reconfigurable for multiple operation modes
- Operation bands
 - Can be tailored for different bands by swapping some modules
 - Current operational bands - 800 MHz and 700 MHz
 - UHF and VHF currently under development

MASTR V: Features



- Typical MASTR V rack configuration
 - 14 slot modular T/R assembly
 - 4 TX modules
 - 4 RX modules
 - 4 HPA/Linearizer integrated assemblies
 - 4 Traffic Controller modules
 - 2 Baseband modules
 - 4 RF Channels
 - 2 Power supply
 - 4 HPA/Linearizer integrated assemblies
- Configuration is highly flexible
 - E.g. can support multiple receiver modules per channel for receiver diversity



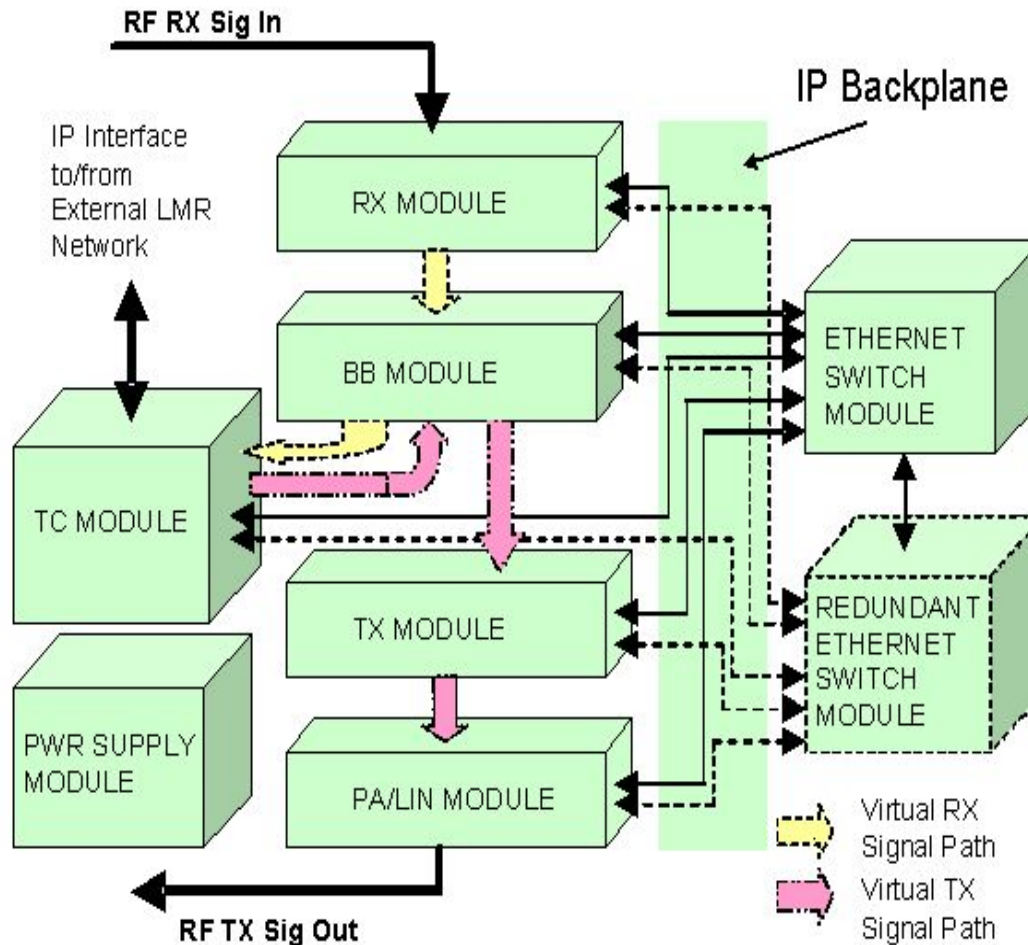
Table 1: MASTR V Transmitter Specifications

Frequency Range	851 - 869 MHz
Modes of Modulation	C4FM (P25 Phase 1), WCQPSK (Linear Simulcast), HDQPSK (P25 Phase 2)*
RMS RF Output Power	10 - 100 Watts -0/+0.79 dB
Modulation Emission Spectrum	Meets 47 CFR 90.210 (d), (g), (h) and NTIA Manual part 5.3.5.2
Frequency Stability	< 0.15 ppm
RF Output Impedance	50 ohms
Radiated and Conducted Spurious Emissions	< -70 dBc

Table 2: MASTR V Receiver Specifications

Frequency Range	799 - 816 MHz
Modes of Modulation	C4FM (P25 Phase 1 and Linear Simulcast), and HCPM (P25 Phase 2) [†]
Static 5% BER Sensitivity	Better than -118 dBm
Adjacent Channel Rejection	≥ 60 dB for C4FM
RF Input Impedance	50 ohms
Frequency Stability	< 0.15 ppm
Signal Displacement Bandwidth	> ± 1.0 kHz
Spurious and Image Rejection	≥ 90 dB

Hardware Architecture and Functional Flow



Seven different modules

- RF Modules
 - Transmitter (TX)
 - Receiver (RX)
 - Power Amplifier with Linearizer (PA/LIN)
- Baseband (BB) Module
- Traffic Controller (TC)
- Ethernet switch
- Power supply (PS)

All software controlled except PS

- All software modules are connected to IP backplane

- **Functions**
 - In charge of two 2 RF channels
 - 2TX, 2 RX, 2 PA/LIN, 2 TCs
 - Distributes operation parameters and monitors health of channels
 - Handles the transmission data
 - Narrowband filtering
 - Demodulation/modulation of data
 - Diversity processing
- **Has two processors**
 - Power PC MPC8321 – Responsible for control and administration
 - TI DSP TMS3206455 – Responsible for data handling

- **Receiver Module**

- Primary Function: Converts of RF signal received at programmed frequency to baseband digital I/Q data
- Components:
 - TI DSP TMS320C6421 – Data handling, interfacing with Ethernet
 - Down-convertoir to IF
 - High performance ADC at IF

- **Transmitter Module**

- Primary Function: Converts baseband digital I/Q data to RF signal on programmed frequency
- Components:
 - TI DSP TMS320C6421 – Data handling, interfacing with Ethernet
 - Altera Stratix II FPGA – Implements various interpolation stages
 - DDS for IF conversion and high speed DAC
 - Up-convertoir from IF

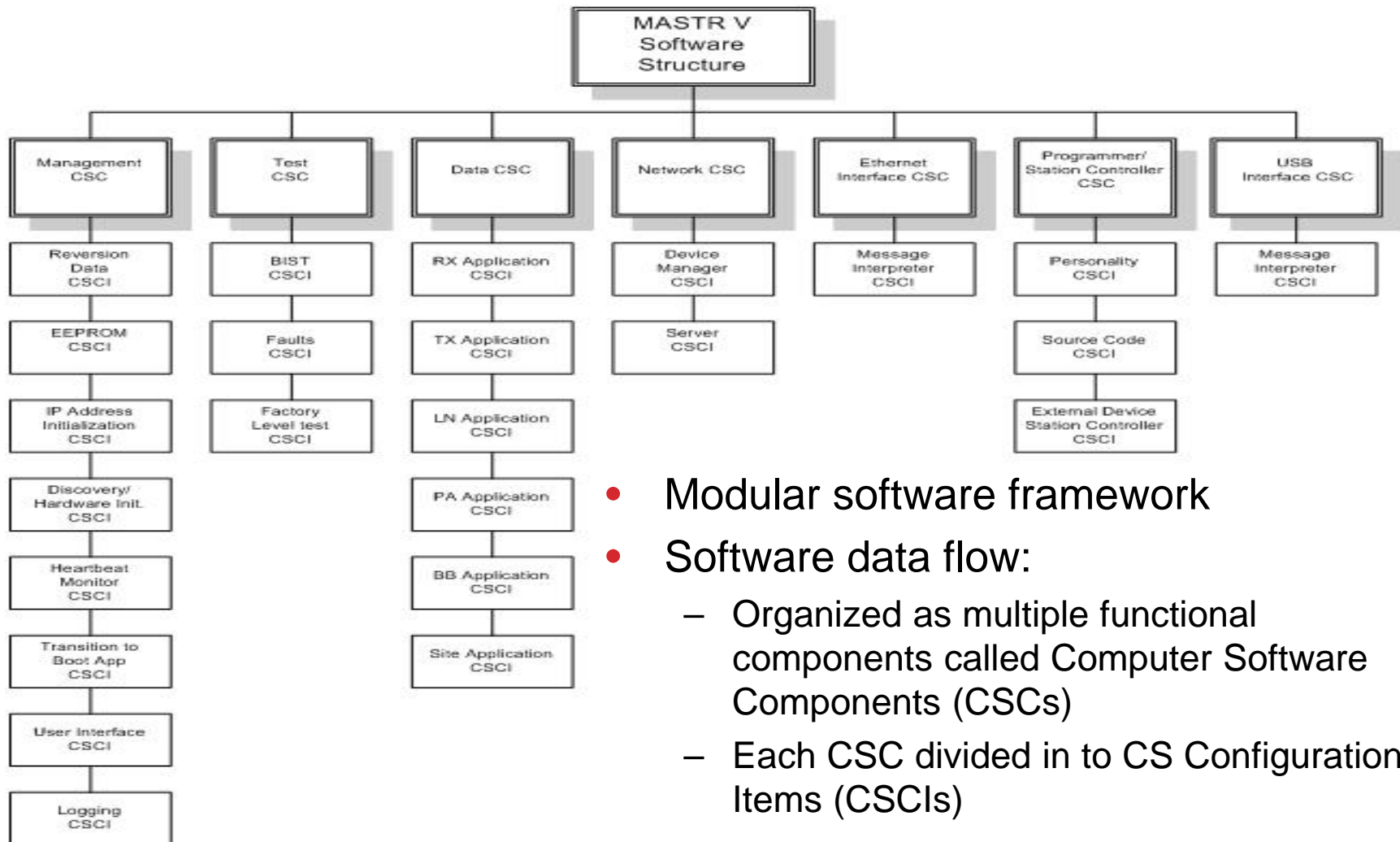
- PA/ Linearizer Module
 - Primary Function: Amplifies exciter output of TX module to base station output level
 - Output level – 10-100watts
 - Linearizes output signal for non-constant envelope signals
 - Components:
 - Polar linearizer subsystem
 - RF High Power Amplifier
 - TI DSP TMS320C6421
 - Interfaces with Ethernet
 - Continual self calibration
 - Continual monitoring of the linearizer and HPA performance

- Functions:
 - Receive path – Decode/interpret data message from BB
 - Transmit path – Code/format data message to BB
 - Provide VoIP interfacing to LMR network
 - Control all aspects of trunking

- Processor
 - PowerPC MPC8360 processor

- Primary Function:
 - Route Ethernet traffic across backplane

- Redundancy of Ethernet connection
 - 2 Switches on each shelf
 - Novel monitoring protocol on switches
 - Minimize duplicate traffic
 - Fast automatic detection of faulty connection on any switch



- Modular software framework
- Software data flow:
 - Organized as multiple functional components called Computer Software Components (CSCs)
 - Each CSC divided in to CS Configurations Items (CSCIs)

- Most critical CSC
- All communication between modules confined to IP messages
- CSC sets up and controls the LAN on the IP backplane
- All IP messages are anchored to the BB module
- Streamlines the operation of the station
 - Flexible
 - Easily reconfigurable

- Control and coordination of module operation across backplane
- Important CSCIs
 - Discovery and hardware initialization CSCI:
 - Orchestrated by BB Module
 - Identifies all associated modules on shelf
 - Distributed initialization parameters
 - Heartbeat CSCI:
 - All modules are periodically pinged by the BB module
 - Monitors health of channel and modules

- Data handling across backplane
- Components:
 - Rx application CSCI:
 - Acquires and transmits I/Q data to BB at required rate
 - TX application CSCI:
 - Receives I/Q data from BB and processes it at required rate
 - Orchestrates power-loop between TX and PA/LIN modules in accordance with data transmission
 - PA/LIN application CSCI
 - Operates power-loop and PA in accordance with data transmission
 - BB application CSCI
 - Receive data path
 - Transmit data path

- Test CSC
 - BIST, POST, Operation faults, Software exceptions, messaging faults
- Network CSC
 - Interface to external tool to set-up operation for station
 - Interface to external networks
- Programmer CSC
 - Code-loads to station
- USB CSC
 - Access fault logs, access test mode, configure IP

- SDR-based multi-mode base station
 - Capable of multiple waveforms using simple software changes
- IP Backplane
 - Facilitates modular architecture
 - Plug and play components
 - Easily reconfigurable
 - Supports remote test capabilities
- Novel polar feedback linearizer
- Ease of software control and processing capability make it amenable for Cognitive Radio Techniques

Questions/ Comments