RDECOM

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Wireless and Modular Test Equipment Design for Weapon System Sustainment

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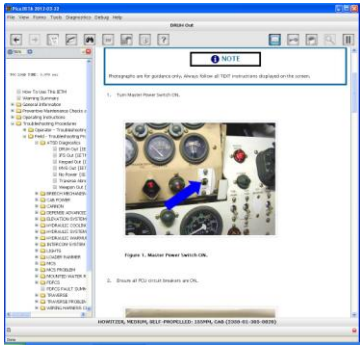
Current Army Maintenance Philosophy

Vehicle Embedded Diagnostics

Crew & Field Mechanic:

- Operational Status Reporting
  - Fault Detection 97%
  - Fault Isolation 36%

At-Vehicle Field (MSD)



At-System with IETM

Field Mechanic:

- Fault Isolation:
  - 65% TM Only
  - 98% w At System
- Remove/Replace
- Parts Ordering

Sustainment (NGATS)

Test Program Sets

Depot Level:

- Fault isolation down to a single circuit card or component within a circuit.

Traditional At-System / At-Vehicle Diagnostics

- Crew calls Maintenance Personnel to diagnose problem or fault code.
- Maintenance Personnel use custom troubleshooting equipment designed specifically for the vehicle under test:
  - Test Cables
  - Test Adapters
  - Interface Device / Measurement Hardware

- Previous philosophies require an interface device and/or measurement equipment that contains all the special measurement and stimulus hardware necessary to diagnose any fault on a vehicle or weapon system.
  - Technologies vary across platforms
  - As technology advances, different Line Replaceable Units (LRUs) may be introduced onto a vehicle, which will require additional measurement and stimulus capability

- Solution: Develop flexible architecture for measurement equipment that can be used across a wide variety of platforms with little or no modification

Proposed Solution

Proposed Solution:

- Inexpensive
- Handheld, improves usability and reduced footprint
  - Estimated size of 3.5” x 3.5” x 3.5”
- Lightweight
  - Less than 3lbs when fully assembled
- Modular design reduces cost of future hardware update
- Government-owned design with Level 3 TDP
- Wireless and USB connections to MSD
  - Improves usability and reduces number of cables needed
- Design includes Ethernet
  - This can mitigate MSD IA risk (Limitations to using Ethernet on MSD)

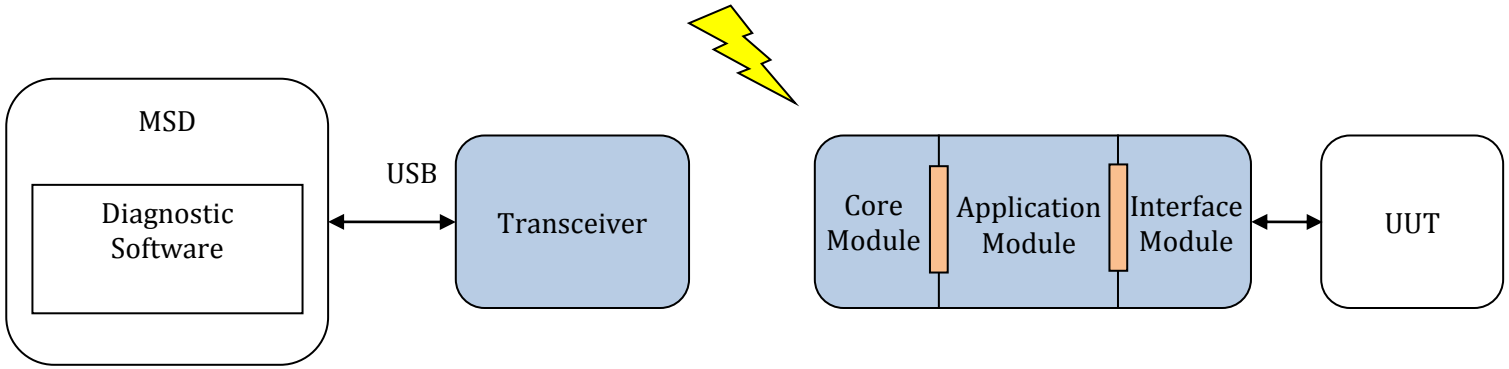
Wireless Acquisition Module (WAM)

Wireless Acquisition Module (WAM) Theory of Operation:

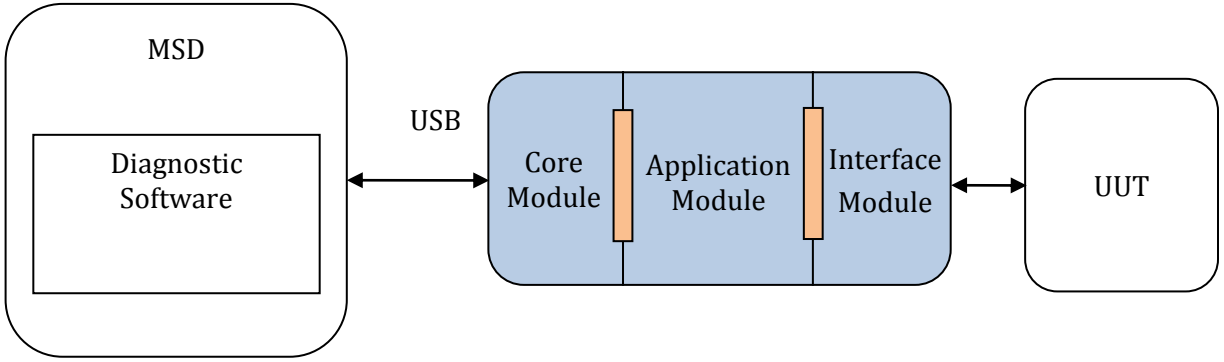
- The system consists of two main components:
  - Transceiver
  - Data Acquisition Device (3-piece design)
- The Transceiver connects to the MSD and provides a USB to IEEE 802.15.4 Wireless gateway to the DAQ Device
- The Data Acquisition Device is split into three subcomponents: a Core Module, an Application Module and a Test Adapter
  - Complex processing, power and system interfaces are in the Core Module and all application specific circuits are in the Application Module. The Test Adapter performs signal routing from the UUT to test hardware.
  - The mechanical and electrical interfaces between the DAQ subcomponents are defined such that any one piece can be replaced independently of the other
- A wireless interface between the MSD and DAQ minimizes cabling while a wired interface is retained to facilitate special functions like charging and firmware updates.
- Wireless design also allows for better mobility within a vehicle or weapon system.
- Two additional accessories, the Charger and the Self Test Adapter, allow plug in fast charging and self testing of the electronics in the Core Module and Application Module

WAM – Theory of Operation

Wireless Operation

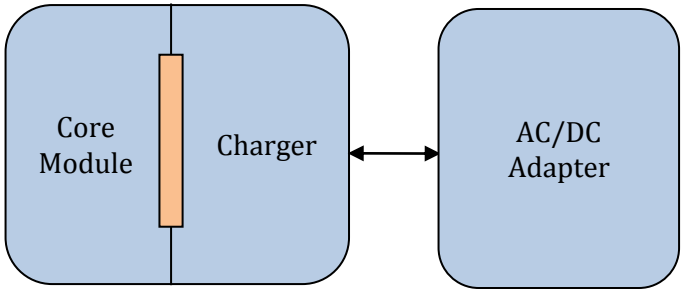


Wired Operation

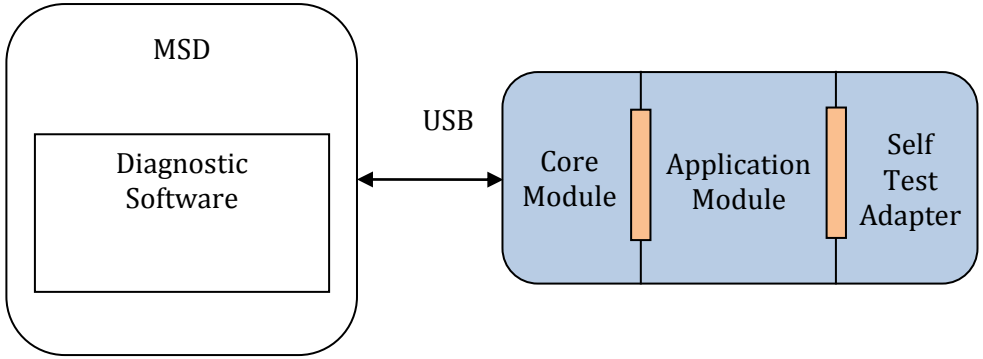


WAM – Theory of Operation

Charging



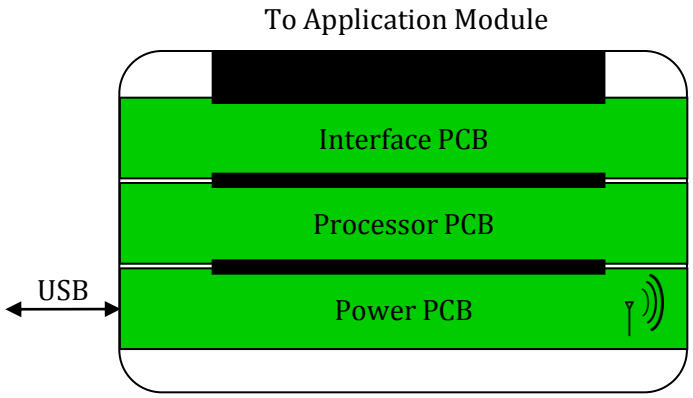
Self Test



WAM Core Module Design

Core Module Specifications:

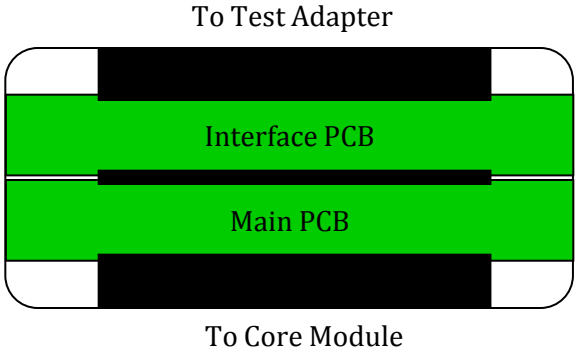
- Three PCB design with stacked board to board connectors
- Arm Cortex-M3 microcontroller running at up to 120 MHz
- Internal Lithium Iron Phosphate rechargeable battery
  - Battery life is comparable to a Li+ battery
  - Size is slightly larger a AA battery
- All external I/O is ESD protected
- Rugged USB Mini-B connector with isolated USB interface
- Three color LED status indicator
- Pushbutton power on/off switch
- Wireless Module and USB IC
- Application Module Interface
  - Power (5V,+/- 15V and battery)
  - 2x 12-bit Differential Analog Input Channels with programmable gain from +/-10mV to +/-10V
  - 2x 12-bit Analog Output Channels with +/-10V Range
  - 2x TTL level UARTS
  - CAN Bus (TTL Level)
  - Ethernet (No Isolation Transformer)
  - USB 2.0 On-The-Go Full Speed
  - I2C Bus
- Estimated runtime >6 hours (dependent on use)
- Estimated time to charge from USB ~4 hours

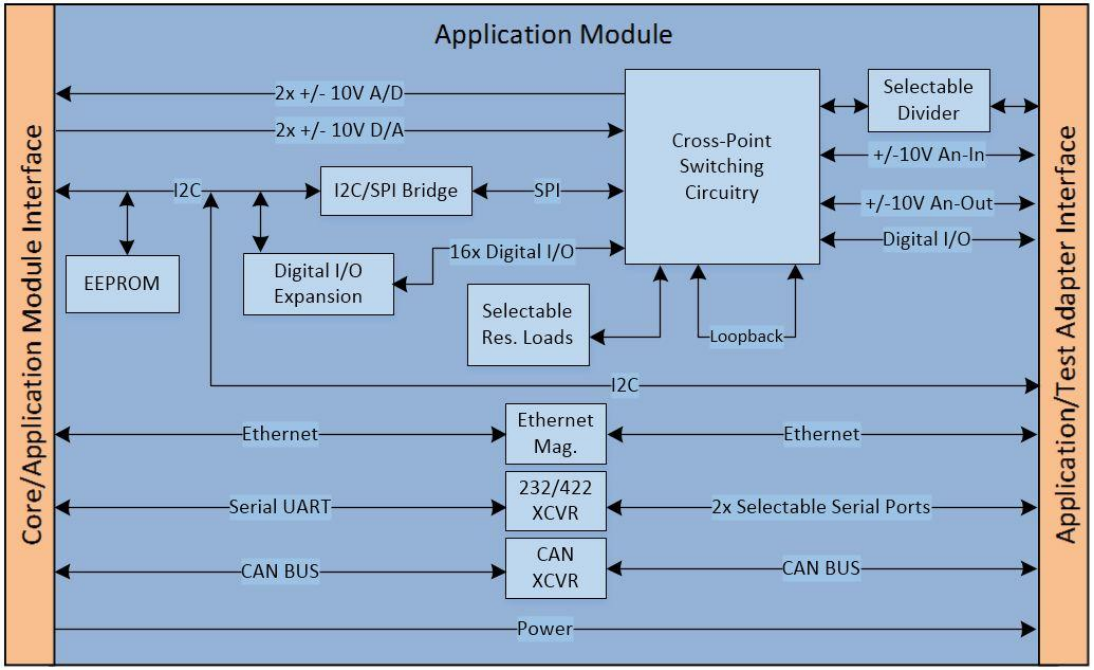


WAM Application Module Design

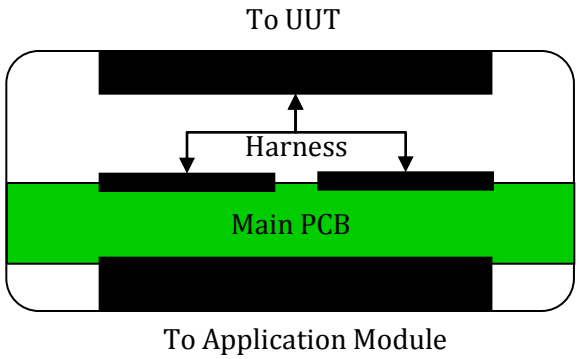
Application Module Specifications:

- Two PCB stacked design (Space and mounts for three PCBs)
- All external I/O is ESD protected
- Provides conditioning and switching for signals between unit under test and Core Module



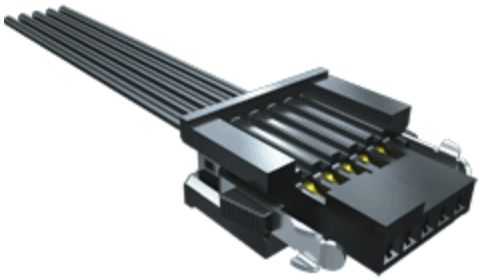


WAM Interface Module Design



Interface Module Specifications:

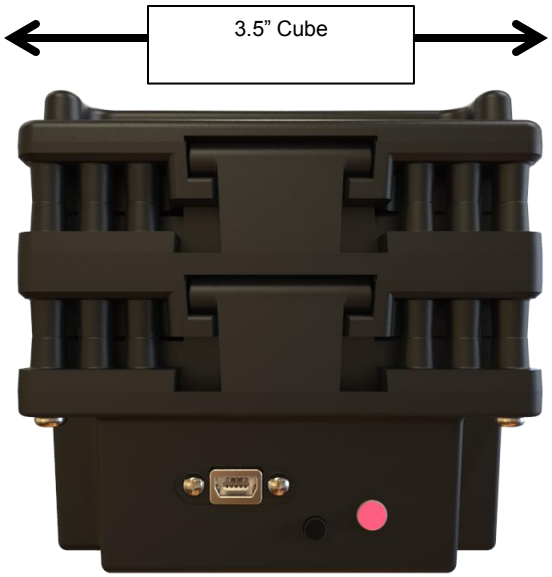
- No active circuitry
  - PCB and Resistors
- Provides routing of circuitry between Application Module and UUT connector
- Two board mount connectors connect to a custom harness.
  - Harness is built using Samtec 50 pin harness connectors populated with 28 AWG wires pre-cut to the appropriate length (~$12 each)
  - These prebuilt ends greatly reduce technician assembly time
- For 3D model, a 78 Pin D-Sub connector was used.
  - Connector can be replaced with a MIL Circle or “Pig-tail” as required.



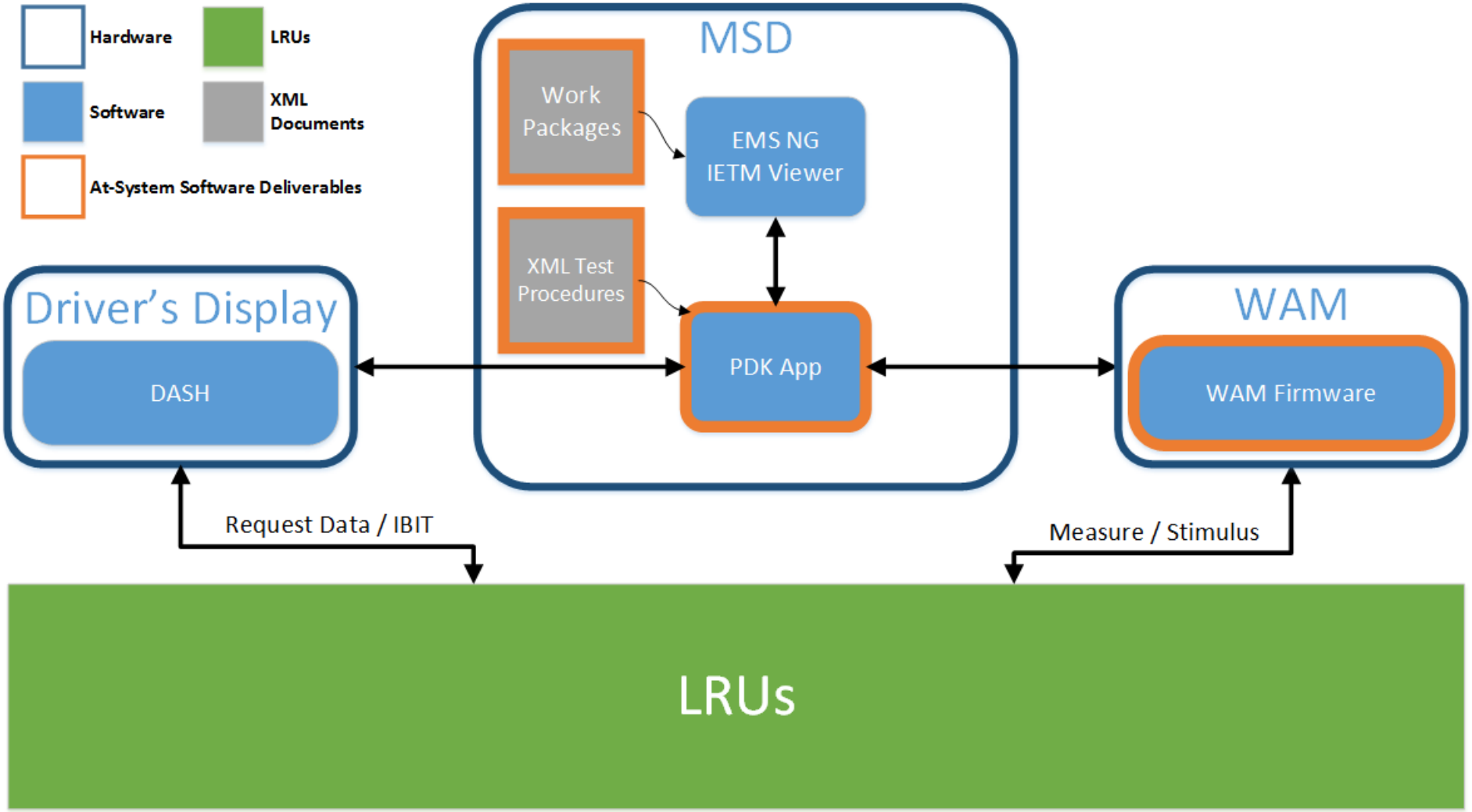
WAM Design Considerations

Assembly Specifications / Design Considerations:

- When fully connected, the Core Module, Application Module, and Test Adapter form a 3.5” cube
  - Maneuverable; easily fits in one hand
- Assembly weighs ~1.5lbs
  - Lightweight; keeps system bulk down
- Keying between modules prevents incorrect assembly
  - Enhances usability; reduces likelihood of accidental damage caused by user error
- Modules are latched together to create a firm connection
  - Prevents intermittent failures
- Electrical connection made between modules via spring-loaded pins
  - Rated for 2A current
  - Rated for 1,000,000 mating cycles



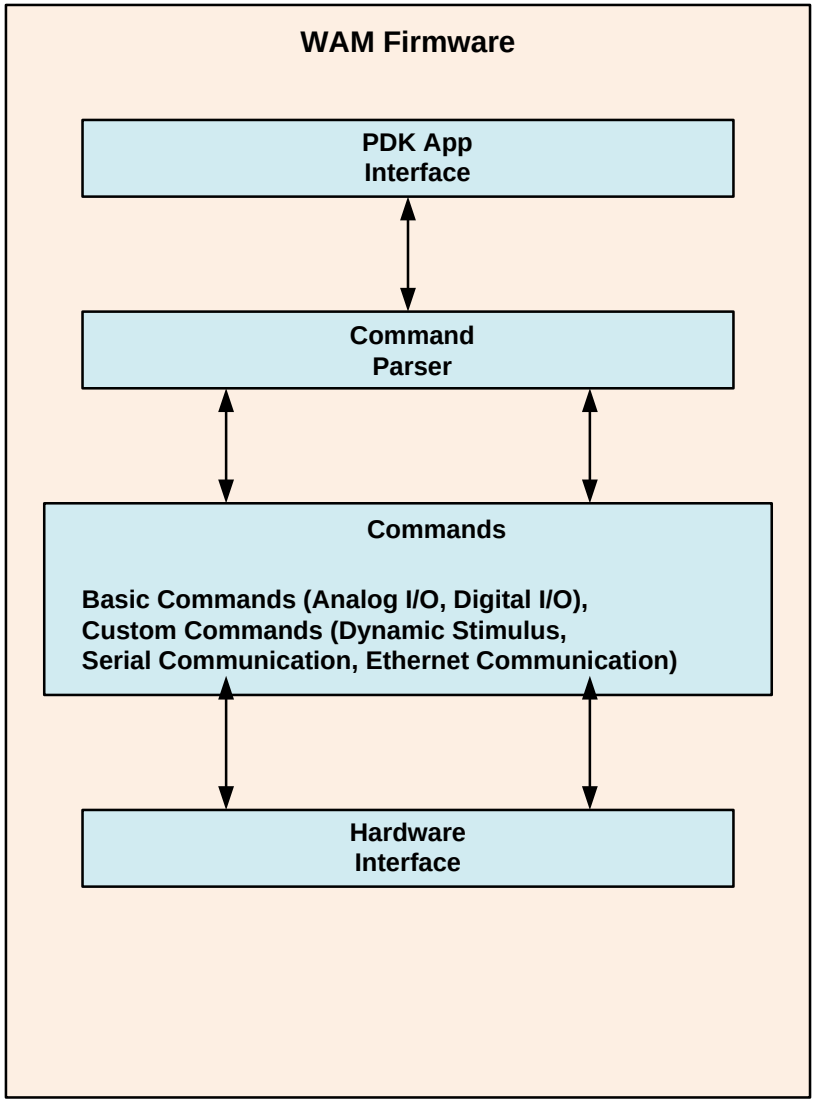
M109A7 - WAM Software Overview



WAM Firmware

- Executes instructions from the MSD At-System software:
  - Performs analog or digital measurements on an LRU.
  - Transmits an analog or digital stimulus to the LRU.
  - Transmits an analog or digital waveform to the LRU.
  - Performs specific serial and Ethernet communication test on the LRU.
- Firmware upgrade capability.
  - Ability to check firmware version and flash new version of firmware to WAM.
- ARM Cortex-M3 firmware written in C.
  - Using ChibiOS/RT real time operating system.
  - Source code managed through ProjectForge.
- Initial configuration of operating system complete and running on WAM prototype hardware

WAM Firmware Architecture



WAM Future Improvements

Future work with the WAM looks to add the following enhancements:

- Optimize latching mechanisms and enclosure for better durability
- Additional application modules with increased functionality
  - Ethernet communication
  - CAN communication
  - High speed serial communication
  - Video / audio generation
- Implement mesh networking to have multiple WAMs in operation simultaneously to enhance diagnostic capability
- FIPS 140.2 certified

Conclusion

Development of a modular and wireless piece of test equipment enables the following benefits in weapon system sustainment:

- Easier to use than older bulkier systems:
  - 3.5” cube is easily maneuverable on-platform
  - Wireless capability reduces system from being tethered to MSD
- Increased flexibility to adapt to new platforms and emerging technologies
  - Rather than developing new pieces of test equipment, only a new application module is necessary to address most test needs
  - Core software does not change and project-specific software modules are added if needed.

Questions