Transforming Your Maker Prototype to a Production-Ready Design

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Introductions

- Omar Rahim
  - Co-Founder, Director of Business Development
  - omar.rahim@criticallink.com
  - 315-425-4045 x208
- Bob Duke
  - MitySOM Product Line Technical Lead
  - bob.duke@criticallink.com
  - 315-425-4045 x279

Class Objective

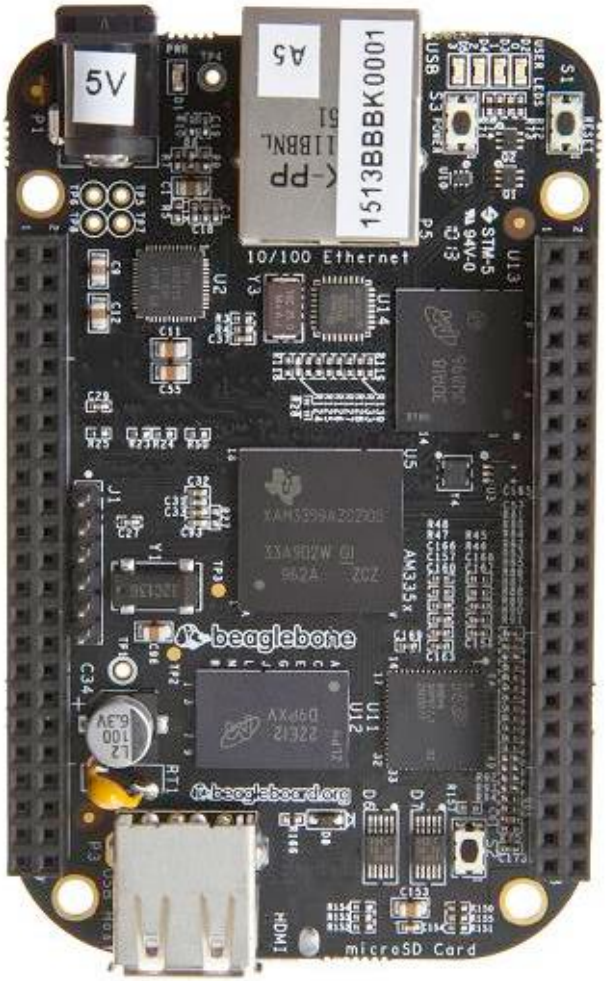
- This class will explain the design considerations necessary to convert your BeagleBone Black based design to a production-ready design using Critical Link's MitySOM Maker Board.

BeagleBone Black

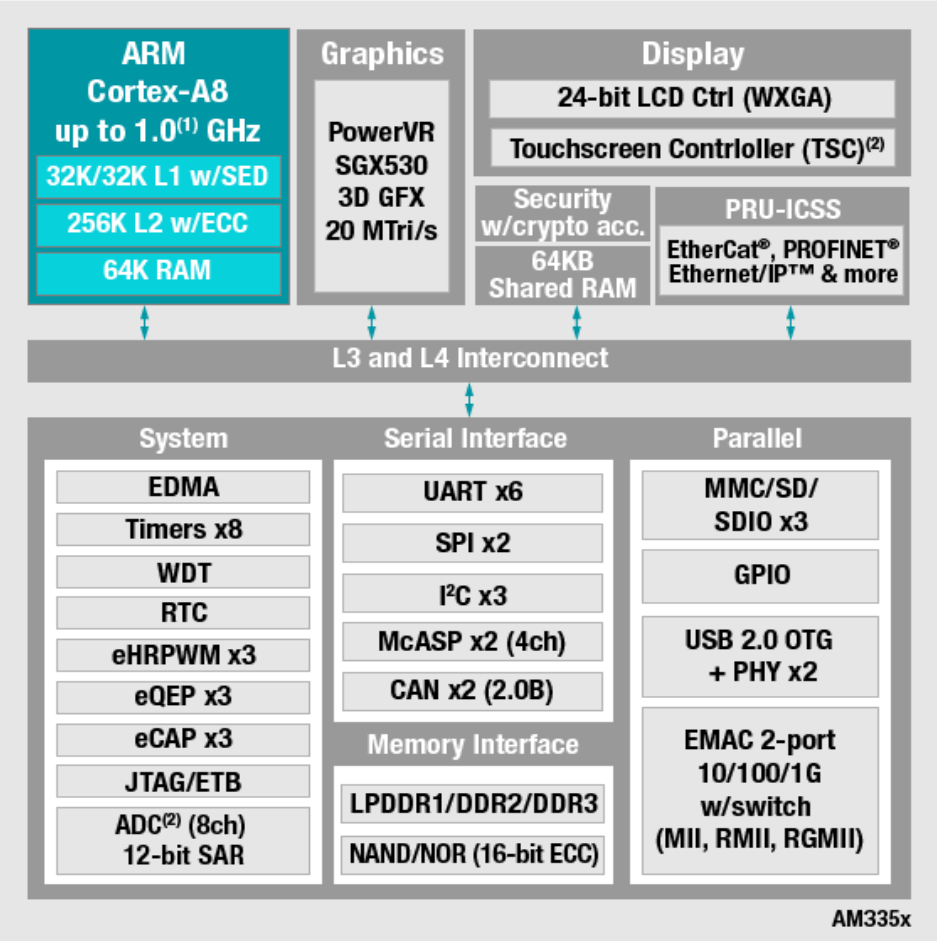
OPEN SOURCE HARDWARE

BeagleBone

- Embedded CPU
- Expandable I/O
- Open Source
- Based on Sitara AM335



Sitara AM335



NOTES:
(1) >800MHz available on 15x15 package,13x13 supports up to 600MHz
(2) Use of TSC will limit available ADC channels
SED: Single error detection/parity

Sitara AM335

AM335x Processors

	AM3359	AM3358	AM3357	AM3356	AM3354	AM3352	AM3351
ARM Cortex-A8 MHz (Max.)	800	600/ 800/ 1000	300/ 600/ 800	300/ 600/ 800	600/ 800/ 1000	300/ 600/ 800/ 1000	300/ 600
Graphics Acceleration	3D graphics	3D graphics			3D graphics		
PRU-ICSS for Industrial Communication*	Dual Core PRU + All Protocols	Dual Core PRU + Standard Protocols	Dual Core PRU + All Protocols	Dual Core PRU + Standard Protocols			
CAN	2	2	2	2	2	2	
Package	15x15 / 0.8mm	15x15 / 0.8mm	15x15 / 0.8mm	15x15 / 0.8mm 13x13 / 0.65mm	15x15 / 0.8mm 13x13 / 0.65mm	15x15 / 0.8mm 13x13 / 0.65mm	13x13 / 0.65mm
	Software and pin-for-pin compatible across devices						

* PRU-ICSS is a programmable real-time core for industrial communication protocols.

* Standard protocols for AM335x processors include protocols such as Ethernet/IP, PROFINET™ RT/IRT, PROFIBUS™, Sercos III, and more.

* All Protocols for AM335x processors include standard protocols plus EtherCAT™ and POWERLINK.

Benefits of Open Source Hardware

- Growth of BBB
  - BBB has been in the Top 10 most popular community-backed boards since 2014
- Capes & I/O support provide quick prototyping for new interfaces
- Community support via online forums
- Other benefits
  - Inexpensive
  - Design files available

Limitations of Open Source Hardware

- Community supported design
  - Issues are generally only supported through forums
  - No manufacturer support
- Industrial temp options are limited and can be hard to get
- **Availability can be a challenge, especially over longer terms (2-10 years)**
- **Design revisions can impact design without notice**
- Can design your own, but now sourcing components

Critical Link Solution

MITYSOM-335X

MitySOM-335x

1GHz Cortex-A8, 3D Graphics, Dual GigE, Dual CAN Bus

FEATURES:

- ❑ AM335x Cortex-A8 Applications Processor
  - ✓ 1GHz Cortex-A8 CPU, NEON SIMD Coprocessor
  - ✓ PowerVR SGX 3D Graphics Engine
  - ✓ 2 Programmable Real-time Units (PRU)
- ❑ 256 MB DDR3 (up to 1GB), 256 MB NAND Flash
- ❑ Integrated Power Management
- ❑ Small form factor, 2.7” x 1.5”
- ❑ Robust IO
  - ✓ 2 Gigabit EMACs, 6 UARTS, 2 USB, 2 CAN,
  - ✓ 24-bit WXGA LCD + Touch Screen Controller
  - ✓ SGX530 3D Graphics Accelerator
  - ✓ 3 MMC/SD/SDIO, 2 4-Channel McASP
  - ✓ 2 SPI, 3 I2C, GPIO
  - ✓ WDT, RTC, 3 eHRPWM, 3 eQEP, PRCM
  - ✓ ADC: 8 Channel 12 bit SAR

Applications

- ❑ Industrial Automation
- ❑ Smart Toll Systems
- ❑ Weighing Scales
- ❑ Connected Vending Machines
- ❑ Medical Appliances
- ❑ Gaming Equipment
- ❑ Measurement Devices

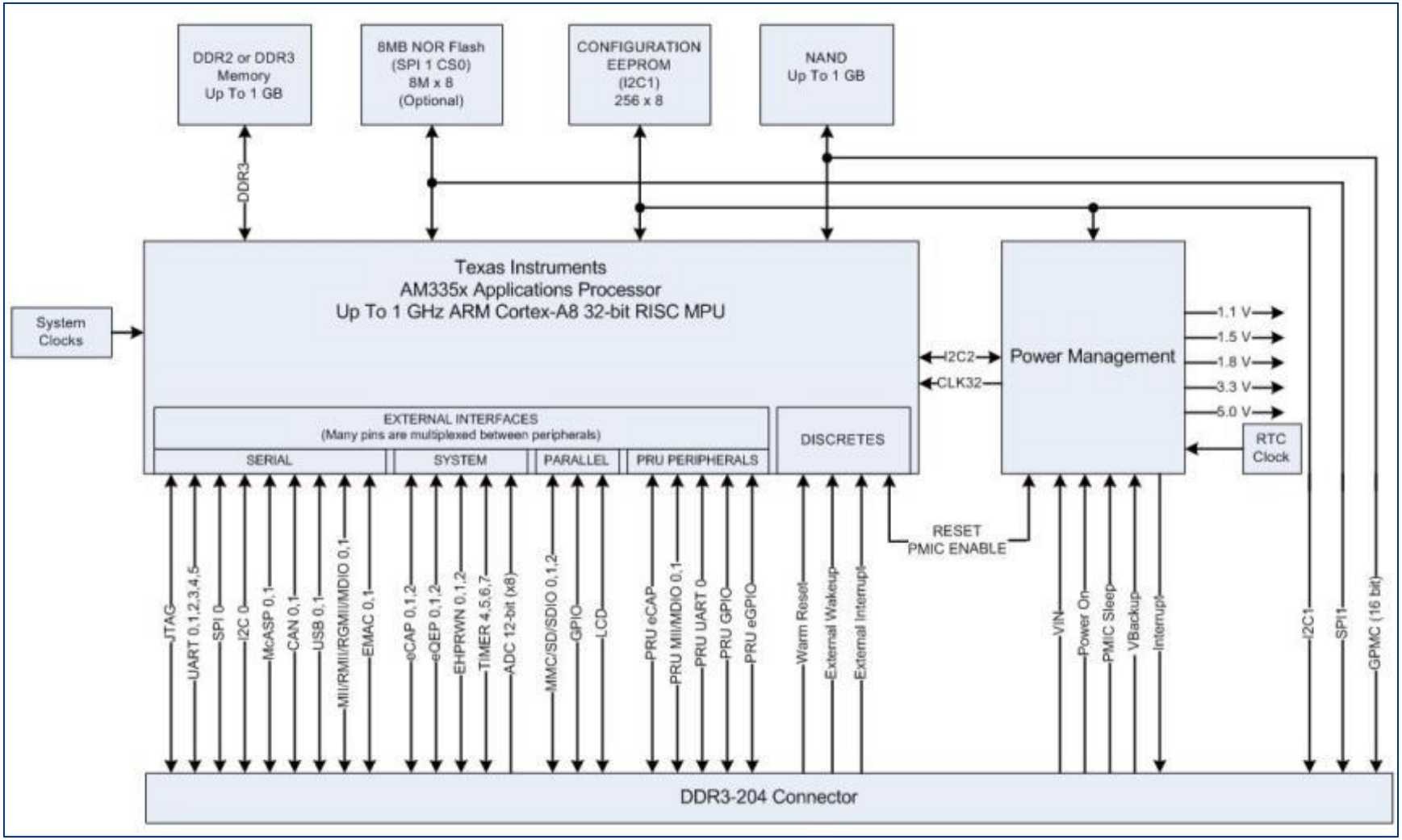
Availability: Shipping

For more information -
http://www.CriticalLink.com/

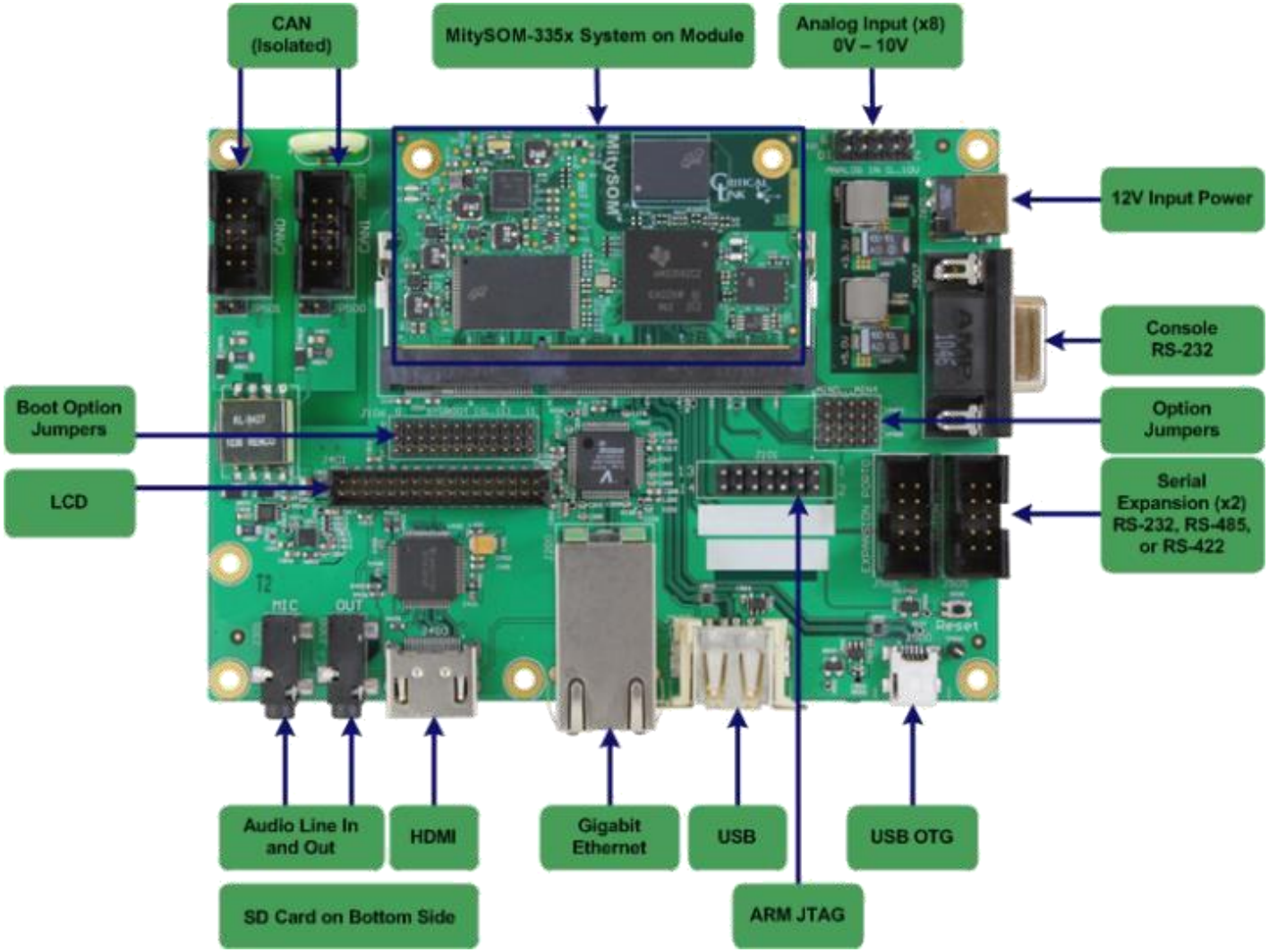
BENEFITS

- ❑ Develop on Production Hardware
- ❑ 3D Graphics for rich UI’s
- ❑ Rapid development, minimize risk
- ❑ Scale with Application Requirements
  - ✓ multiple speed grades available
- ❑ Advanced Operating System Support
  - ✓ Real-time Linux (Timesys), QNX
  - ✓ Windows Embedded 7
- ❑ Industrial Temperature Range

MitySOM-335x Block Diagram



MitySOM-335x Development Kit



Converting BBB to the MitySOM Maker Board

MitySOM Maker Board (MMB)

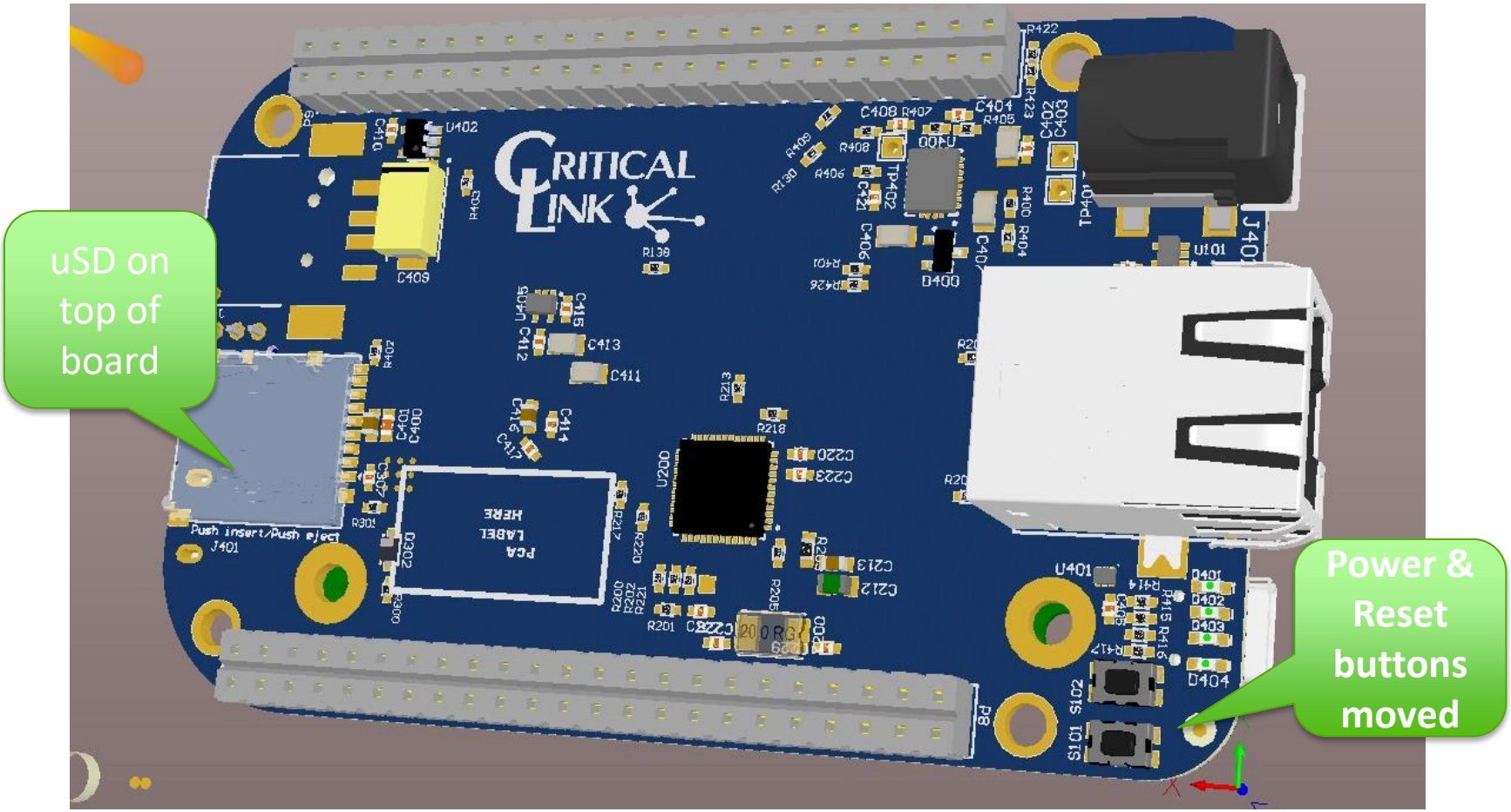
- The MMB has been designed to minimize the number of changes required for those transitioning from the BBB.
- In many cases, no significant changes will need to be made: the MMB is a drop-in replacement.
- There are a few Mechanical, Electrical, and Software changes that need to be reviewed as part of the design transition.

The MitySOM Maker Board is designed to minimize the amount of time you need to get your design "production-ready."

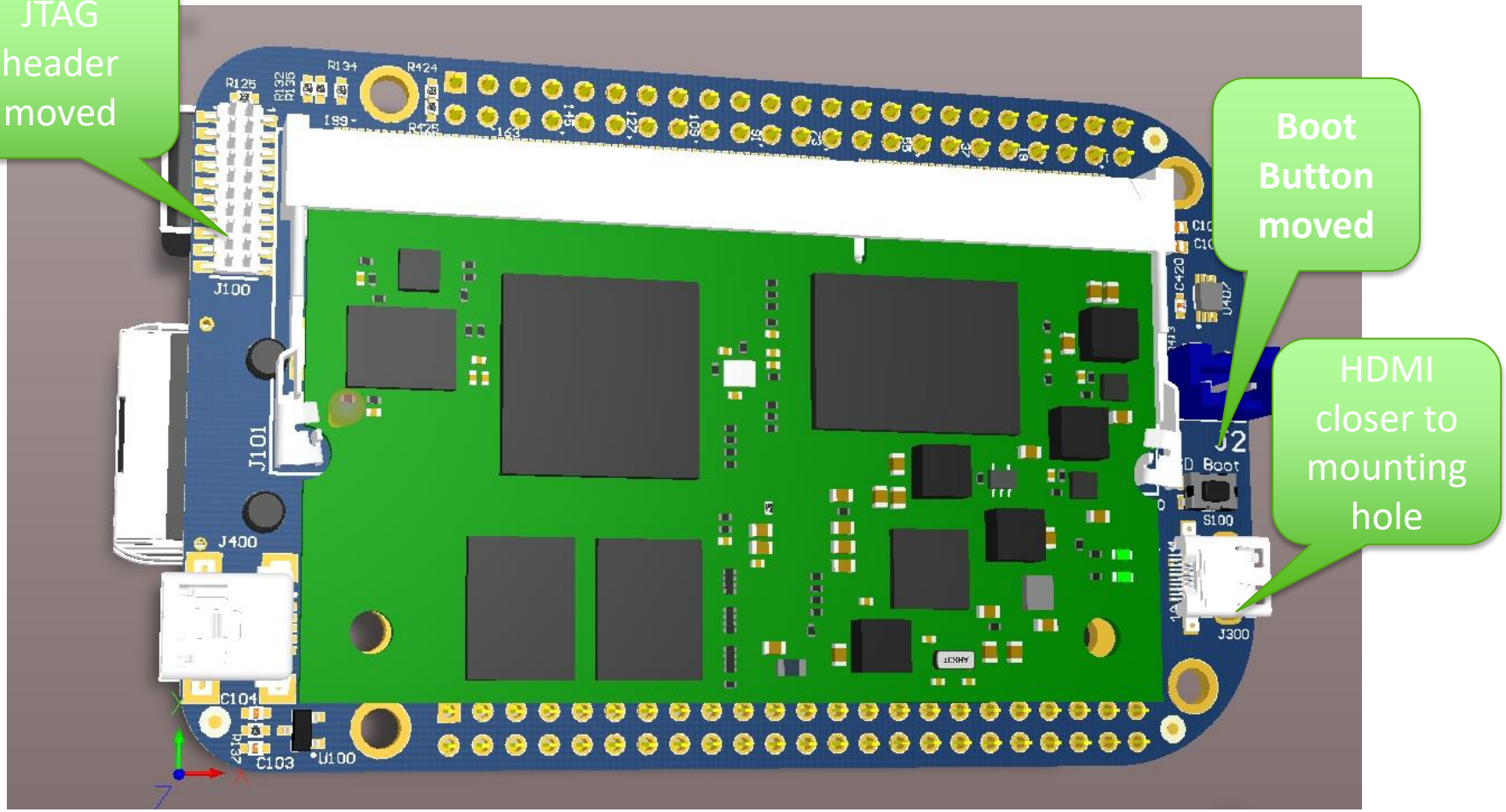
Mechanical Differences

- The MMB has the same basic dimensions as the BBB.
- There are some differences to accommodate the MitySOM-335x module and connector:
  - MitySOM-335x connector raises the height of one side of the board.
  - Power, Reset, and Boot buttons have been moved.
  - HDMI connector moved closer to board edge.

Mechanical Differences (cont.)



Mechanical Differences (cont.)



Electrical Differences

- Ethernet Phy
  - MMB uses KSZ9031 instead of the LAN8710A.
  - KSZ9031 used on the full-size MitySOM-335x Dev Kit.
  - KSZ9031 connected to the RGMII1 interface (LAN8710A uses MII1 on the BBB).
  - Ethernet reset tied to a dedicated GPIO instead of SYS_RESETn.
  - Phy address of 010 is used instead of 000.

- i2c2:
  - The MitySOM-335x uses the i2c2 bus on-board the SOM, so the i2c2 pins on the expansion header were replaced with the i2c0 equivalents:
    - P9 Pin 19 on the BBB uses ball D17 while the MMB uses C16 (I2C0_SCL).
    - P9 Pin 20 on the BBB uses ball D18 while the MMB uses C17 (I2C0_SDA).

Electrical Differences (cont.)

- i2C1
  - i2C1 is used on the SOM, but the pins are available on the edge connector.
  - If you have a cape that is currently using i2c1, you will need to connect to balls H17 (Pin 147) and J15 (Pin 149) from our module.
  - If you have a cape that is currently using the i2c1 for some other function, you will need to connect balls A16 (Module Pin 191) and B16 (Module Pin 185) balls to the expansion connector.
  - The MMB has 0 ohm resistors on the appropriate signals to allow either option to be chosen.
- UART:
  - Debug UART header on the MMB is different, but a cable will be provided.
- Video:
  - The HDMI interface chip on the BBB uses ball C12 for the McASP0_AXR2 data pin. The MMB uses ball B12 for that interface which keeps the same McASP0_AXR2 function but a different mux of it.

Electrical Differences (cont.)

- PMIC:
  - The MMB uses a different PMIC (TPS65910A) than the BBB so there may be some differences in the control and operation of the RTC.
- GPIO:
  - Expansion header P8 Pin 26 is connected to ball E18 (GPIO1_8) on the MMB. On the BBB, P8 pin 26 is connected to ball V6 (GPIO1_29).
- SPI:
  - Expansion header P9 Pin 28 (SPI_CS0) on the BBB uses ball C12 while the MMB uses ball H18 (module pin 145) for the same function.

Electrical Differences (cont.)

Beaglebone Expansion Header P8									
Header Pin	**Beaglebone Ball**	**Beaglebone Mode**	**MitySOM Ball**	**MitySOM Pin**	**Header Pin**	**Beaglebone Ball**	**Beaglebone Mode**	**MitySOM Ball**	**MitySOM Pin**
1	GND	N/A	N/A	N/A	**2**	GND	Power	N/A	Power
3	R9	MMC1_DAT6	R9	87	**4**	T9	MMC1_DAT7	T9	89
5	R8	MMC1_DAT2	R8	79	**6**	T8	MMC1_DAT3	T8	81
7	R7	TIMER4	R7	88	**8**	T7	TIMER7	T7	90
9	T6	TIMER5	T6	86	**10**	U6	TIMER6	U6	98
11	R12	GPIO1_13	R12	103	**12**	T12	GPIO1_12	T12	101
13	T10	EHRPWM2B	T10	95	**14**	T11	GPIO0_26	T11	97
15	U13	GPIO1_15	U13	107	**16**	V13	GPIO1_14	V13	105
17	U12	GPIO0_27	U12	99	**18**	V12	GPIO2_1	V12	84
19	U10	EHRPWM2A	U10	93	**20**	V9	MMC1_CMD	V9	111
21	U9	MMC1_CLK	U9	113	**22**	V8	MMC1_DAT5	V8	85
23	U8	MMC1_DAT4	U8	83	**24**	V7	MMC1_DAT1	V7	77
25	U7	MMC1_DAT0	U7	75	**26**	V6	GPIO	E18 - GPIO1_8	165
27	U5	LCD_VSYNC	U5	67	**28**	V5	LCD_PCLK	V5	65
29	R5	LCD_HSYNC	R5	69	**30**	R6	LCD_DE	R6	71
31	V4	LCD_DATA14	V4	61	**32**	T5	LCD_DATA15	T5	63
33	V3	LCD_DATA13	V3	59	**34**	U4	LCD_DATA11	U4	53
35	V2	LCD_DATA12	V2	57	**36**	U3	LCD_DATA10	U3	51
37	U1	LCD_DATA8	U1	47	**38**	U2	LCD_DATA9	U2	49
39	T3	LCD_DATA6	T3	43	**40**	T4	LCD_DATA7	T4	45
41	T1	LCD_DATA4	T1	39	**42**	T2	LCD_DATA5	T2	41
43	R3	LCD_DATA2	R3	33	**44**	R4	LCD_DATA3	R4	35
45	R1	LCD_DATA0	R1	29	**46**	R2	LCD_DATA1	R2	31

Electrical Differences (cont.)

Beaglebone Expansion Header P9									
Header Pin	**Beaglebone Ball**	**Beaglebone Mode**	**MitySOM Ball**	**MitySOM Pin**	**Header Pin**	**Beaglebone Ball**	**Beaglebone Mode**	**MitySOM Ball**	**MitySOM Pin**
1	GND	Power	N/A	Power	**2**	GND	Power	N/A	Power
3	3V3	Power	N/A	Power	**4**	3V3	Power	N/A	Power
5	5V	Power	N/A	Power	**6**	5V	Power	N/A	Power
7	SYS 5V	Power	N/A	Power	**8**	SYS 5V	Power	N/A	Power
9	TPS Pin25 Power Btn		TBD?		**10**	A10	SYS_RST_n	A10	158
11	T17	UART4_RXD	T17	100	**12**	U18	GPIO1_28	U18	102
13	U17	UART4_TXD	U17	104	**14**	U14	EHRPWM1A	U14	62
15	R13/T13	GPIO1_16	R13/T13	58/94	**16**	T14	EHRPWM1B	T14	64
17	A16	I2C1_SCL	A16	191	**18**	B16	I2C1_SDA	B16	185
19	D17	I2C2_SCL	C16 - I2C0_SCL	179	**20**	D18	I2C2_SDA	C17 - I2C0_SDA	177
21	B17	UART2_TXD	B17	183	**22**	A17	UART2_RXD	A17	187
23	V14	GPIO1_17	V14	60	**24**	D15	UART1_TXD	D15	175
25	A14	GPIO3_21	A14	154	**26**	D16	UART1_RXD	D16	173
27	C13	GPIO3_19	C13	148	**28**	C12	SPI1_CS0	H18 - SPI1_CS0	145
29	B13	SPI1_D0	B13	195	**30**	D12	SPI1_D1	D12	197
31	A13	SPI1_SCLK	A13	152	**32**	VDD_ADC	Power	N/A	Power
33	AIN4	Analog Input	AIN4	192	**34**	GND_ADC	Power	N/A	Power
35	AIN6	Analog Input	AIN6	196	**36**	AIN5	Analog Input	AIN5	194
37	AIN2	Analog Input	AIN2	188	**38**	AIN3	Analog Input	AIN3	190
39	AIN0	Analog Input	AIN0	184	**40**	AIN1	Analog Input	AIN1	186
41	D14	CLKOUT2	D14	201	**42**	C18 OR B12	GPIO0_7 OR GPIO3_18	C18 OR B12	150 or 193
43	GND	Power	N/A	Power	**44**	GND	Power	N/A	Power
45	GND	Power	N/A	Power	**46**	GND	Power	N/A	Power

Software Changes

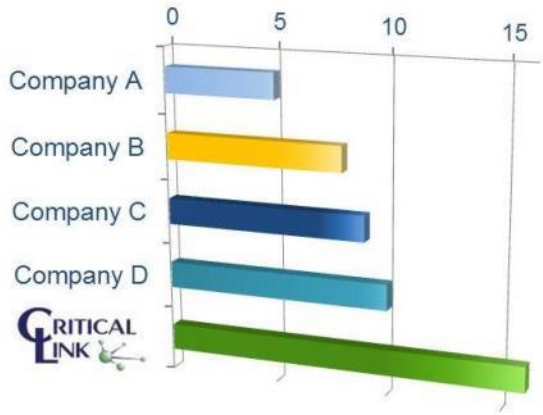
- **Most userspace software will run with no changes**
- Critical Link currently supports Linux kernel 3.14
  - Includes device tree to support the MMB
  - Incorporates hardware changes previously discussed:
    - I2c2 → i2c0
    - Ethernet Phy
- Multiple options for toolchain and filesystem:
  - Use TI-provided Processor SDK
  - Use Critical Link provided MDK (Yocto-based)
  - Use third party (e.g. Timesys)

MitySOM Solutions

GETTING DESIGNS TO PRODUCTION

What Does it Mean to be Production-Ready?

- Advantages of a Production-Ready SOM:
  - Whether you order 5 or 5,000, you can depend on availability
  - Professionally supported, directly by the team who developed it
  - Designed for long life in the field with 24/7 operation (not a reference design)
  - Lifetime product maintenance with published PCNs, meaning no unexpected rev changes
  - Commercial & industrial temps
  - 100% US-based development and assembly
  - Escrow service available for all designs



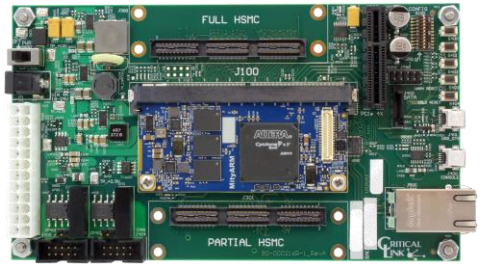
Critical Link SOMs have 10-15+ years availability at product release, compared to 5, 7, or 8 year availability projections of other SOM manufacturers – both International & US-based

MitySOMs At-a-Glance

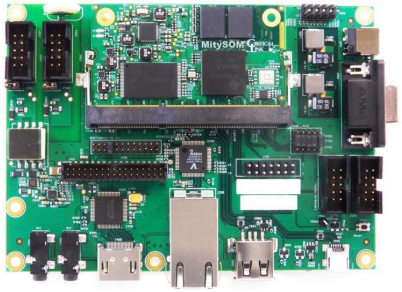
	MityDSP-L138	MityDSP-L138F	MitySOM-335x	MitySOM-5CSX
High performance ARM or applications processor	●	●	●	● (Dual ARM)
DSP - Fixed or Floating Point	●	●	●	● (DSP blocks in FPGA fabric)
FPGA	●	●	●	●
LCD Capable	●	●	●	● (via FPGA support)
Graphics Acceleration	●	●	●	●
Profibus	●	●	●	●
High Speed Interfaces	●	●	● (Dual Gigabit Ethernet)	● (Dual Gigabit Ethernet, PCIe, 6 High Speed Transceivers)
CAN bus/industrial protocols	●	●	●	●
Low Power	●	●	●	●
What is it good for?	Signal processing, Audio signal processing, Analog data acquisition, FFT/DFT	Software Defined Radio, Radar, Signal processing, Analog data acquisition, FFT/DFT	Add a UI or ethernet interface to an existing industrial product	High speed data acquisition, Machine Vision

SOM Development Kits

- Development Kits are available for all SOM families
- Customers get up and running within minutes, starting software development months ahead of typical schedules
- Contents include:
  - Baseboard
  - Compatible SOM
  - Necessary cables/connectors
  - Power supply
  - Bootable SD card with pre-loaded Linux OS
  - USB drive with development VM & documentation
  - Quick Start Guide
- All baseboard schematics, BOM, Gerbers, and Altium design files are available online



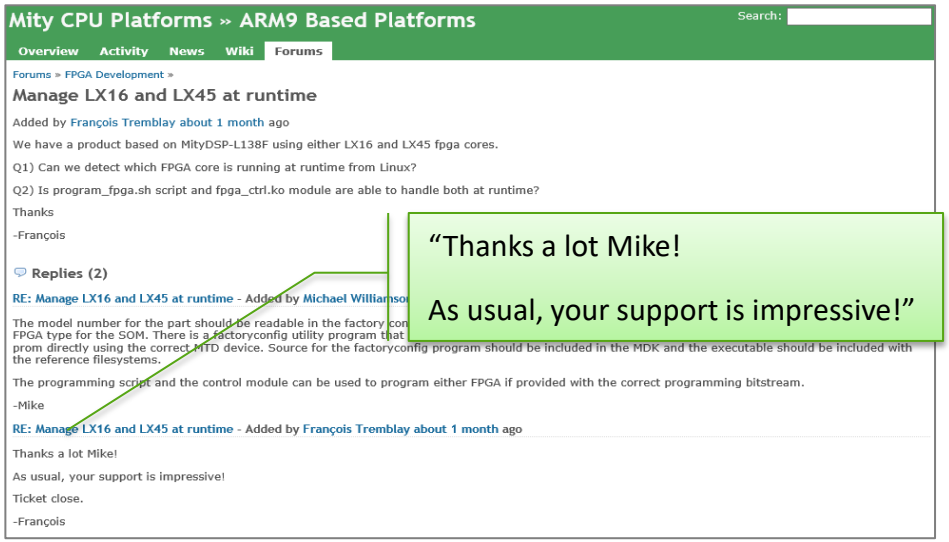
MitySOM-5CSX Dev Kit


MitySOM-335x Dev Kit


MityDSP-L138(F) Dev Kit

How does Critical Link support the customer?

- Online Documentation and Support:
  - Active forums
  - Base board design guide
  - Wiki based documentation
  - Step-by-step instructions
  - Software & sample applications provided free
  - Source code
- Personalized Support Options:
  - Personalized training
  - Internal apps engineer support
  - Paid engineering support
  - Local sales support



MitySOM-335x

1GHz Cortex-A8, 3D Graphics, Dual GigE, Dual CAN Bus

FEATURES:

- ❑ AM335x Cortex-A8 Applications Processor
  - ✓ 1GHz Cortex-A8 CPU, NEON SIMD Coprocessor
  - ✓ PowerVR SGX 3D Graphics Engine
  - ✓ 2 Programmable Real-time Units (PRU)
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- ❑ Robust IO
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- ❑ Connected Vending Machines
- ❑ Medical Appliances
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- ❑ Measurement Devices

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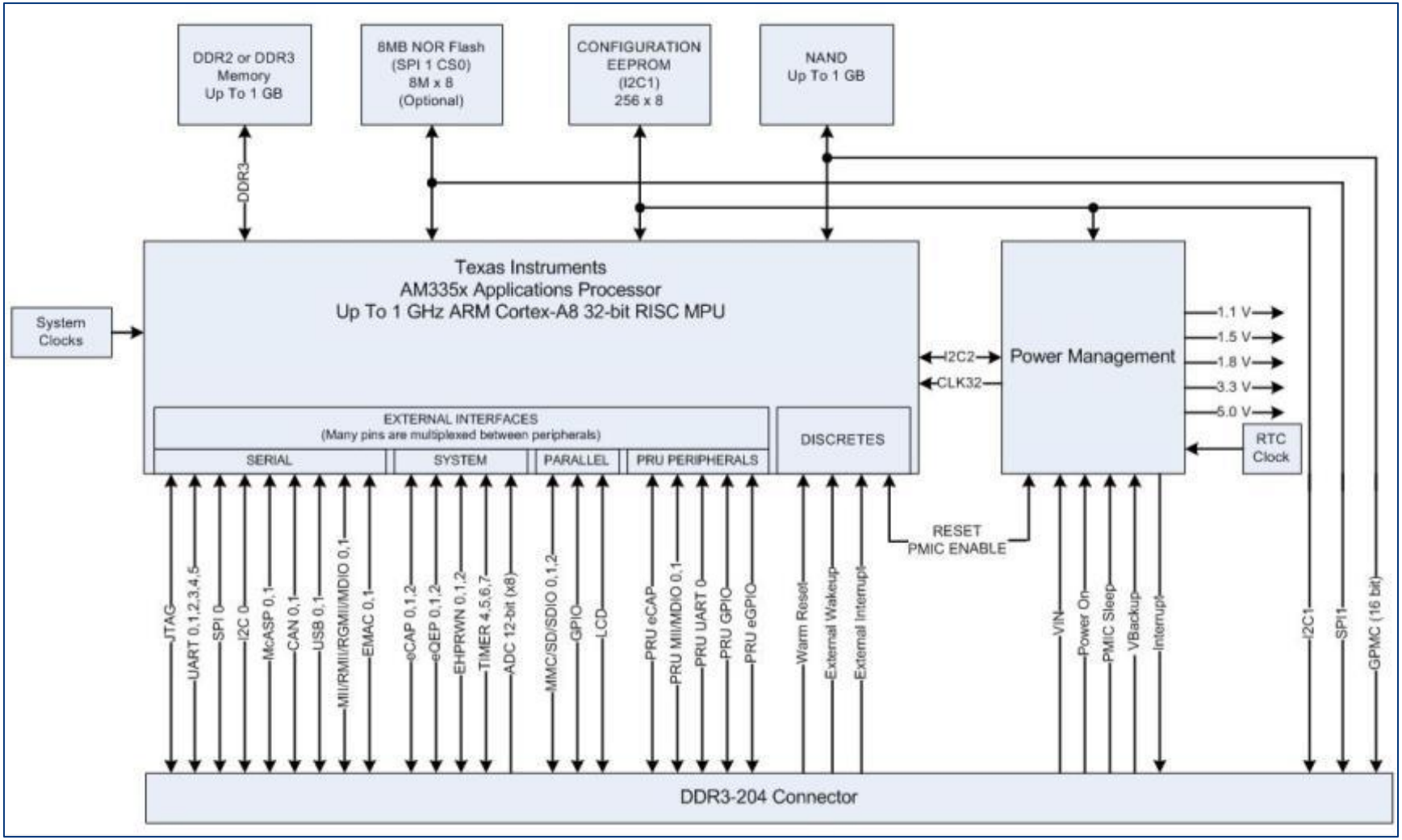
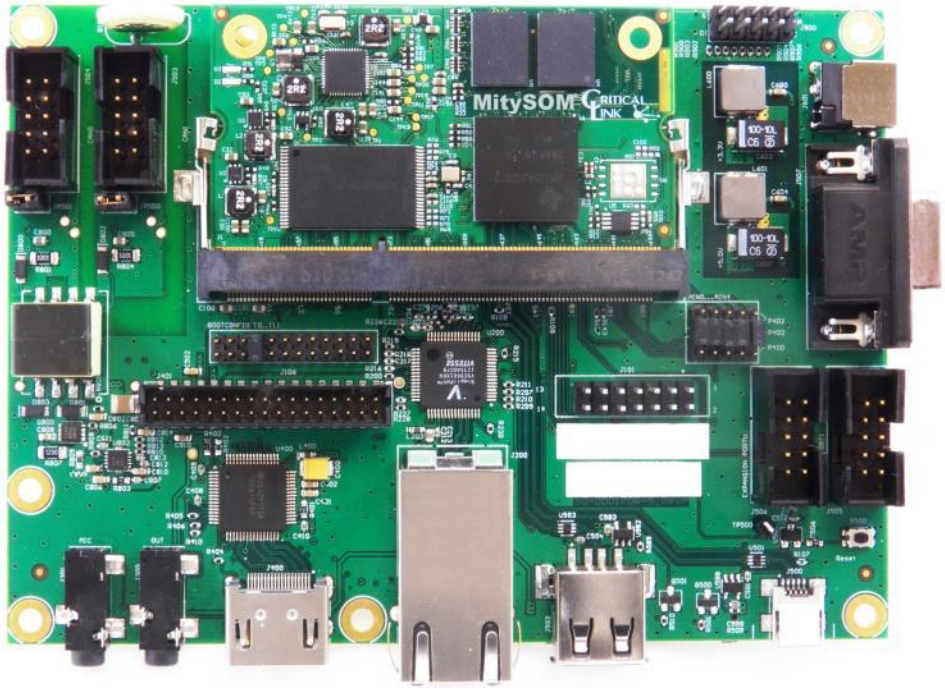
  - ✓ Windows Embedded 7
- ❑ Industrial Temperature Range

MitySOM-335x Block Diagram



MitySOM-335x Development Kit / Reference Design



FEATURES:

- ❑ Gigabit Ethernet
- ❑ HDMI Display interface
- ❑ Touch screen capable
- ❑ 2 CAN Interfaces, Isolated power supplies
- ❑ 8 ADC Inputs, SD Card
- ❑ Multiple Boot Options
- ❑ Two USB (incl one OTG)
- ❑ RS-232 Console Port
- ❑ Two Serial Expansion Ports
  - ✓ RS-232, RS-485, or RS-422
- ❑ Audio line in and out
- ❑ JTAG Debug
- ❑ Expansion connector for WiFi/Bluetooth
- ❑ Small Form Factor

Baseboard Schematics, BOM, Gerbers, and Altium Design Files Provided

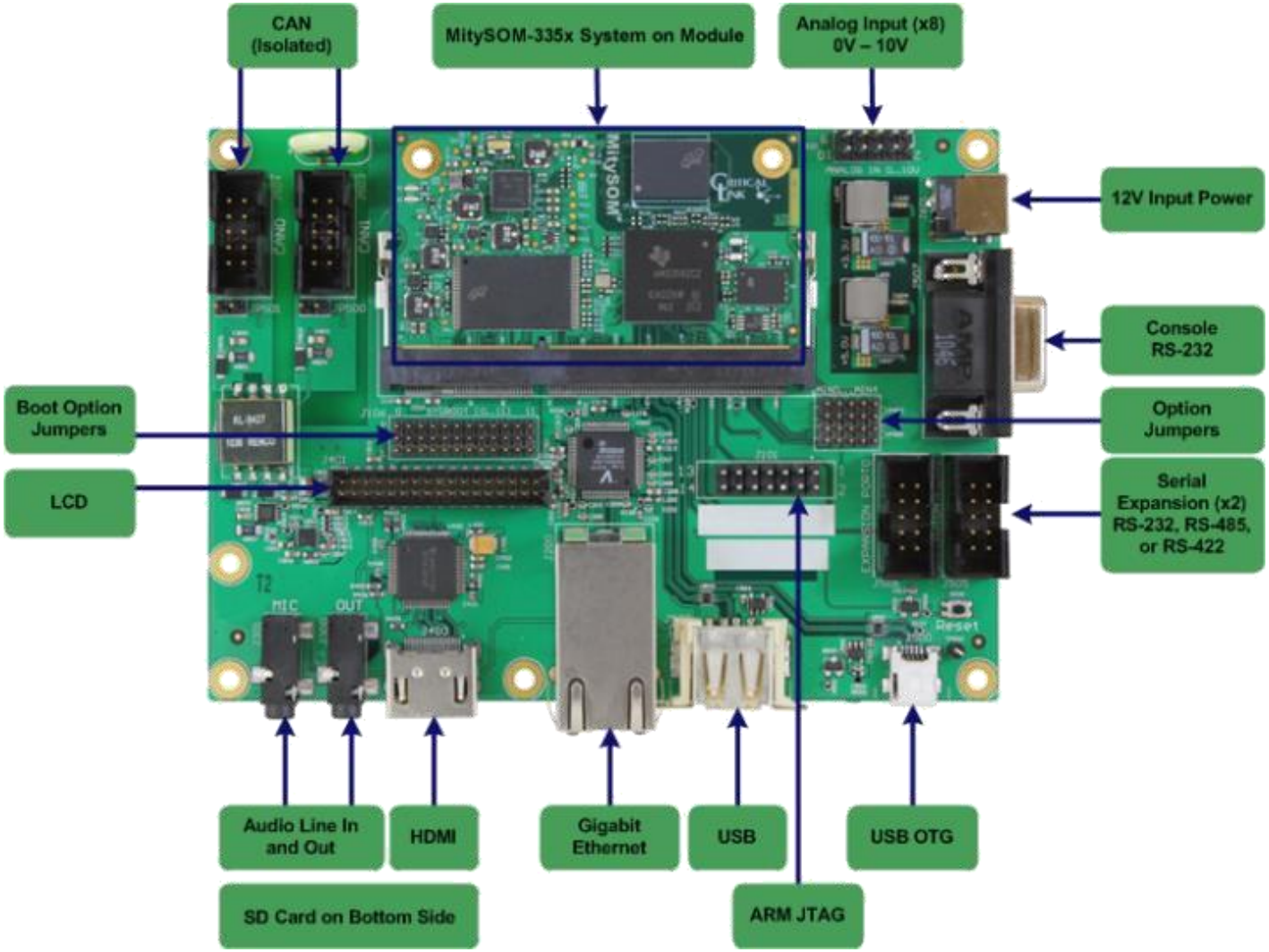
Availability – Shipping
MSRP – $495 (incl. CPU)

For more information -
http://www.CriticalLink.com/

BENEFITS

- ❑ TI SDK Compatibility
  - ✓ Wide software support
- ❑ Rapid development, minimize risk
- ❑ Long term and production volume availability
- ❑ Use as-is or customize to meet specific need
- ❑ Eliminate forced embedded PC upgrades

MitySOM-335x Development Kit



MitySOM-335x LCD Display/Wireless Reference Kit

FEATURES:

- ❑ 6.5” LVDS NEC Displa
  - ✓ 1024 x 768
  - ✓ 640 x 480
- ❑ 24-bit Color
- ❑ 500 NIT, LVDS Interface
- ❑ Integrated Touch Screen
- ❑ LSR TiWi Module
  - ✓ 802.11 b/g/n
  - ✓ Bluetooth
  - ✓ FCC/IC/CE/C-Tick certified
- ❑ All features of MitySOM-3359 Development Kit

BENEFITS

- ❑ TI SDK Compatibility
  - ✓ Wide software support
- ❑ Compatibility with a range of NEC displays
- ❑ Fast time to market for products requiring embedded display or wireless capability

Baseboard Schematics, BOM, Gerbers, and Altium Design Files Provided

Availability – Shipping
MSRP – $795

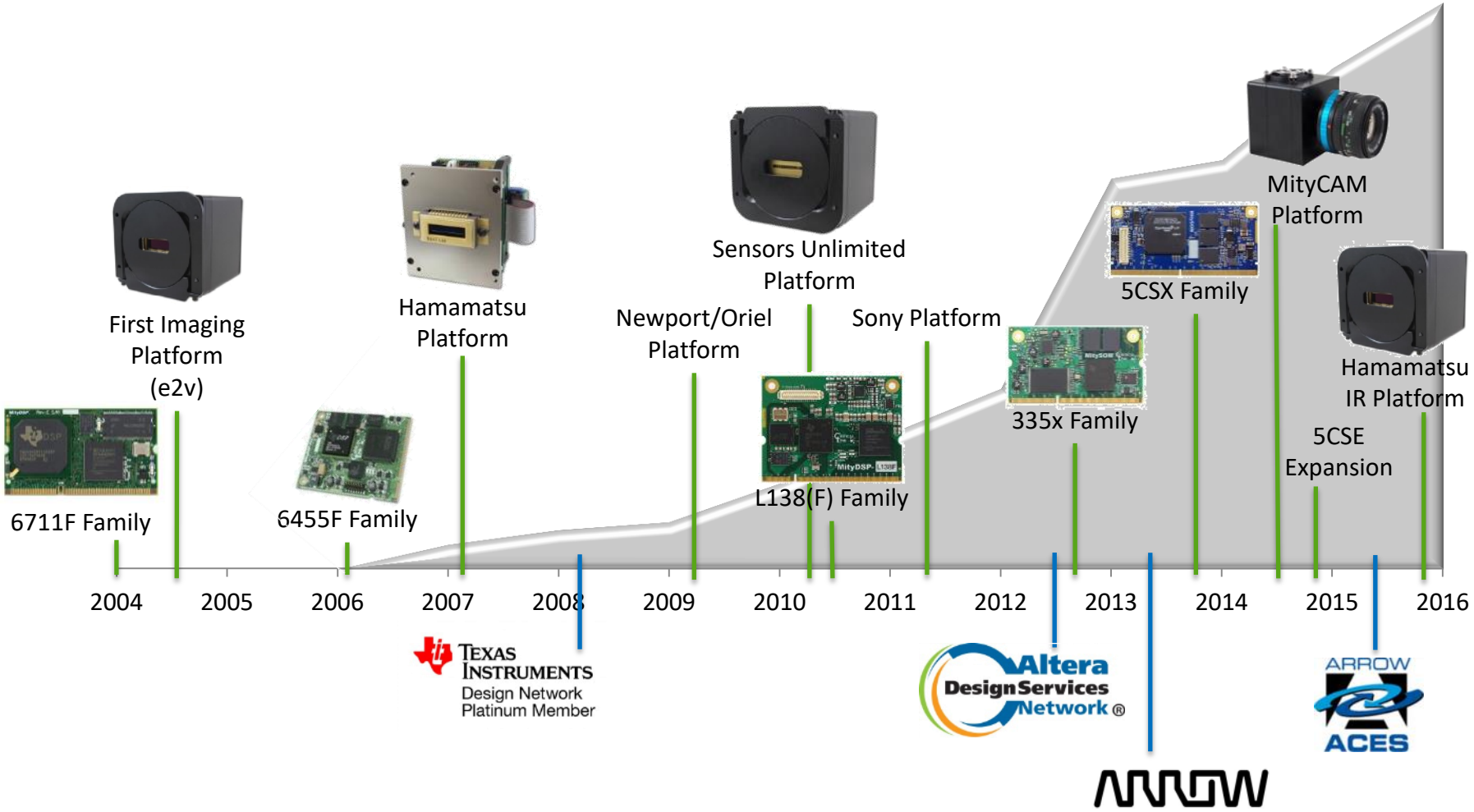
For more information -
http://www.CriticalLink.com/

About Critical Link

About Critical Link

- Design House with SOM & Imaging solutions
  - Founded in 1997 in Syracuse, NY
  - ISO 9001:2008 & 14001 Registered
- 40+ person engineering team skilled in:
  - Systems engineering
  - Hardware design
  - Mechanical engineering
  - Software development
  - FPGA design (VHDL)
- Building SOMs & Imaging products since 2004
  - Currently supporting 5 families of SOMs
  - Scientific Imaging & Machine Vision products leverage SOMs for processing

10+ Years of Production Growth



Value-Added Business Model

- Engineering services key part of our business

- Maintain strategic alliances for product development
- Growing product reach through distribution

Critical Link is a services-based company, and we apply that same expertise, customer focus, and responsiveness to our product support.

Critical Link Competitive Advantage

We are a services-based company

- Critical Link built its business on engineering services – that same expertise, customer focus, and responsiveness drives our SOM product support

Long product lifespan

- Our SOMs have 10-15+ yrs availability at product release. The original MityDSP – released in 2004 – is still in full production today.

Product maintenance & support

- Design & Application Engineering support is available throughout the life of your product; others limit support to 1 yr post-purchase

Value-added connections

- Key partnerships & industry connections enable us to get answers faster than customers are able to on their own

Critical Link Sales Support

- Tom Catalino, Vice President

  Tom.catalino@criticallink.com

  Work: +1-315-425-4045 x201

  Cell: +1-315-427-3779

- Omar Rahim, Vice President

  Omar.rahim@criticallink.com

  Work: +1-315-425-4045 x208

  Cell: +1-315-427-0666

- Alex Block, Applications Engineer

  Alex.block@criticallink.com

  Work: +1-315-425-4045 x204

  Cell: +1-315-345-9414

- Website
  - http://www.CriticalLink.com