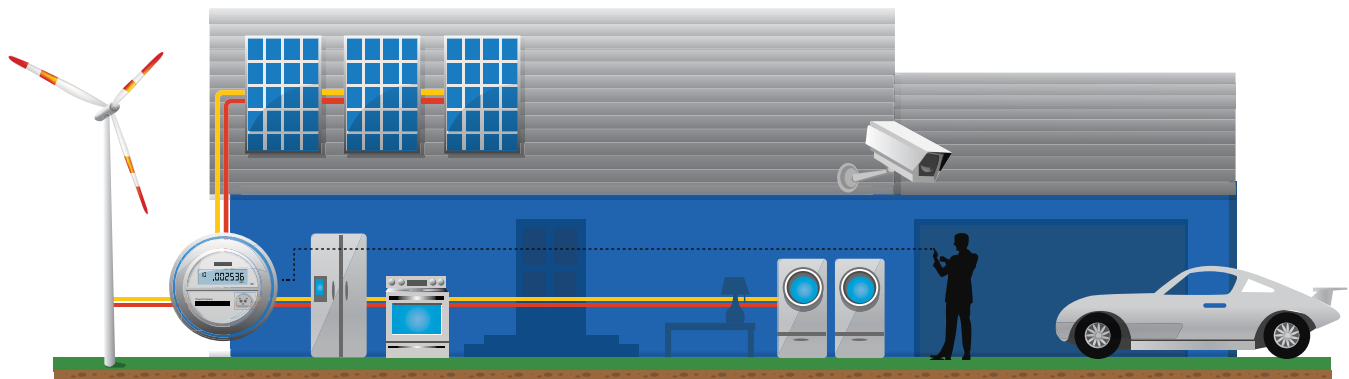


# Atmel<sup>®</sup>



## Atmel Smart Energy Solution Guide



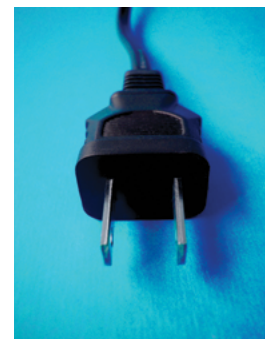
## Smart Energy Applications

It's all about energy management

- Smart Grid
- Industrial Lighting and Automation
- Home Automation
- Street Lighting
- Solar Energy
- PHEV Charging Stations

The market for energy, water, and gas metering systems is rapidly changing, driven by new environmental and conservation concerns and regulations. Traditional standalone meters are now being replaced by complex networked systems that utilize a variety of communication methods. To meet the needs of this evolving smart grid, metering developers need solutions that can provide:

- Leading Edge Connectivity
- Best-in-class Metrology
- Integration & Flexibility
- Advanced Security



## Atmel Smart Energy Solutions

Not just a Chip, but a Platform

Atmel® addresses the needs of the smart energy market with application-specific, as well as standard microcontroller, microprocessor, security, memory, wireless and power-line connectivity devices. The application-specific portfolio is defined from the ground up to offer designers best-in-class feature sets and performance in various classes of equipment used in the smart grid.

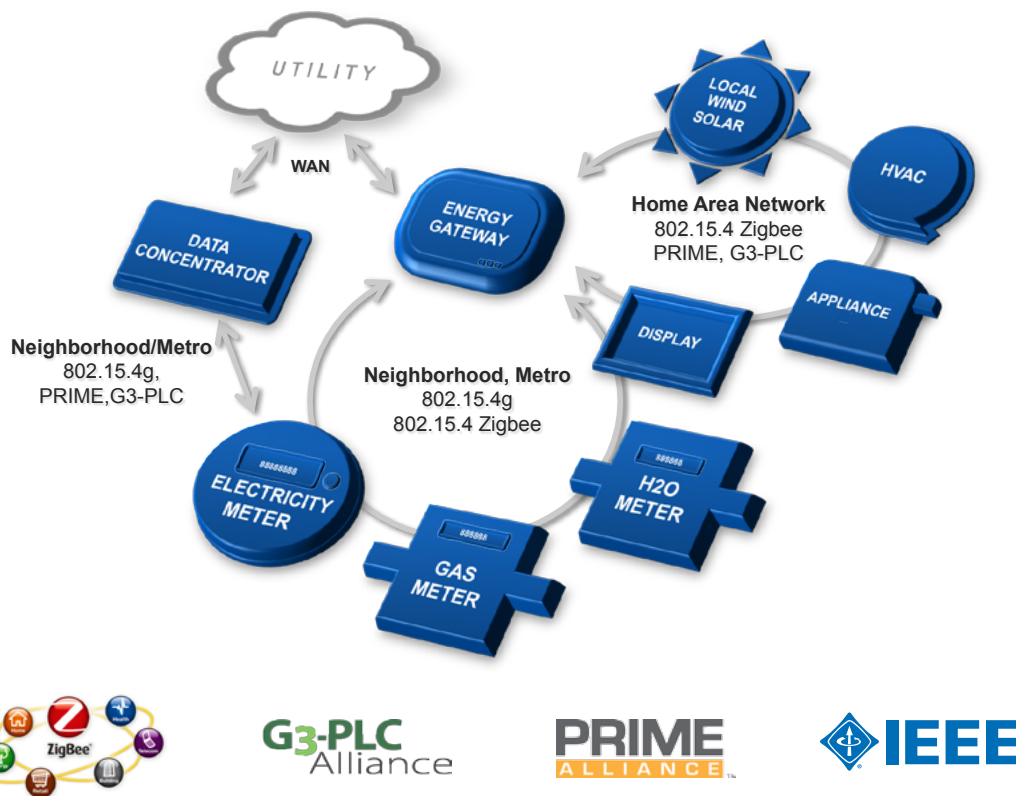


Figure 1. Smart Grid Equipment and Governing Communications Standards

Home Area Network Equipment	Energy Gateway	Data Concentrator	Electricity Meter	Gas & Water Meter
SAM4C SAM4L RF233 RF212B SAM4CP M90E32AS/36A ATPL230	SAMA5 SAM4C RF233 RF212B SAM4CP ATPL230	SAMA5 SAM4C/CM SAM4CP M90E32AS/36A ATPL230	SAM4C/CM SAM4CP SAM4L M90Exx RF233 RF212B ATPL230	SAM4C SAM4L SAM4D RF233 RF212B

Table 1. Atmel Platform Products by Equipment Type

## Atmel Smart Metering Platform

Today's smart meter architect demands various levels of integration depending on system architecture partitioning, project timelines, and the level of flexibility needed to address various utility and geographical requirements. The Atmel platform provides a unique multi-level architecture built around the same multi-core architecture as outlined below. Various devices integrate the building blocks of the smart meter, namely, Metrology sensing (ADC), Metrology DSP, application, communication, and security processing, as well as connectivity to home area and neighborhood area networks.

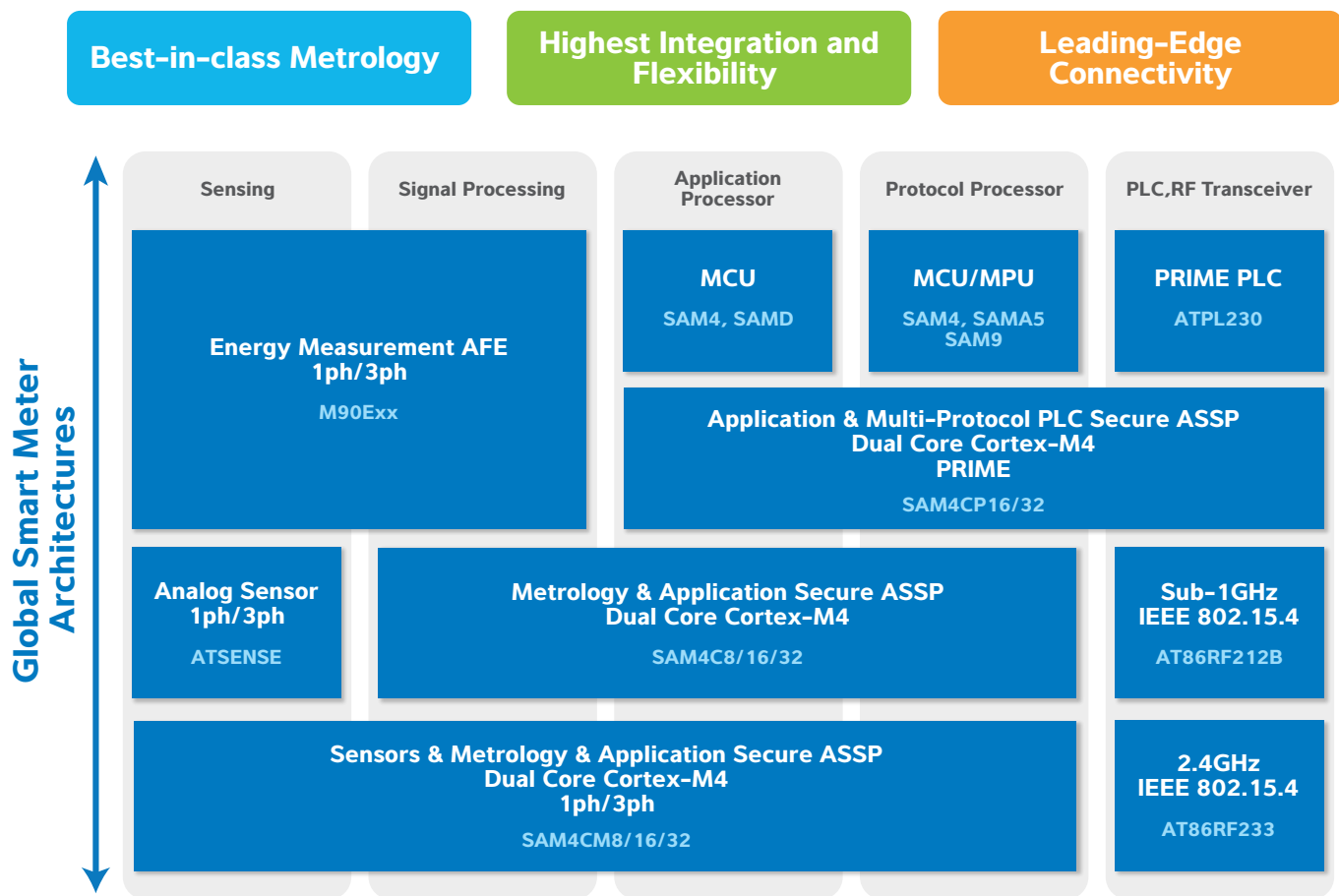


Figure 2. Atmel Smart Metering Platform

# Atmel Smart Energy Solutions Guide

## Atmel Advantage

A new platform with many differentiators.

- Leading-Edge Connectivity
  - Low power 802.15.4/4g wireless devices
  - Field proven, Low power PLC (PRIME)
- Integration & Flexibility
  - Flexible (SW or HW) metrology
  - Multi-standard Wireless and PLC solutions
  - Advanced cryptography
- Best-in-class Metrology
  - Dynamic range of up to 6000:1
  - 25M units shipped since 90's
- Broad MCU Portfolio
  - Large array of SAMD, SAM4 and SAM5 solutions
  - Best-in-class tools from Atmel, IAR, Keil

## Smart Metering Products

At the core of Atmel's smart energy platform is the SAM4C series of products starting with SAM4C16 and SAM4C8 system-on-chip solutions for smart energy applications built around two high performance 32-bit ARM® Cortex®-M4 RISC processors. These devices operate at a maximum speed of 120 MHz and feature up to 2Mbyte of embedded Flash, 304 Kbytes of SRAM, and on-chip cache for each core.

The dual ARM Cortex -M4 architecture allows for integration of application layer, communications layers, and metrology functions in a single device. It has options for integrated software metrology or external hardware metrology AFE (analog front end) as well as integrated or external power-line carrier (PLC) physical layer solution. It's a modular approach that is sure to meet various design needs.

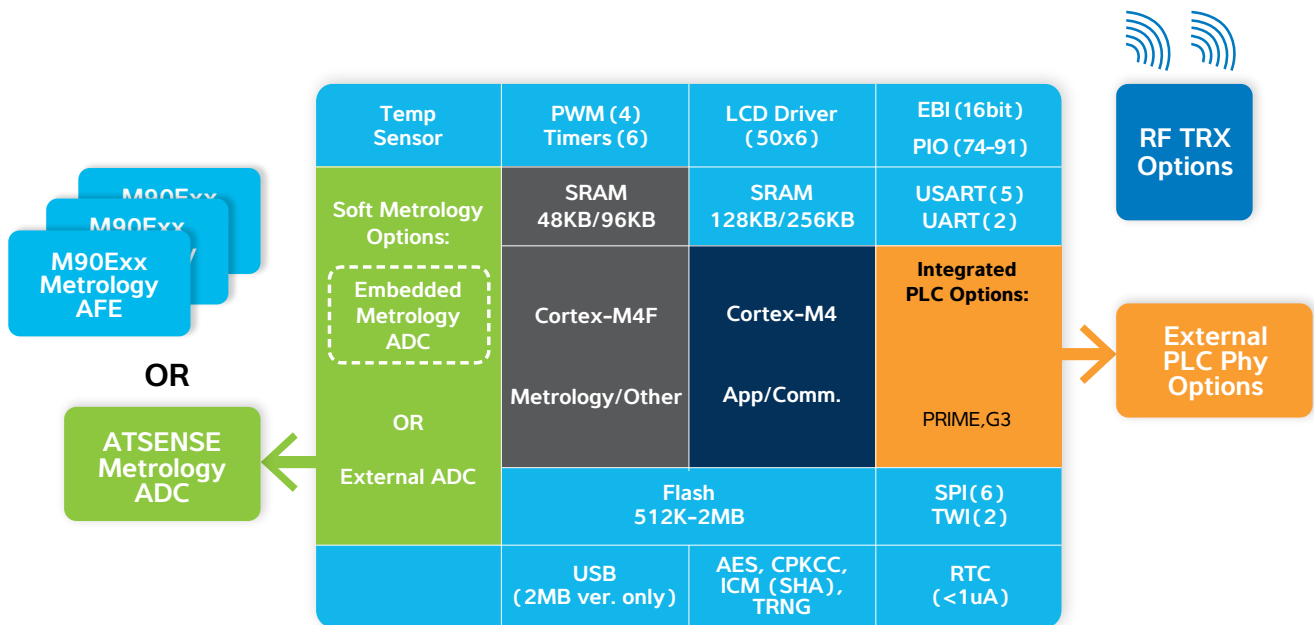
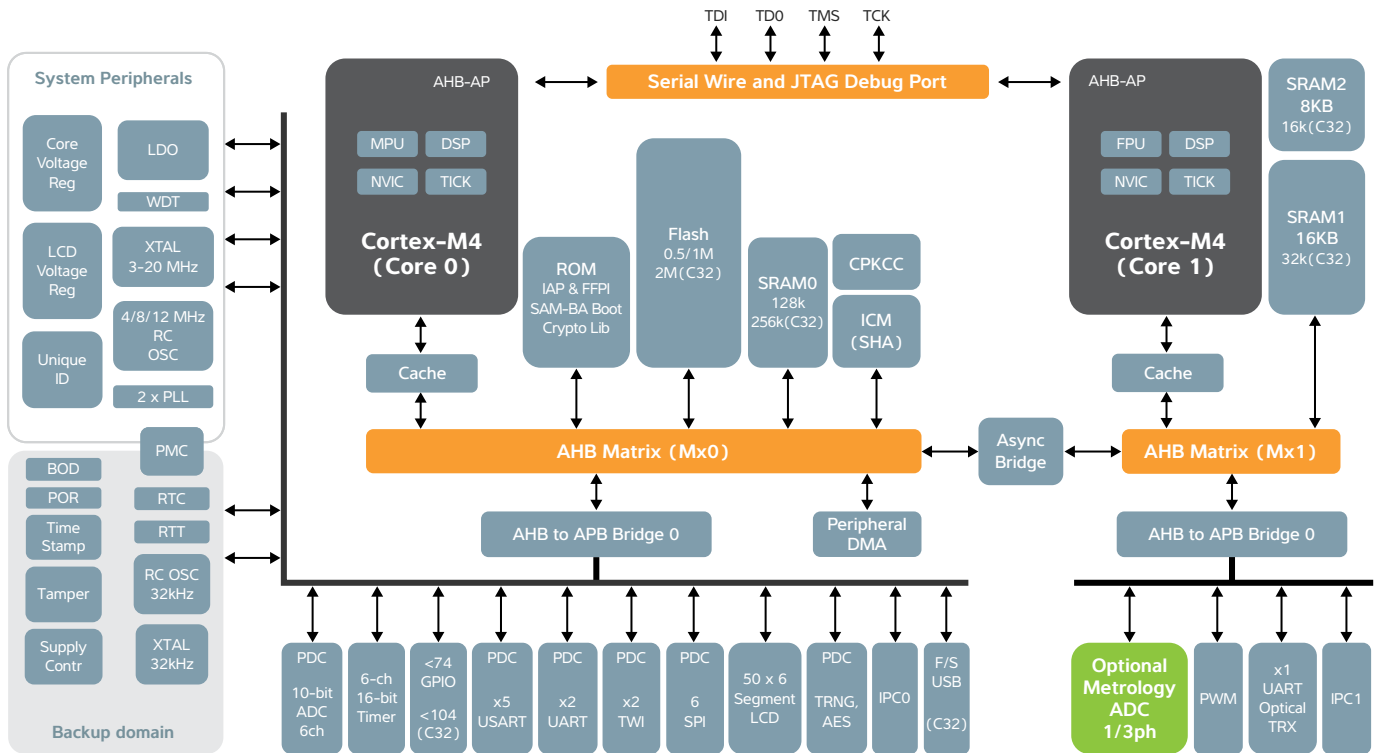


Figure 3. SAM4C Platform



C32 devices have 2M flash, full speed USB, more GPIO, more RAM

Figure 4. SAM4C Block Diagram

	SAM4C8	SAM4C16	SAM4C32C	SAM4C32E	SAM4CMP8/ SAM4CMS8	SAM4CMP16/ SAM4CMS16	SAM4CMP32/ SAM4CMS32
Flash	512KB	1MB	2MB		512KB	1MB	2MB
SRAM	128 + 16 + 8KB		256 + 32 + 16KB		128 + 16 + 8KB		256 + 32 + 16KB
Package	100 LQFP			144 LQFP	100 LQFP		
GPIO	74			106	52 / 57		
PWM	4				3		
UART+USART	7				5/6		
SPI	2 Controllers - 8 CS, + 5 USARTs in SPI Mode				1 Controller - 4 CS + 3/4 USARTs in SPI Mode		
ADC	10bit, 6 x Externals + 2 x Internals				10bit, 4 x Externals + 2 x Internals		
Metrology AFE	-				7 x Channels / 4 x Channels		
Segment LCD	50 x 6				32 x 6		
USB FS	-			Host/ Device	-		
Timer	6 Channels						
TWI	2						

Table 2. SAM4C Metering SOC Feature Comparison

# Atmel Smart Energy Solutions Guide

## SAM4Cx Software Metrology

Flexibility to support various country-specific requirements

Atmel's software metrology library provides unprecedented level of performance, scalability, and flexibility which supports the integration of proprietary advanced metrology and signal processing algorithms. Atmel's standard library enables residential, commercial, and industrial meter design up to class 0.2 accuracy, dynamic range of 3000:1, and are compliant with IEC 62052-11, 62053-22/23, ANSI C12.1, C12.20 and MID.

The ATSENSE-301 and ATSENSE-101 are analog front end (AFE) devices targeting metrology applications. They feature up to 7 channels of high-precision sigma-delta Analog to Digital Converters (ADCs) with a 16ksps sample rate and a highly accurate, integrated voltage reference with 10 ppm/°C temperature stability. They also include a programmable current signal amplification, a temperature sensor and a SPI (serial peripheral interface).

## Features

- Software Metrology supports shunt, Current Transformer and Rogowski coil current sensing
- Poly-phase Energy Metering Analog Front End for Atmel's MCUs and Metrology library
- Compliant with Class 0.2 standards (ANSI C 12.20-2002 and IEC 62053-22)
- Up to 7 Sigma Delta ADC measurement channels: 3 Voltages, 4 Currents, 102 dB Dynamic Range
- Current Channels with Pre-Gain (x1, x2, x4, x8)
- Supports Shunt, Current Transformer, and Rogowsky Coils
- 3.0V to 3.6V operation, Ultra Low Power: < 22 mW typ (device fully active @ 3.3V)
- Precision Voltage Reference
- Temperature drift: 50ppm typ (ATSENSE-301) and 10ppm typ (ATSENSE-301H)
- Factory measured temperature drift and die temperature sensor to perform software correction.
- 8 MHz Serial Peripheral Interface (SPI) compatible mode 1 (8-bit) for ADC data and AFE controls.
- Interrupt Output Line signaling ADCs' end of conversion, under-run and over-run.
- Package: 32-lead TQFP, 7 x 7 x 1.4 mm

## Active Energy

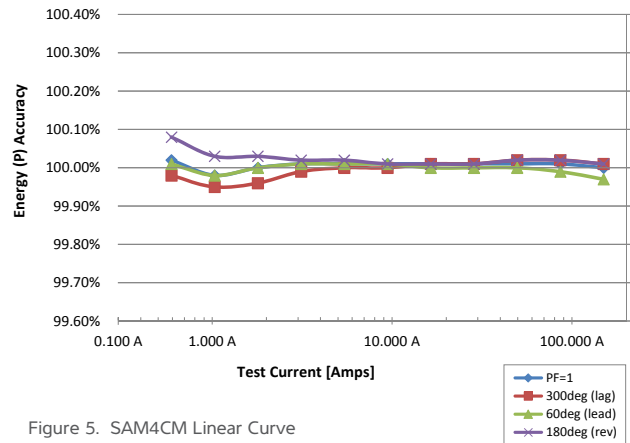


Figure 5. SAM4CM Linear Curve

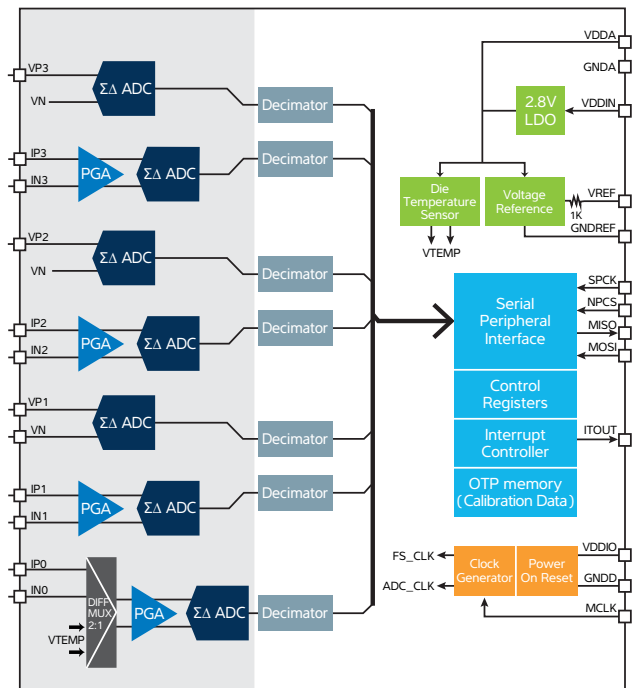
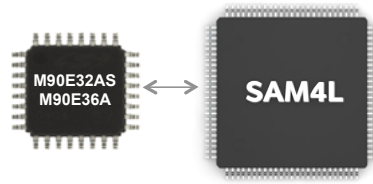


Figure 6. ATSENSE301 Block Diagram

## Hardware Metrology AFE

Out of the box solution for basic metering



- Ideal for basic meter designs
  - Up to class 0.2 accuracy
  - Exceeds IEC, ANSI standards
  - Best-in-class temperature drift
- Best-in-class dynamic range (up to 6000:1)
  - Improves performance
  - Reduces OEM's cost of manufacturing
- Great fit with SAM4L
  - picoPower® Technology
  - Active mode @ 90µA/MHz
  - Full RAM retention @ 1.5µA
  - SleepWalking™
  - 4x40 Segment LCD Controller
  - Hardware Crypto block

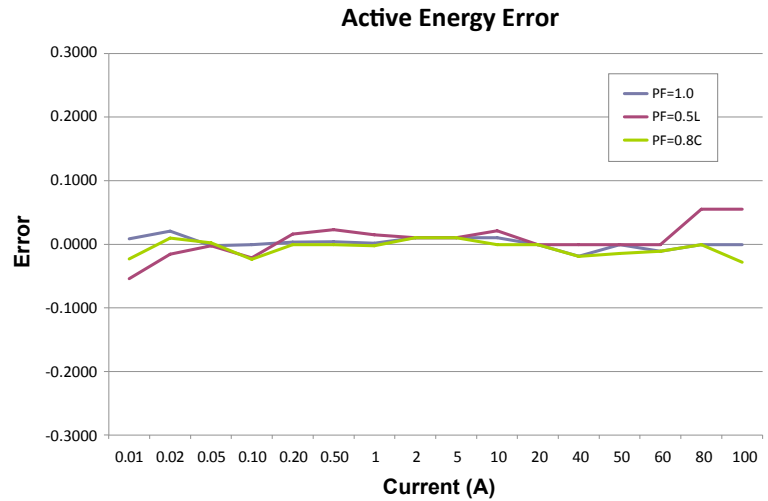


Figure 7. M90E36A Linearity

	Service Type	Dynamic Range	Active Energy Accuracy	Reactive Energy Accuracy	Key Features/ Availability
SAM4CMS8/16	1 phase	3000:1	0.1%	0.2%	High End Metrology SOC
SAM4CMP8/16	3 phase	3000:1	0.1%	0.2%	
SAM4C8/16	-	-	-	-	Security SOC
SAM4CMS32	1 phase	3000:1	0.1%	0.2%	High End Metrology SOC
SAM4CMP32	3 phase	3000:1	0.1%	0.2%	
SAM4C32	-	-	-	-	Security SOC
ATSENSE101	1 phase	3000:1	1%	1%	Software Metrology ADC
ATSENSE301	3 phase	3000:1	0.2%	0.2%	Software Metrology ADC
M90E26	1 phase	5000:1	0.1%	0.2%	AFE, active, reactive energy, instantaneous and anti-tamper
M90E32AS	3 phase	6000:1	0.1%	0.2%	AFE, active, reactive energy, instantaneous, fundamental & harmonics measurement, piece-wise compensation, event detection
M90E36A	3 phase	6000:1	0.1%	0.2%	AFE, active, reactive energy, instantaneous, fundamental & harmonics measurement, DFT Function, raw data capture

Table 3. Atmel Metrology Solutions

# Atmel Smart Energy Solutions Guide

## PLC Connectivity Products

Atmel offers a family of system-on-a-chip (SoC) PLC solutions designed specifically for narrowband communications using the low-voltage electric grid. Drawing on our deep expertise in PLC modem technology and extensive collaboration with utilities and metering OEMs, we've created solutions offering an unprecedented level of integration and performance. Our solutions support various modulation schemes including the PRIME (PowerLine Intelligent Metering Evolution) specification, an open and multi-provider industry standard promoted by an industry alliance of more than 30 leading utilities, meter manufacturers, and silicon providers. – Atmel provides a free software stack that turns the management of PLC networks into a transparent process. You can focus on top-level applications and access the Atmel PLC software stacks via user-friendly application programming interfaces (APIs).

- Best-in-class sensitivity and high-temperature stability.
- Improved analog front end (AFE) providing outstanding efficiency.
- Price-competitive, high-performance solutions.
- Free software stacks for PLC

## Enhanced Performance

Atmel SAM4CP16B and ATPL230A are offered in single chip (SOC) and two-chip (PHY base band + MCU) configuration, respectively. These PRIME devices include enhanced features in addition to the current requirements of PRIME specification, such as additional robust modes and frequency band extension up to 470 kHz.

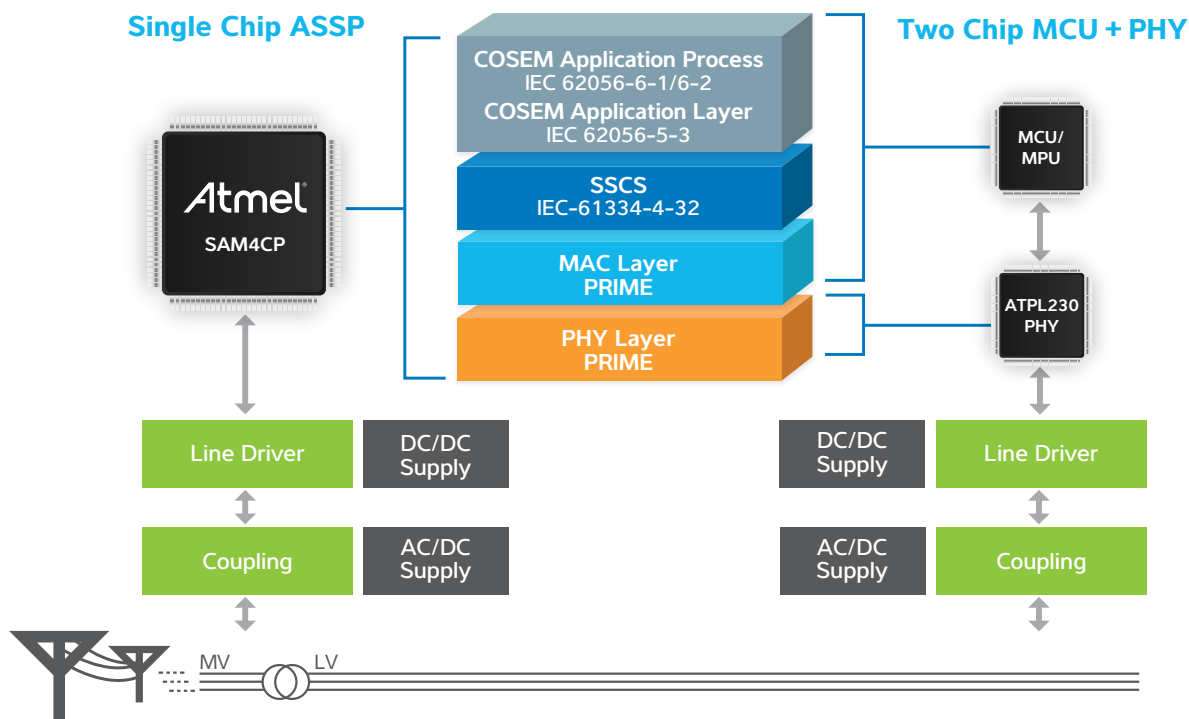


Figure 8. PRIME Device, Flexible Hardware and Software Architecture

A built in Class-D amplifier architecture is up to 30% more efficient than competing solutions with only a handful of external discrete components, reducing power waste due to heat dissipation and increasing long-term reliability due to the better thermal behavior.

An extensive array of system IO, LCD, memory, RTC, DMA and cryptographic resources available in SAM4CP16B allow integration of application, communication and metrology software (using external Atmel metrology devices) to achieve highly reliable, flexible and cost effective smart meter designs.

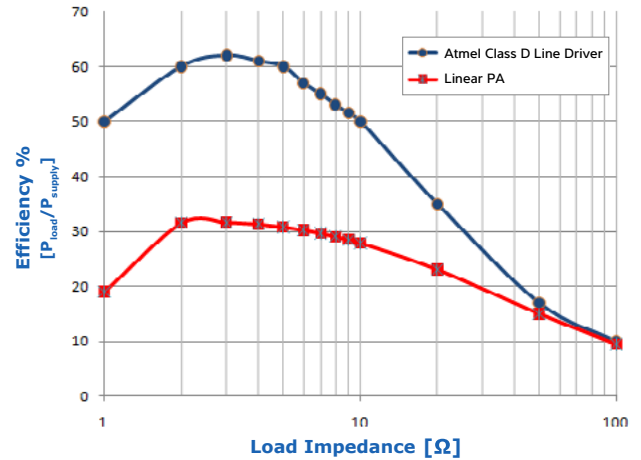


Figure 9. Class D Amplifier vs. Linear Power Amplifier Efficiency

	Standard	Frequency Band	Core	CPU Clock	Flash	SRAM	Package
SAM4CP16B	PRIME	CEN / ARIB / FCC	Dual Cortex-M4	120 MHz @core	1 MB	128 + 16 + 8 KB	LQFP 176
PL230A	PRIME	CEN / ARIB / FCC	--	--	--	--	LQFP 80

Table 4. PLC Product Features

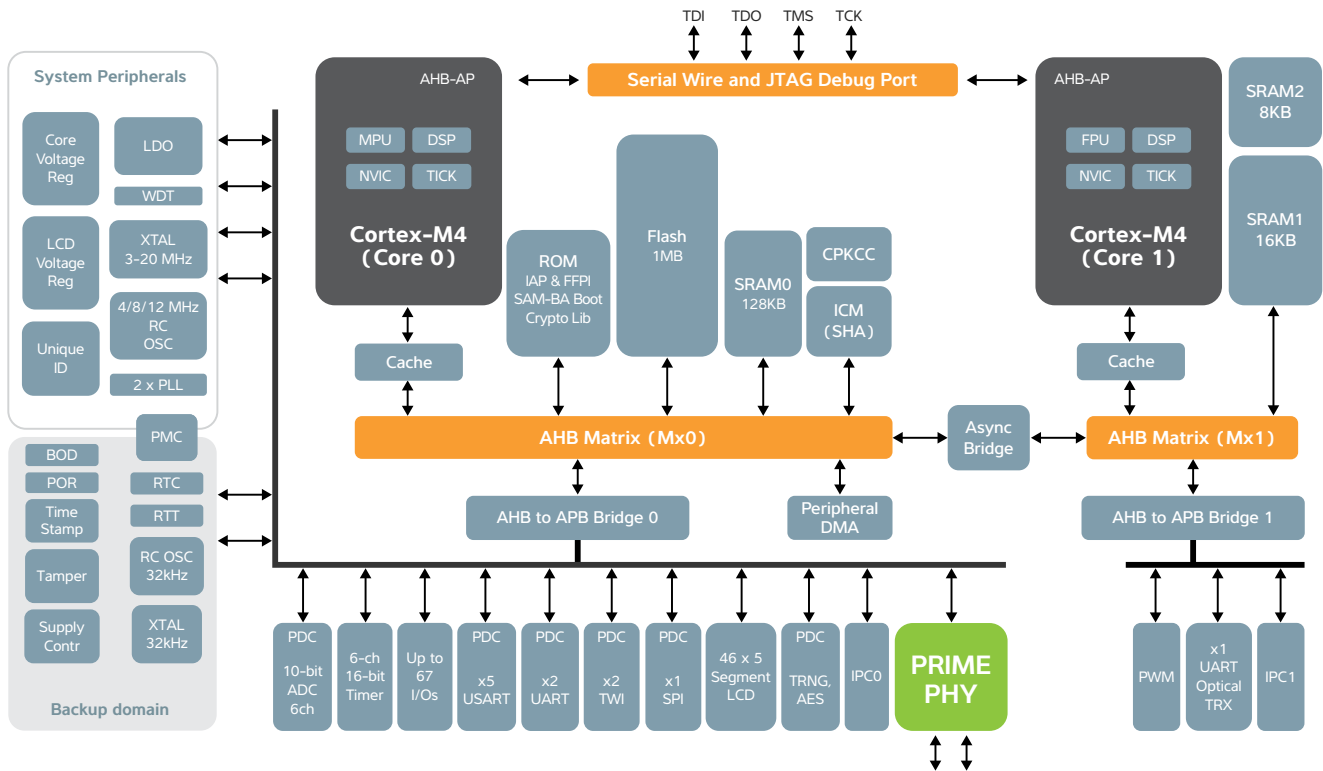


Figure 10. SAM4CP16B Block Diagram

# Atmel Smart Energy Solutions Guide

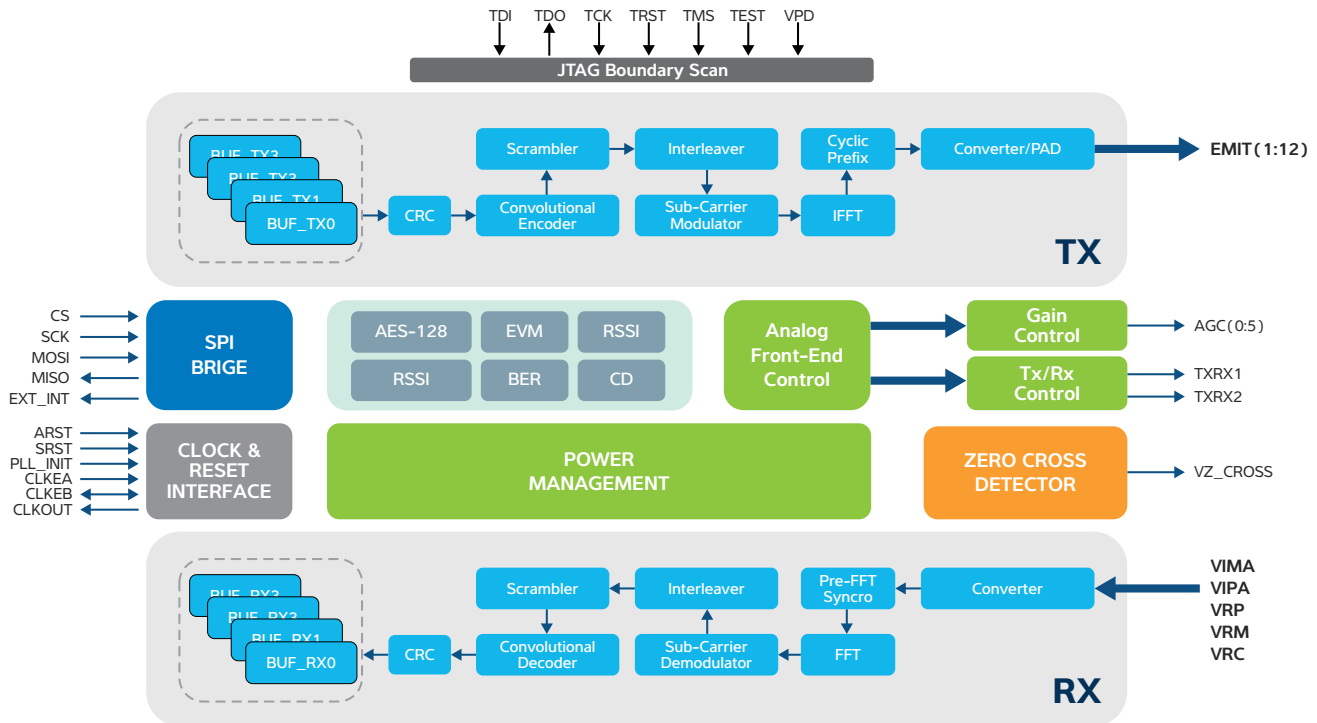


Figure 11. ATPL230 Block Diagram

## Atmel PRIME Software Stack

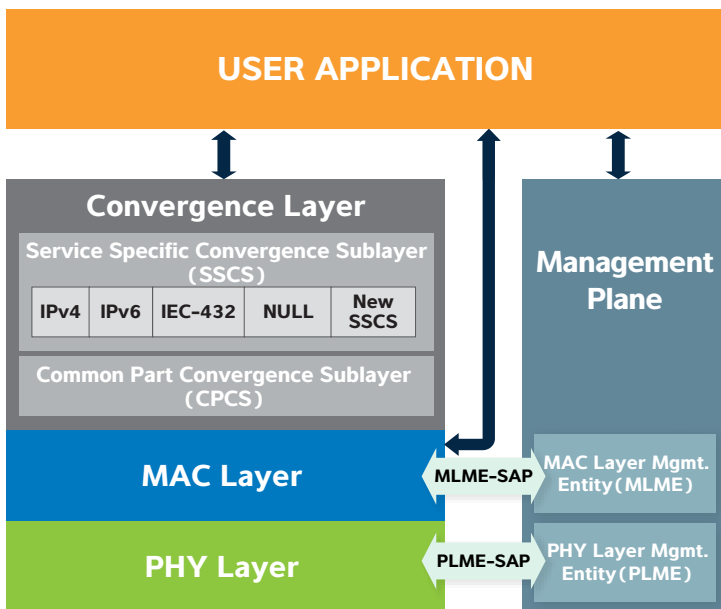


Figure 12. Drawing PRIME Stack

Atmel provides a free software stack that turns the management of PLC networks into a transparent process. You can focus on top-level applications and access the Atmel PLC software stacks via user-friendly application programming interfaces (APIs).

## Wireless Connectivity Products

Efficient smart energy wireless applications require both high-performance and power efficiency. Atmel transceivers deliver the leading RF link budget with the industry's lowest power consumption.

Additionally, Atmel offers the most feature-rich IEEE 802.15.4-compliant transceiver family available. Our transceivers support both regional 700/800/900MHz, as well as global 2.4GHz frequency bands. This enables you to develop wireless applications for customers worldwide, including emerging markets like China.

## Enhanced Performance

Powerful hardware features like antenna diversity or external power amplifier support let you further boost transceiver performance to maximize network reliability and RF range of your system. Atmel MCU wireless transceivers support not only IEEE 802.15.4-compliant applications, but provide on-air data rates up to 2Mbit/s for general purpose ISM applications. Pin compatibility ensures an easy transition between devices or frequency bands.

To help you speed up system development and prototyping, Atmel offers a variety of free software suites, various hardware evaluation boards, and development kits and modules.

## Key Products

The AT86RF212B is a low-power, low-voltage RF transceiver for the regional 700/800/900 MHz frequency bands available in Japan, China, Europe and North America. This transceiver offers an extremely good 120 dB link budget (-110 dBm receiver sensitivity / +10 dBm transmit power) designed for low-cost IEEE 802.15.4, ZigBee and high data rate ISM (industrial scientific medical) applications.

The Atmel AT86RF233 transceiver is designed to operate in the 2.4GHz ISM band, available worldwide. This transceiver offers link budgets up to 105dB (-101dBm receiver sensitivity/+4dBm transmit power). For a complete overview of features, key parameters, and targeted application areas, please see the data sheet.

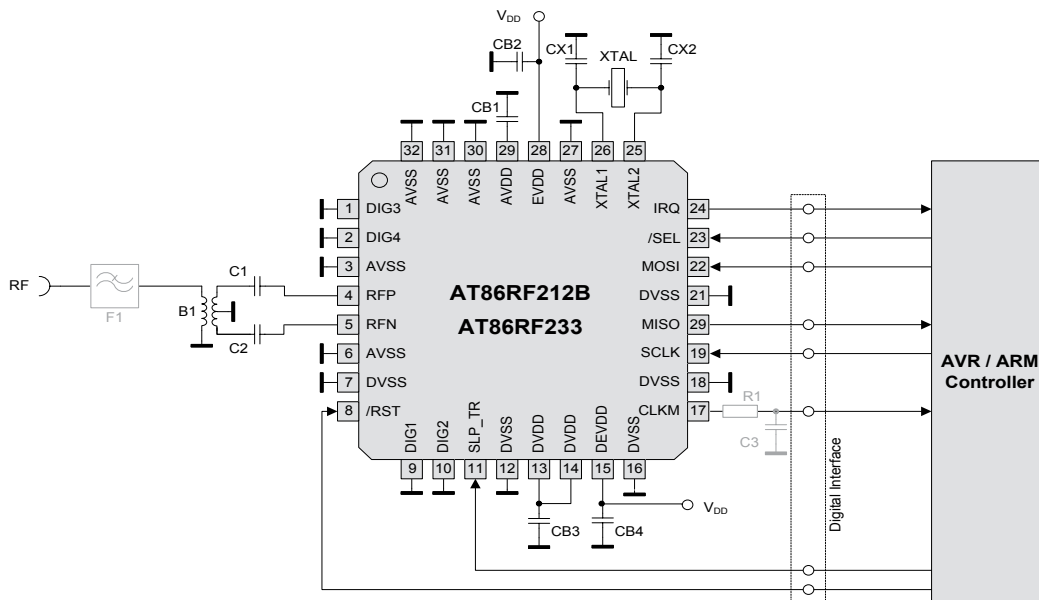


Figure 13. Wireless Transceiver Application Diagram

# Atmel Smart Energy Solutions Guide

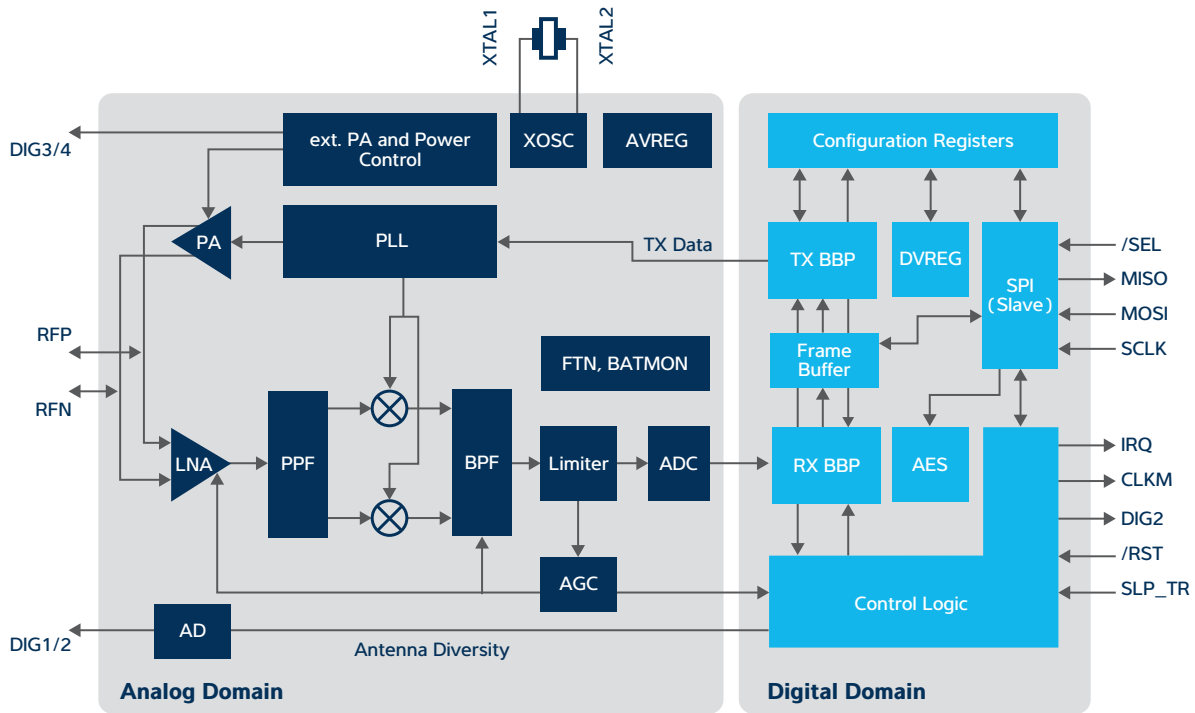




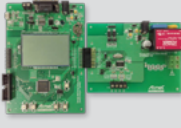

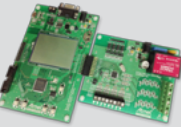


Figure 14. RF233 Block Diagram


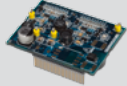








Device	Band [MHz]	Modulation	Data Rate [kbit/s]	RX Sens. [dBm]	Max.TX Power [dBm]	Current: SLEEP, TRX_OFF, RX_ON, BUSY_TX	Temp. [°C]	Pack.	Comment
<b>AT86RF212B</b> Transceiver	769 ... 935	BPSK, O-QPSK	20, 40, 100, 250  200, 400, 500, 1000	-110	10	0.2 µA 0.4 mA 9.2 mA  17.0 mA @ 5 dBm	-40 ... +85	QFN32	IEEE 802.15.4-2006/2011
<b>AT86RF233</b> Transceiver	2322 ... 2527	O-QPSK	250  500, 1000, 2000	-101	4	0.02/0.2 µA 0.3 mA 6.0 mA  13.8 mA @ 4 dBm	-40 ... +85	QFN32	Successor of AT86RF231 with new features
<b>ATmega64RFR2</b> <b>ATmega128RFR2</b> <b>ATmega256RFR2</b> System-on-Chip with 64k/8k/2k 128k/16k/4k 256k/32k/8k Flash/SRAM/EEPROM	2400 ... 2483	O-QPSK	250  500, 1000, 2000	-100	3.5	0.02 µA 0.4 mA 8.0 mA  14.5 mA @ 3.5 dBm	-40 ... +125	QFN64	Successor of ATmega128RFA1 with new features; based on RF23X transceiver and ATmega1281 controller

Table 5. Smart Energy Wireless Products

## Development Tools

	Device Part Number	Tool Part Number	Kit Contents Pictures	IDE	RTOS	STACKS/ LIBRARIES		
Metering MCU	ATSAM4C16CA-AU	ATSAM4C-EK		ATMEL Studio & ASF IAR KEIL (2Q2014)	FreeRTOS	ATMEL Metrology & Crypto Libraries ATMEL Metrology & Crypto Libraries		
	ATSAM4C16CA-AUR							
	ATSAM4C8CA-AU							
	ATSAM4C8CA-AUR							
	ATSAM4C32EA-AU	ATSAM4C32-EK						
	ATSAM4C32EA-AUR							
	ATSAM4C32CA-AU							
	ATSAM4C32CA-AUR							
Metrology SoC	ATSAM4CMS32CA-AU-ES	TBC		ATMEL Studio & ASF IAR KEIL (2Q2014)	FreeRTOS	ATMEL Metrology & Crypto Libraries		
	ATSAM4CMS16CA-AU	ATSAM4CMS-DB						
	ATSAM4CMS16CA-AUR							
	ATSAM4CMS8CA-AU							
	ATSAM4CMS8CA-AUR							
	ATSAM4CMP32CA-AU-ES	TBC						
	ATSAM4CMP16CA-AU	ATSAM4CMP-DB						
	ATSAM4CMP16CA-AUR							
	ATSAM4CMP8CA-AU							
	ATSAM4CMP8CA-AUR							
SAM4C AFE Companion Chip	Single Phase	ATSENSE101A-SU	Use Metrology SoC Tools					
		ATSENSE101A-SUR						
	Two Phase	ATSENSE201A-AU						
		ATSENSE201A-AUR						
		ATSENSE201HA-AU						
		ATSENSE201HA-AUR						
	3 Phase	ATSENSE301A-AU						
		ATSENSE301A-AUR						
		ATSENSE301HA-AU						
		ATSENSE301HA-AUR						
Stand Alone AFE (90E series)	Single Phase	ATM90E26-YU-R	ATM90E2X-DB		All SAM4C Software tools + Metrology Libraries			
		ATM90E26-YU-B						
	3 Phase	ATM90E32AS-AU-R	ATM90E32AS-DB			All SAM4C Software tools + Metrology Libraries		
		ATM90E32AS-AU-Y						
		ATM90E36A-AU-R	ATM90E36A-DB					All SAM4C Software tools + Metrology Libraries
		ATM90E36A-AU-Y						

# Atmel Smart Energy Solutions Guide

		Device Part Number	Tool Part Numbers	Kit Contents Pictures			IDE	RTOS	STACKS/ LIBRARIES
PLC	PRIME Modem	ATPL230A-AKU-Y	ATPL213A-EK (2 Modem Boards + 2 Couplings)						PRIME PHY layer
	PRIME SoC	ATSAM4CP16B-AHU-Y-ES	ATSAM4CP16B-EK (2 Boards + 4 Couplings)				ATMEL Studio & ASF IAR	FreeRTOS	PRIME
Smart RF	Sub-1GHz Transceiver (IEEE 802.15.4-2011)	AT86RF212B-ZU	ATSAM4L-XPRO + ATZB-212B-XPRO				ATMEL Studio ASF Wireless Performance Analyzer	FreeRTOS eCOS (SAM9)	Exegin Libraries & Support: 802.15.4 MAC ZigBee Pro / SEP 1.x ZigBee IP / SEP 2.0 6LoWPAN
		AT86RF212B-ZUR							
	2.4 GHz Transceiver (IEEE 802.15.4-2006)	AT86RF233-ZU	ATSAM4L-XPRO + ATREB233-XPRO or ATZB-A-233-XPRO (Amplified)						
		AT86RF233-ZUR							

# Devices

Device	Part Number	
Metering MCU	ATSAM4C16CA-AU	
	ATSAM4C16CA-AUR	
	ATSAM4C8CA-AU	
	ATSAM4C8CA-AUR	
	ATSAM4C32EA-AU	
	ATSAM4C32EA-AUR	
	ATSAM4C32CA-AU	
	ATSAM4C32CA-AUR	
Metrology SoC	Single Phase	ATSAM4CMS32CA-AU-ES
		ATSAM4CMS16CA-AU
		ATSAM4CMS16CA-AUR
		ATSAM4CMS8CA-AU
	3 Phase	ATSAM4CMS8CA-AUR
		ATSAM4CMP32CA-AU-ES
		ATSAM4CMP16CA-AU
		ATSAM4CMP16CA-AUR
SAM4C AFE Companion Chip	Single Phase	ATSENSE101A-SU
		ATSENSE101A-SUR
	Two Phase	ATSENSE201A-AU
		ATSENSE201A-AUR
		ATSENSE201HA-AU
	3 Phase	ATSENSE201HA-AUR
		ATSENSE301A-AU
		ATSENSE301A-AUR
Stand Alone AFE (90E series)	Single Phase	ATSENSE301HA-AU
		ATSENSE301HA-AUR
	3 Phase	ATM90E26-YU-B
		ATM90E26-YU-R
		ATM90E32AS-AU-R
PLC	PRIME Modem	ATPL230A-AKU-Y
	PRIME SoC	ATSAM4CP16B-AHU-Y-ES
Smart RF	Sub-1GHz Transceiver (IEEE 802.15.4-2011)	AT86RF212B-ZU
		AT86RF212B-ZUR
	2.4 GHz Transceiver (IEEE 802.15.4-2006)	AT86RF233-ZU
		AT86RF233-ZUR

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