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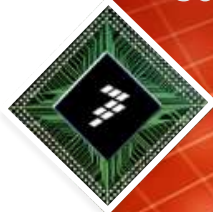
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sales@integrated-circuit.com

Hands-on Workshop: Designing Applications with the S12 MagniV Family

AMF-AUT-T0665

Derrick Klotz
Regional FAE
Senior Member of Technical Staff



November 2013

FreeScale, the FreeScale logo, iM8MC, iC3, iC4, iC6, iC7, iC8, iC9, iC10, iC11, iC12, iC13, iC14, iC15, iC16, iC17, iC18, iC19, iC20, iC21, iC22, iC23, iC24, iC25, iC26, iC27, iC28, iC29, iC30, iC31, iC32, iC33, iC34, iC35, iC36, iC37, iC38, iC39, iC40, iC41, iC42, iC43, iC44, iC45, iC46, iC47, iC48, iC49, iC50, iC51, iC52, iC53, iC54, iC55, iC56, iC57, iC58, iC59, iC60, iC61, iC62, iC63, iC64, iC65, iC66, iC67, iC68, iC69, iC70, iC71, iC72, iC73, iC74, iC75, iC76, iC77, iC78, iC79, iC80, iC81, iC82, iC83, iC84, iC85, iC86, iC87, iC88, iC89, iC90, iC91, iC92, iC93, iC94, iC95, iC96, iC97, iC98, iC99, iC100, iC101, iC102, iC103, iC104, iC105, iC106, iC107, iC108, iC109, iC110, iC111, iC112, iC113, iC114, iC115, iC116, iC117, iC118, iC119, iC120, iC121, iC122, iC123, iC124, iC125, iC126, iC127, iC128, iC129, iC130, iC131, iC132, iC133, iC134, iC135, iC136, iC137, iC138, iC139, iC140, iC141, iC142, iC143, iC144, iC145, iC146, iC147, iC148, iC149, iC150, iC151, iC152, iC153, iC154, iC155, iC156, iC157, iC158, iC159, iC160, iC161, iC162, iC163, iC164, iC165, iC166, iC167, iC168, iC169, iC170, iC171, iC172, iC173, iC174, iC175, iC176, iC177, iC178, iC179, iC180, iC181, iC182, iC183, iC184, iC185, iC186, iC187, iC188, iC189, iC190, iC191, iC192, iC193, iC194, iC195, iC196, iC197, iC198, iC199, iC200, iC201, iC202, iC203, iC204, iC205, iC206, iC207, iC208, iC209, iC210, iC211, iC212, iC213, iC214, iC215, iC216, iC217, iC218, iC219, iC220, iC221, iC222, iC223, iC224, iC225, iC226, iC227, iC228, iC229, iC230, iC231, iC232, iC233, iC234, iC235, iC236, iC237, iC238, iC239, iC240, iC241, iC242, iC243, iC244, iC245, iC246, iC247, iC248, iC249, iC250, iC251, iC252, iC253, iC254, iC255, iC256, iC257, iC258, iC259, iC260, iC261, iC262, iC263, iC264, iC265, iC266, iC267, iC268, iC269, iC270, iC271, iC272, iC273, iC274, iC275, iC276, iC277, iC278, iC279, iC280, iC281, iC282, iC283, iC284, iC285, iC286, iC287, iC288, iC289, iC290, iC291, iC292, iC293, iC294, iC295, iC296, iC297, iC298, iC299, iC300, iC301, iC302, iC303, iC304, iC305, iC306, iC307, iC308, iC309, iC310, iC311, iC312, iC313, iC314, iC315, iC316, iC317, iC318, iC319, iC320, iC321, iC322, iC323, iC324, iC325, iC326, iC327, iC328, iC329, iC330, iC331, iC332, iC333, iC334, iC335, iC336, iC337, iC338, iC339, iC340, iC341, iC342, iC343, iC344, iC345, iC346, iC347, iC348, iC349, iC350, iC351, iC352, iC353, iC354, iC355, iC356, iC357, iC358, iC359, iC360, iC361, iC362, iC363, iC364, iC365, iC366, iC367, iC368, iC369, iC370, iC371, iC372, iC373, iC374, iC375, iC376, iC377, iC378, iC379, iC380, iC381, iC382, iC383, iC384, iC385, iC386, iC387, iC388, iC389, iC390, iC391, iC392, iC393, iC394, iC395, iC396, iC397, iC398, iC399, iC400, iC401, iC402, iC403, iC404, iC405, iC406, iC407, iC408, iC409, iC410, iC411, iC412, iC413, iC414, iC415, iC416, iC417, iC418, iC419, iC420, iC421, iC422, iC423, iC424, iC425, iC426, iC427, iC428, iC429, iC430, iC431, iC432, iC433, iC434, iC435, iC436, iC437, iC438, iC439, iC440, iC441, iC442, iC443, iC444, iC445, iC446, iC447, iC448, iC449, iC450, iC451, iC452, iC453, iC454, iC455, iC456, iC457, iC458, iC459, iC460, iC461, iC462, iC463, iC464, iC465, iC466, iC467, iC468, iC469, iC470, iC471, iC472, iC473, iC474, iC475, iC476, iC477, iC478, iC479, iC480, iC481, iC482, iC483, iC484, iC485, iC486, iC487, iC488, iC489, iC490, iC491, iC492, iC493, iC494, iC495, iC496, iC497, iC498, iC499, iC500, iC501, iC502, iC503, iC504, iC505, iC506, iC507, iC508, iC509, iC510, iC511, iC512, iC513, iC514, iC515, iC516, iC517, iC518, iC519, iC520, iC521, iC522, iC523, iC524, iC525, iC526, iC527, iC528, iC529, iC530, iC531, iC532, iC533, iC534, iC535, iC536, iC537, iC538, iC539, iC540, iC541, iC542, iC543, iC544, iC545, iC546, iC547, iC548, iC549, iC550, iC551, iC552, iC553, iC554, iC555, iC556, iC557, iC558, iC559, iC560, iC561, iC562, iC563, iC564, iC565, iC566, iC567, iC568, iC569, iC570, iC571, iC572, iC573, iC574, iC575, iC576, iC577, iC578, iC579, iC580, iC581, iC582, iC583, iC584, iC585, iC586, iC587, iC588, iC589, iC590, iC591, iC592, iC593, iC594, iC595, iC596, iC597, iC598, iC599, iC600, iC601, iC602, iC603, iC604, iC605, iC606, iC607, iC608, iC609, iC610, iC611, iC612, iC613, iC614, iC615, iC616, iC617, iC618, iC619, iC620, iC621, iC622, iC623, iC624, iC625, iC626, iC627, iC628, iC629, iC630, iC631, iC632, iC633, iC634, iC635, iC636, iC637, iC638, iC639, iC640, iC641, iC642, iC643, iC644, iC645, iC646, iC647, iC648, iC649, iC650, iC651, iC652, iC653, iC654, iC655, iC656, iC657, iC658, iC659, iC660, iC661, iC662, iC663, iC664, iC665, iC666, iC667, iC668, iC669, iC670, iC671, iC672, iC673, iC674, iC675, iC676, iC677, iC678, iC679, iC680, iC681, iC682, iC683, iC684, iC685, iC686, iC687, iC688, iC689, iC690, iC691, iC692, iC693, iC694, iC695, iC696, iC697, iC698, iC699, iC700, i



Agenda

- Automotive Body Electronics
- MagniV Solutions and Roadmap
- Lab 1 —————
 - Getting Started with CodeWarrior 10.4
- S12Z Enhanced CPU Core
- S12ZVM for BLDC Motor Control
- S12ZVL for General Purpose LIN
- S12ZVC for General Purpose CAN
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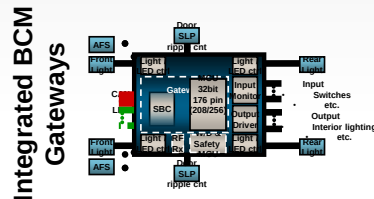
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Automotive Market Trends – Sensors and Actuators

- **Reduction of power consumption**
 - LIN to reduce **cables** weight
 - **Smarter** motor control techniques
 - **Smarter** and **more** sensors
- **Reduction of physical size**
 - Electro-mechanical **integration**
 - **High temperature** >125°C Ta
- **High Growth**
 - Driven by affordability of **LIN**
 - Driven by **comfort and convenience** features



What's Behind Body Electronics?



Comfort Features

- Door Module
- Window Lift
- Seat Module/position
- HVAC
- Electric sunroof/shade
- Interior lighting

Vehicle Networking

- Central Body Control Module
- Central Gateways: CAN, LIN, Flexray, Ethernet, MOST

Safety Related

- Steering column lock
- Steering column adjustment
- AFS
- Anti-pitch power windows
- Wipers and rain sensors

Security

- Immobilizer
- Keyless Entry
- Preventing hacking and counterfeit modules

- Body systems embrace a broad variety of applications inside the cabin
- Body systems cover the widest range of performance requirements
 - Small 8-bit controllers and watchdogs
 - General purpose 16-bit controllers
 - High performance 32-bit compute engines

Body Market Trends and Challenges



- More complex Gateways with higher performance and multicore usage (Expanding memory)
- Ethernet and wireless communication
- Personalization options driving LIN nodes



- **Functional Safety - ISO26262**
Several body-apps need ASIL A/B (some C/D)
- **Reduced ASIL-assessment effort**
- **Security/Cryptography for Gateway and BCM modules**



- Power management in stop and run modes
- Autosar SW management of partial/pretended networking
- EC-motors, LED-lighting



- **Cost reduction via ECU integration**
- **Electrification of the car replacing mech. components**
- **Scalability of hardware and software**
- **Auto generated code to decrease dev costs**

Software Integration:

- **Autosar:**
 - Multicore-support
 - OS
 - MCAL
- **Safety:**
 - SW-routines supporting self-test (Core/Memory)
- **Security:**
 - Cryptography algorithmic support
- **Application-support**
 - Motor Control-library
 - Reference designs

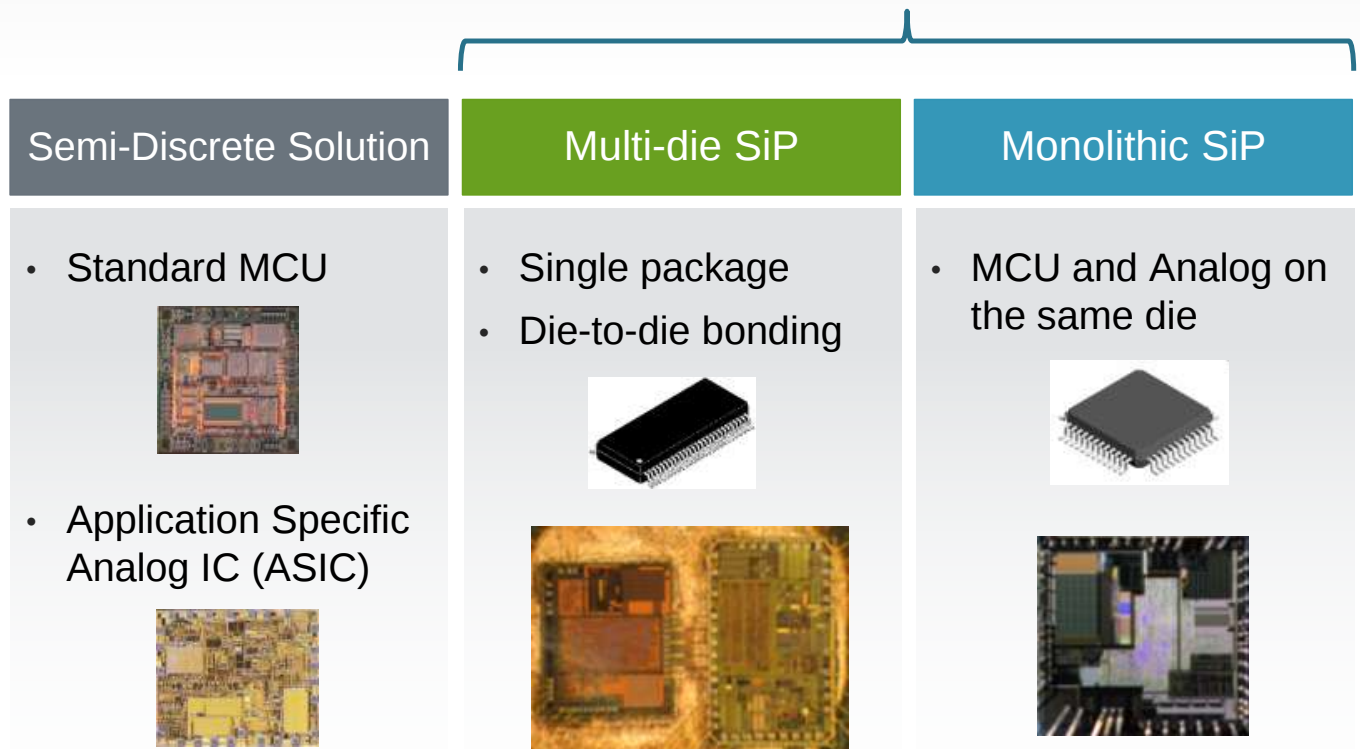
Automotive Microcontroller Portfolio

Target Applications

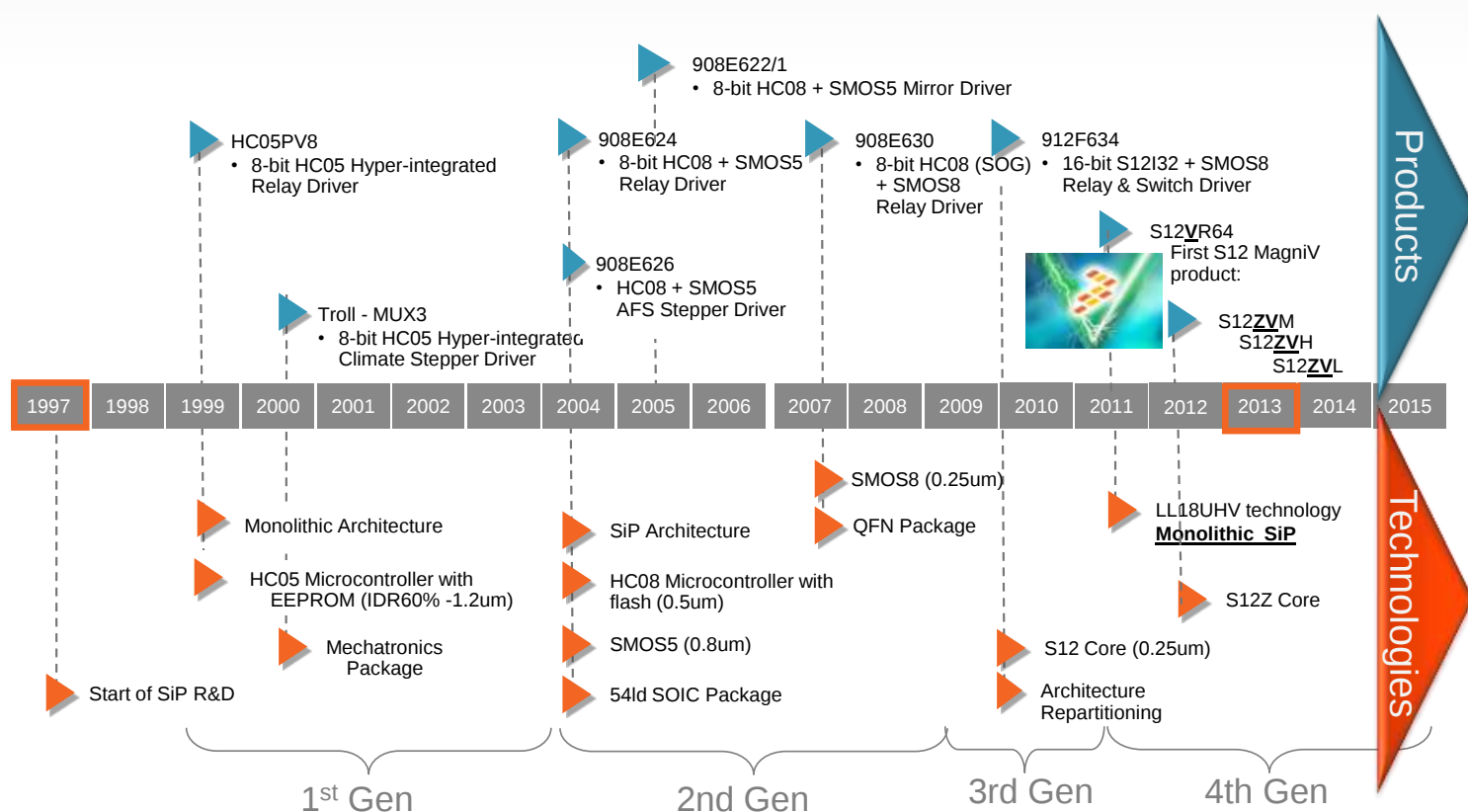
MPU	i.MX 	Multimedia processors	➔	Multicore and graphics performance	• Center stack • Instrument cluster • Telematics
32-bit MCU	Qorivva 	Highest-performance automotive MCU	➔	Multicore with integrated safety and security	• Powertrain • Safety & chassis • Central body • Vehicle networking
16-bit MCU	S12 	An industry-leading 16-bit architecture	➔		• Body electronics • Instrument cluster • LIN slaves
8-bit MCU	S08 	15-year automotive workhorse	➔		• Sensor/Actuators • Switch and touch panels • Companion MCUs

What is S12 MagniV?

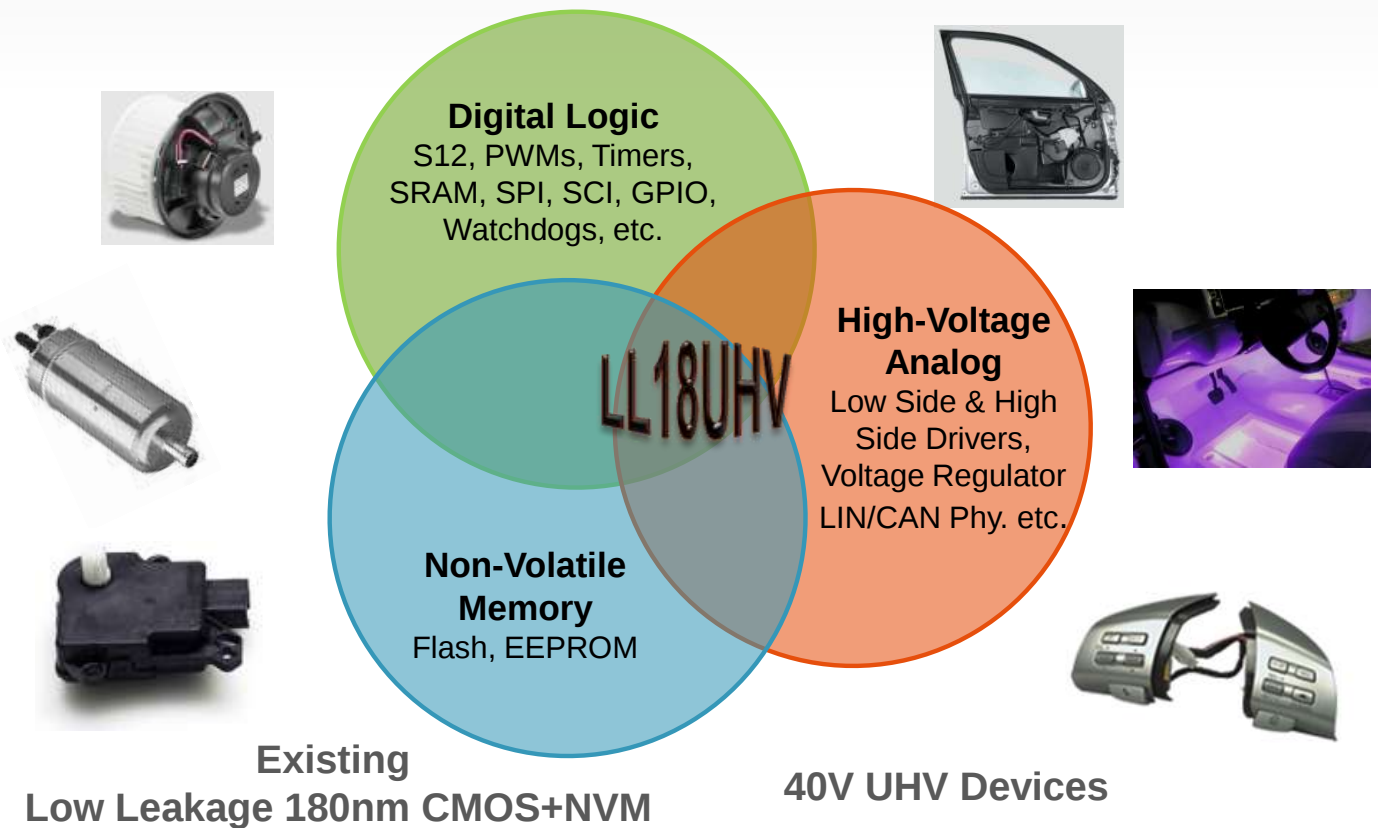
SiP = System in Package



Over 15 Years of System in Package (SiP) Experience



LL18UHV Technology Summary for S12 MagniV

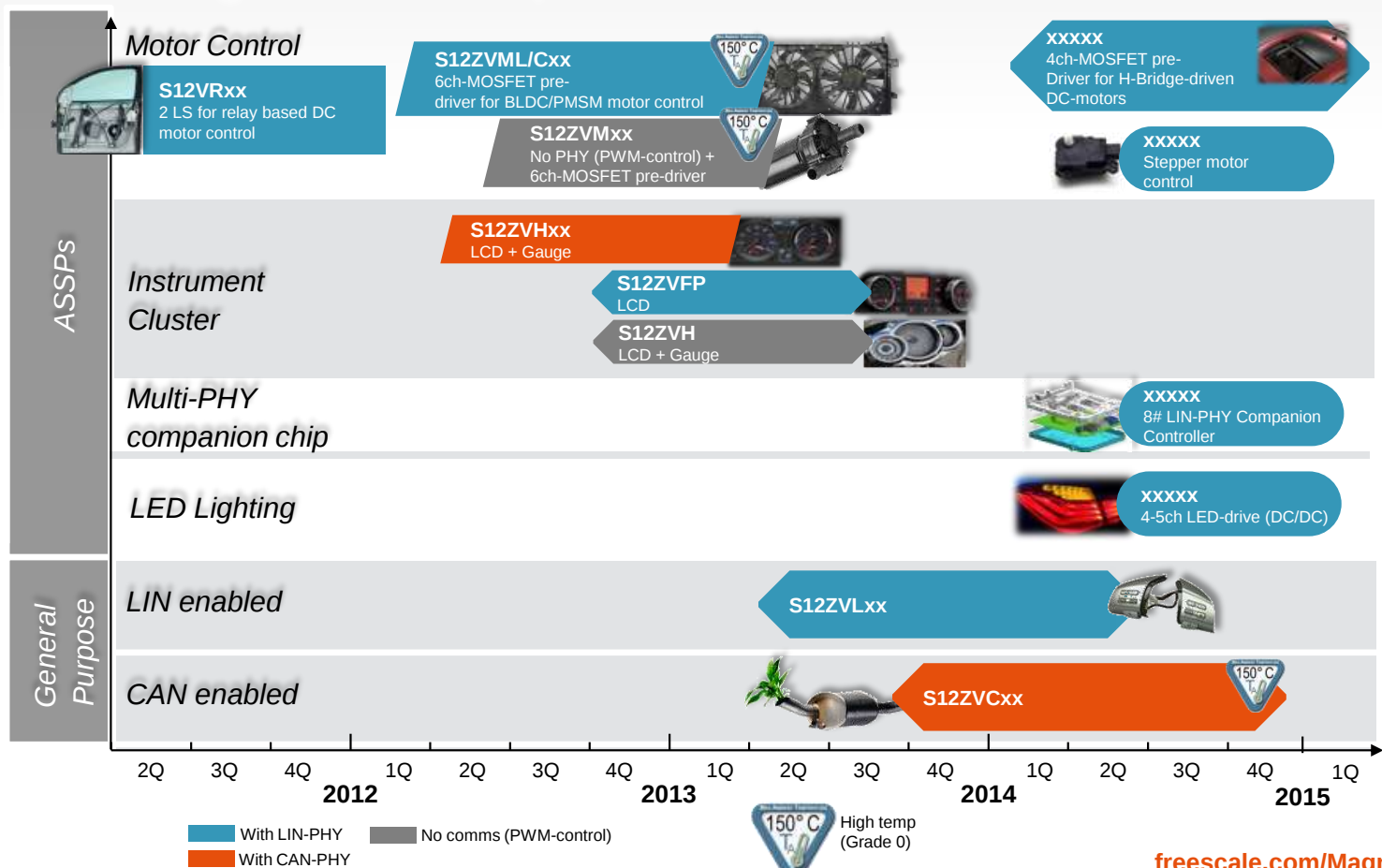


MagniV building blocks

High-Voltage Components	Digital Components	MCU Core and Memories	5V Analogue Components	Packaging
VREG for tot. supply: •70mA w/o ext comp. or •170mA with ext. ballast	MS-CAN SPI	S12- or S12Z-CPU 25/32/50MHz bus	ADC 10-12Bit resolution 1-2 S/H-units Up to 16ch total	LQFP: 32/48/64/100/144-pin
LIN-PHY CAN-PHY	GPIO PGPIO 20mA NGPIO 25mA	Flash (ECC) 8kB – 128kB	Temp Sense	LQFP-EP: 48/64-pin
V-BAT SENSE V-SUP SENSE	BDM/BDC	EEPROM (ECC) 128B – 4kB	Current Sense (2 x Op-Amp)	QFN: 32-pin (5x5mm)
HVI (12V-input with ADC)	Key Wakeups Win Wdog	RAM (ECC) 512B - 8kB	Pierce Osc.	
LS-drivers HS-drivers	RTC		RCosc. +/-1.3% PLL	
Charge Pump	Timer 16Bit (25-64MHz) PWM 8/16Bit (25-50MHz)			
4-6ch MOSFET Predriver (50-100nC)	Motorcontrol PWM With Fault protection Prog. Trigger Unit Sound Generator Segment LCD (4x40) Stepper Motor Driver with SSD			

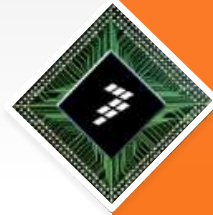


S12 MagniV Roadmap





Agenda

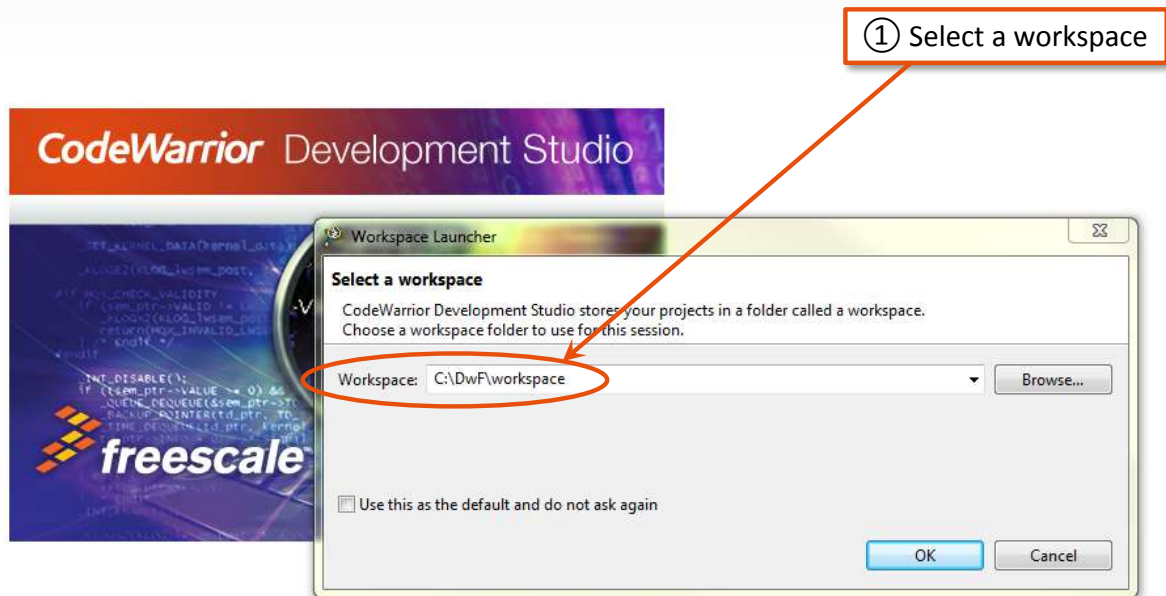


Lab 1

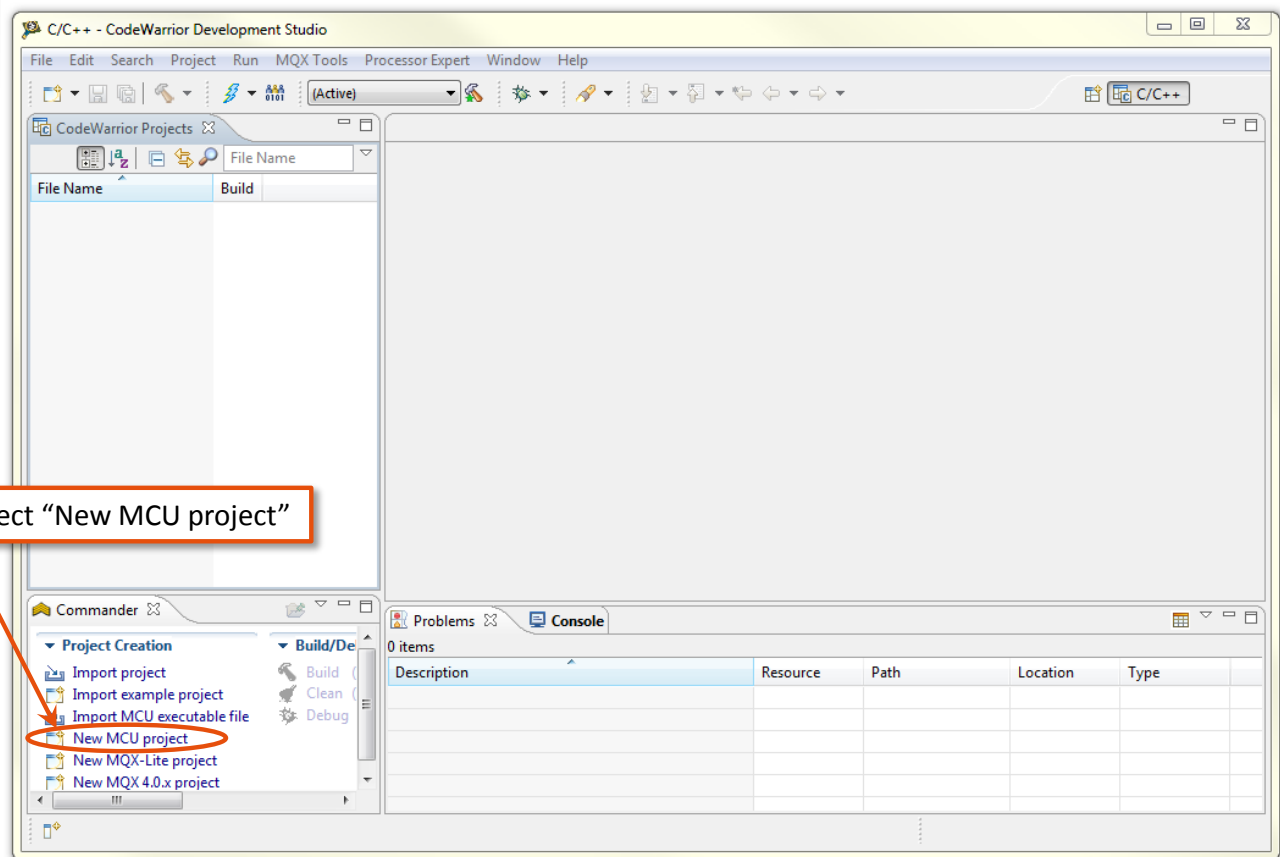
Getting Started with CodeWarrior 10.4

freescale.com/automotive

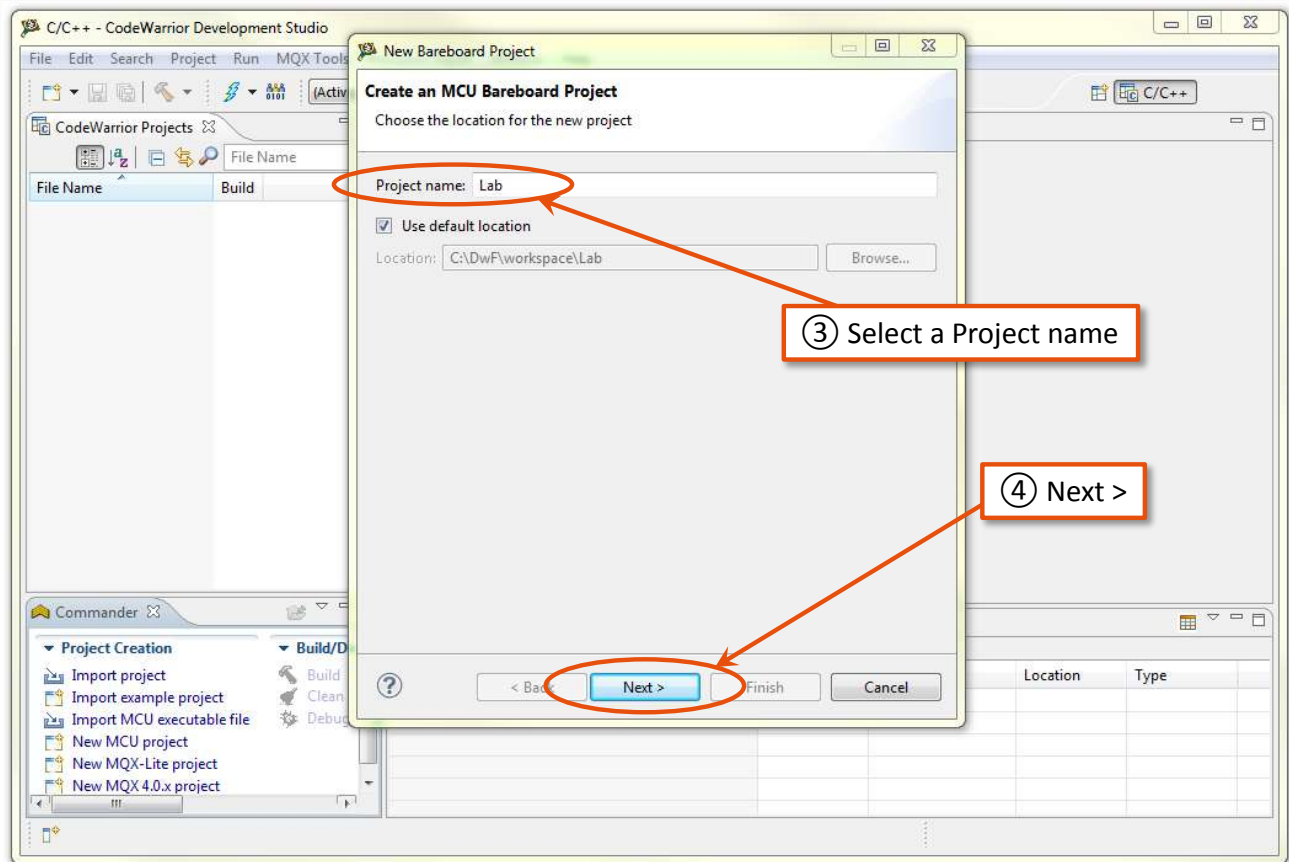
Launch CodeWarrior 10.4



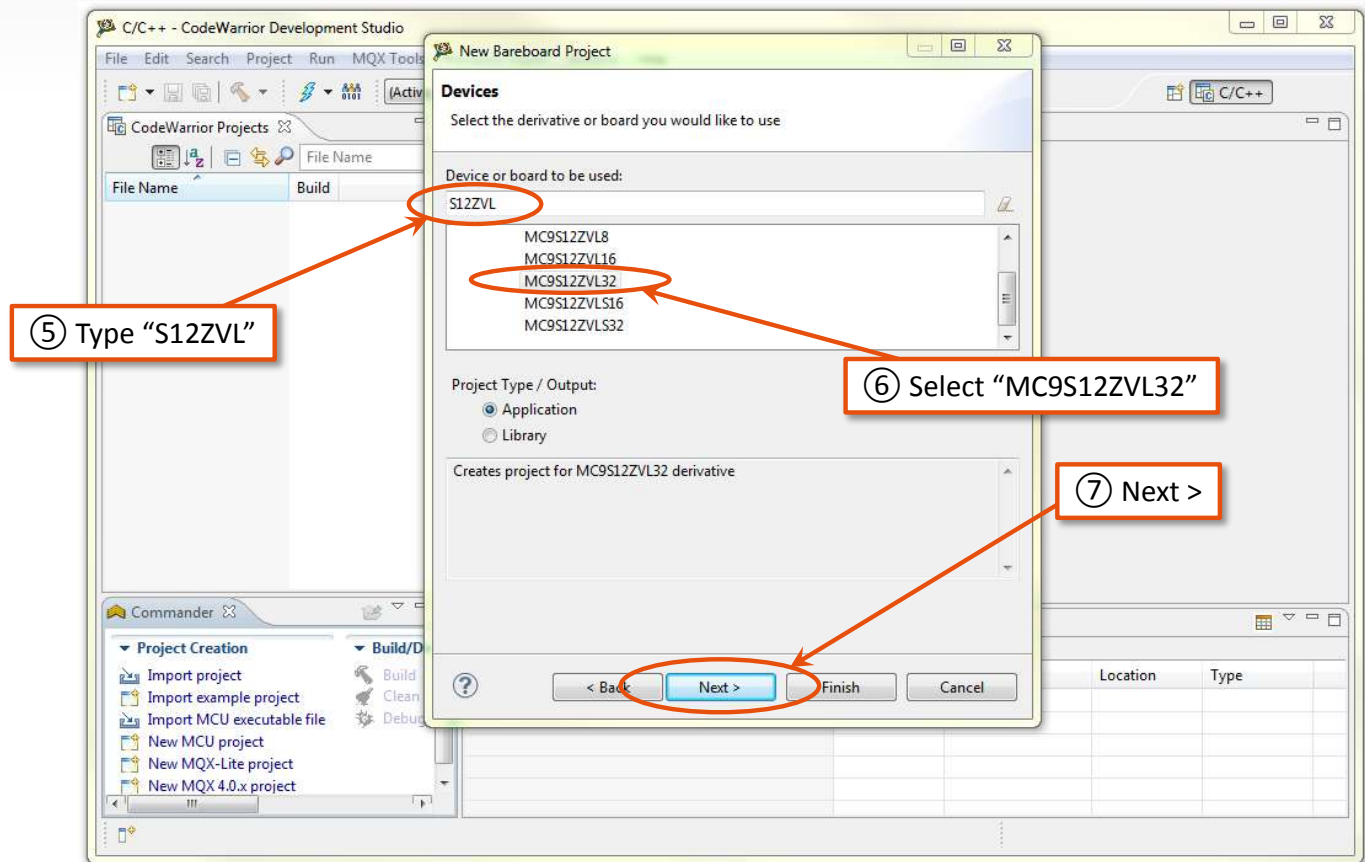
The C/C++ Perspective



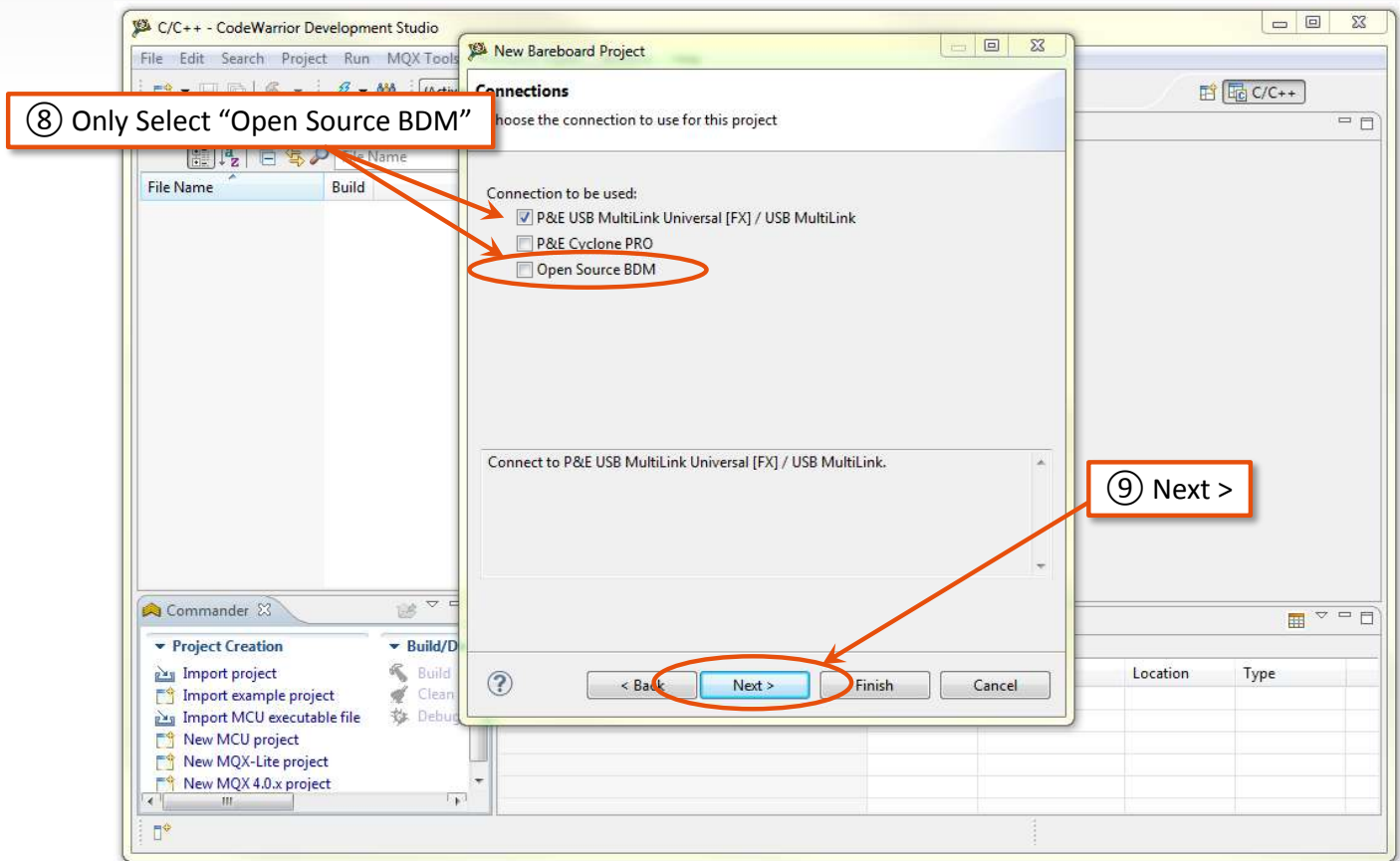
Start a New Project – “Lab”



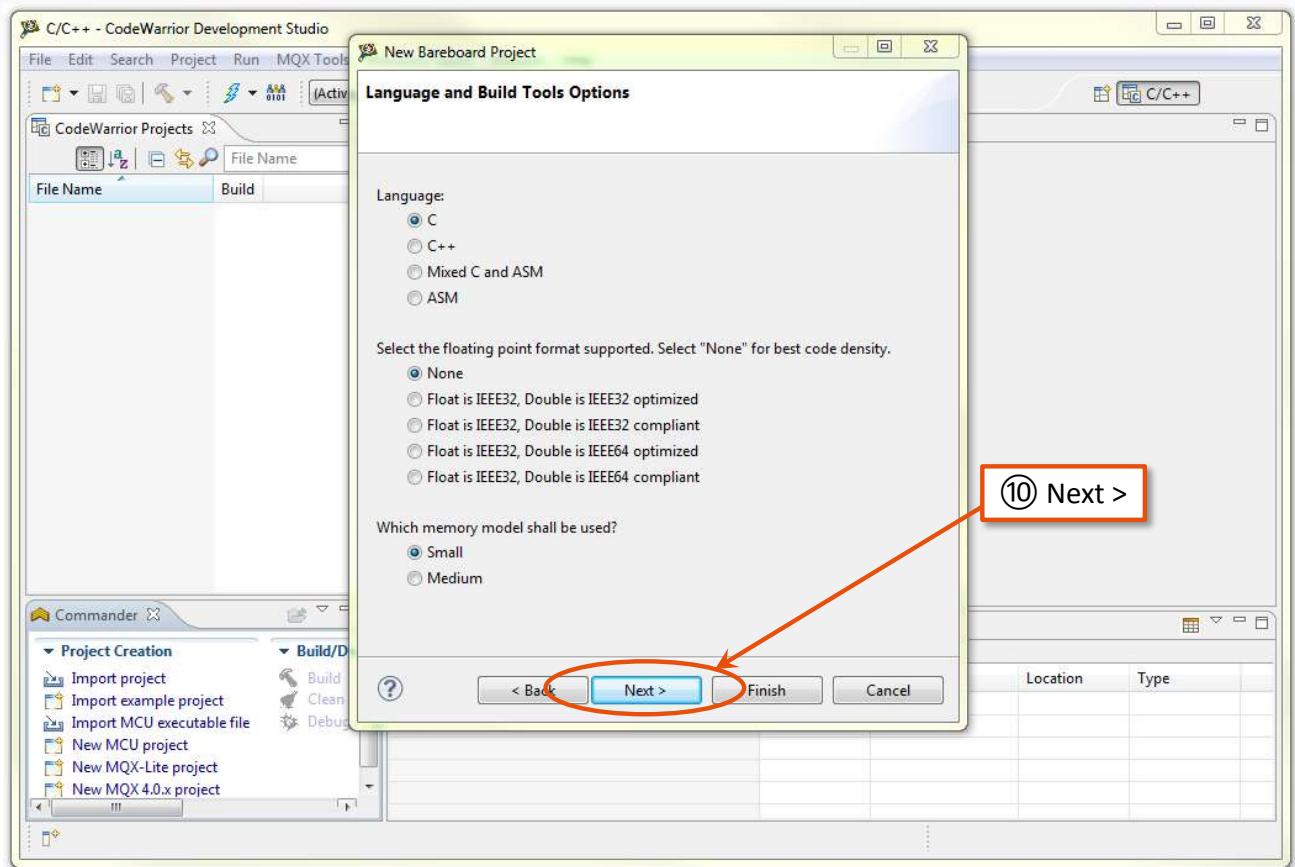
Select the Target Device



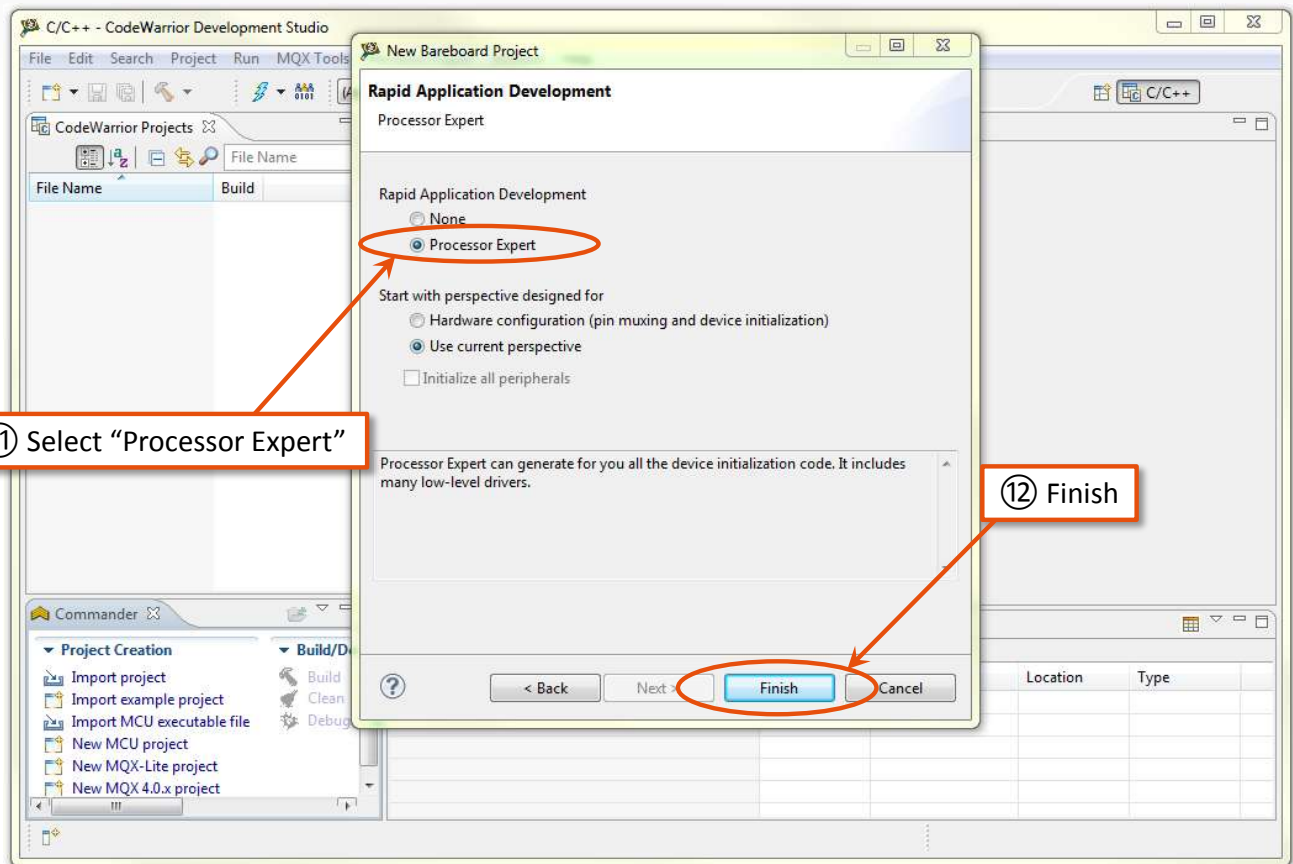
Select the Debug Connection



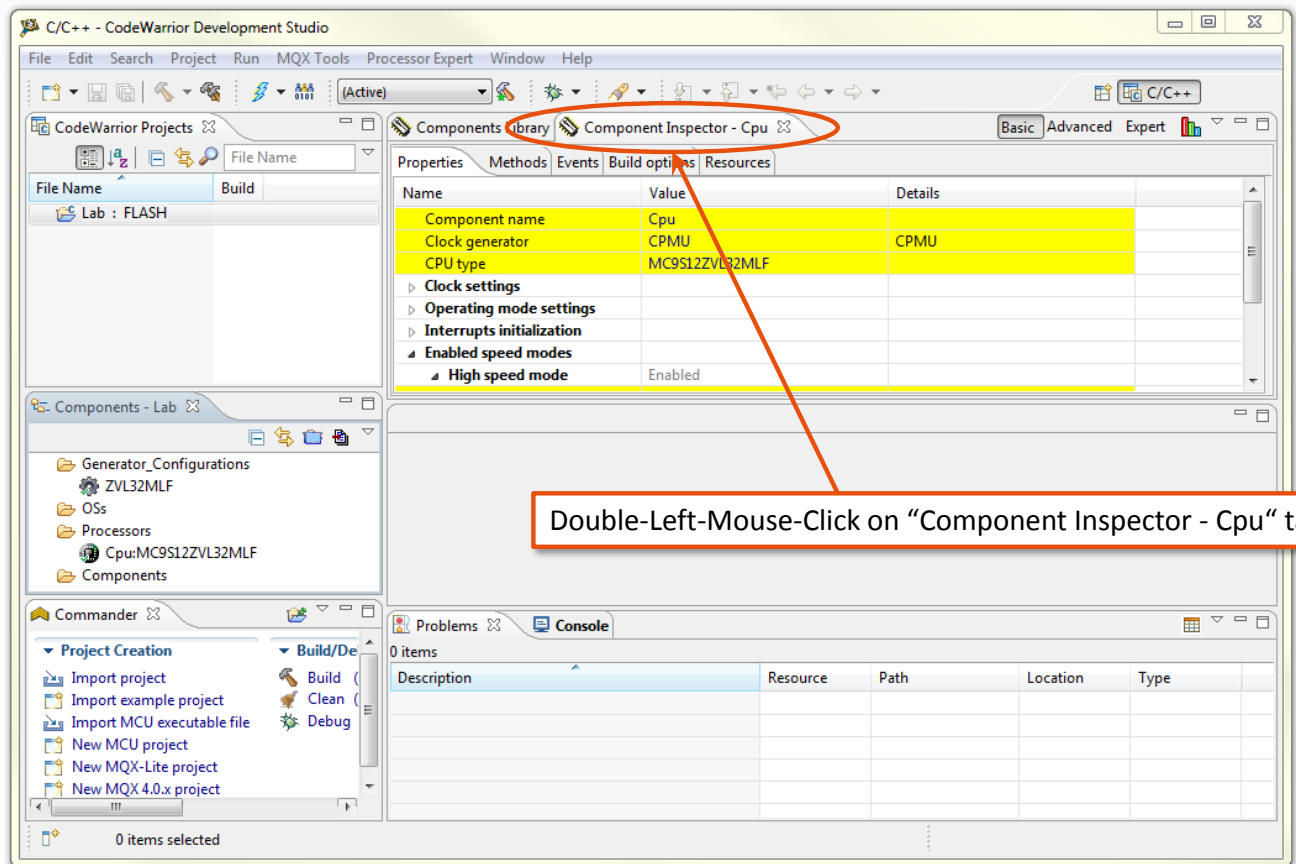
Language and Build Options



Enable Processor Expert

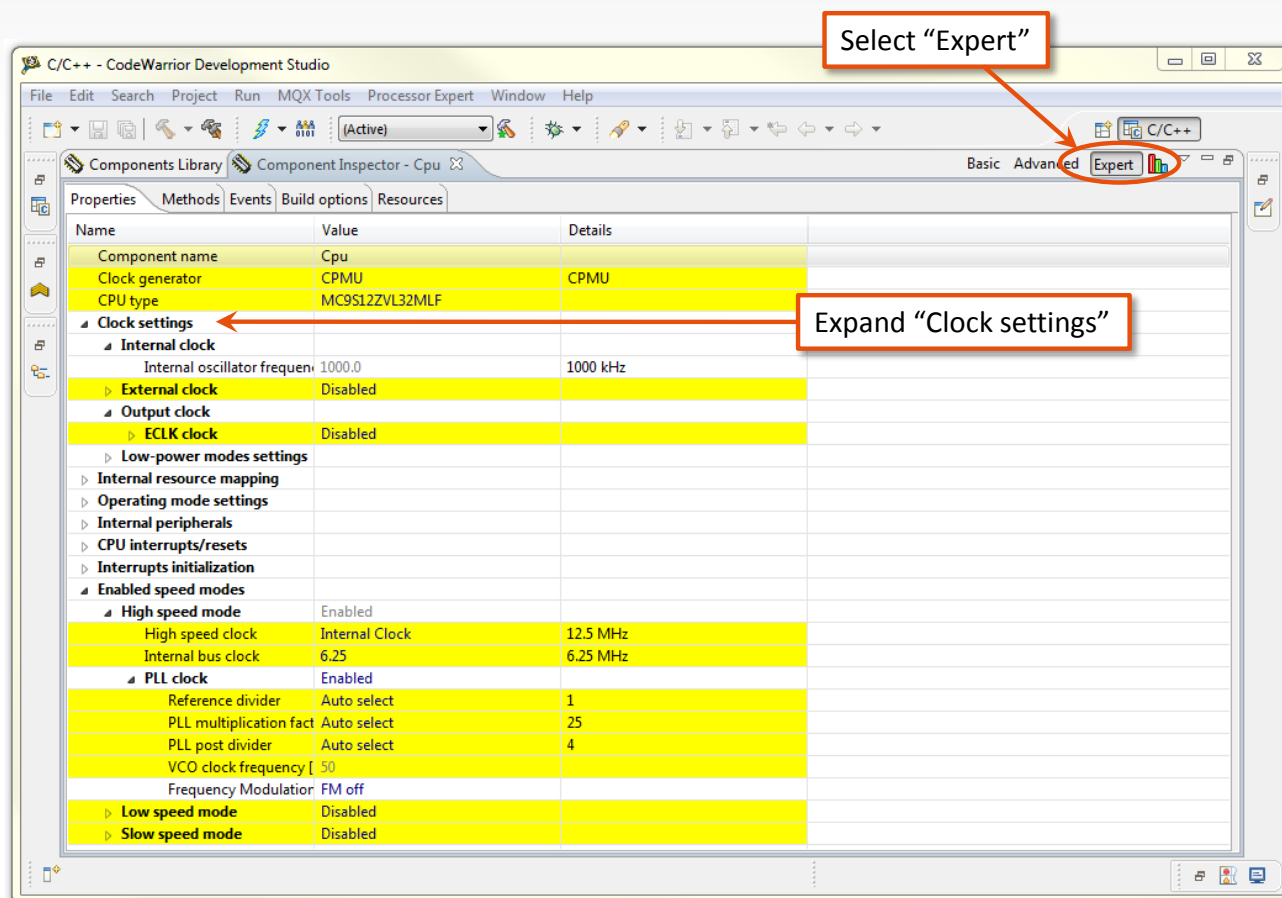


The C/C++ Perspective with Processor Expert



Double-Left-Mouse-Click on “Component Inspector - Cpu” tab

Component Inspector - Cpu



S12 Clock, Reset and Power Management Unit

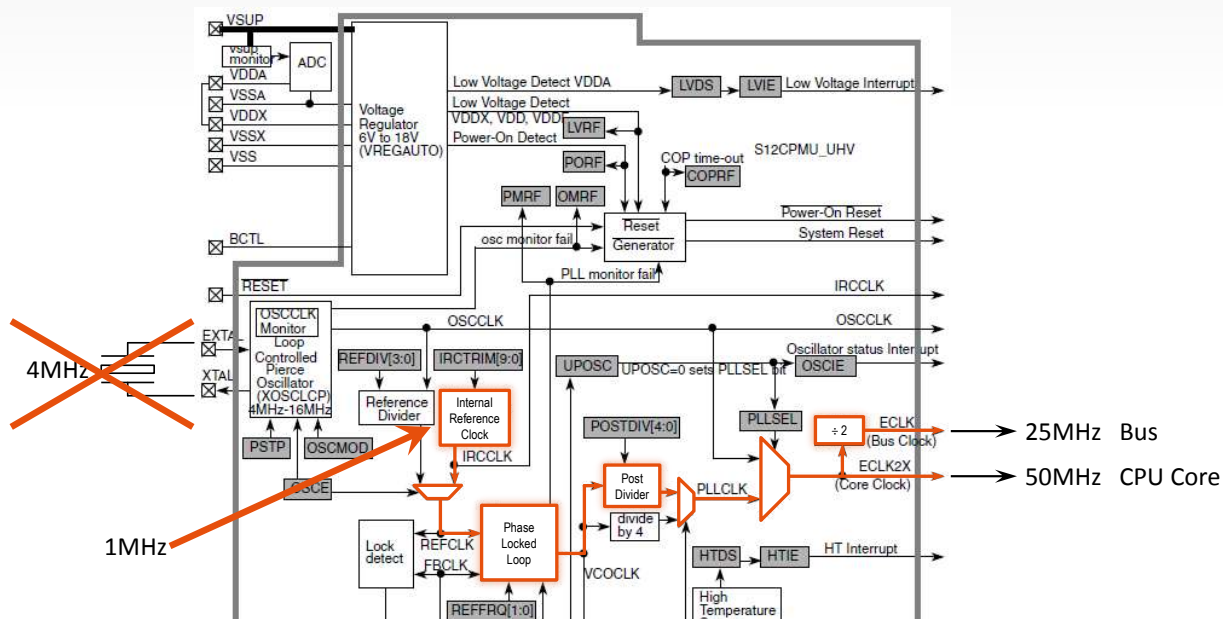
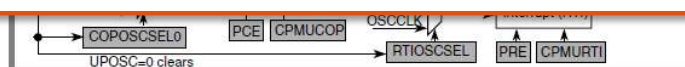


Table A-19. IRC electrical characteristics

Num	C	Rating	Symbol	Min	Typ	Max	Unit
1	P	Junction Temperature - 40 to 150 Celsius Internal Reference Frequency, factory trimmed	f _{IRC1M_TRIM}	0.987	1	1.013	MHz

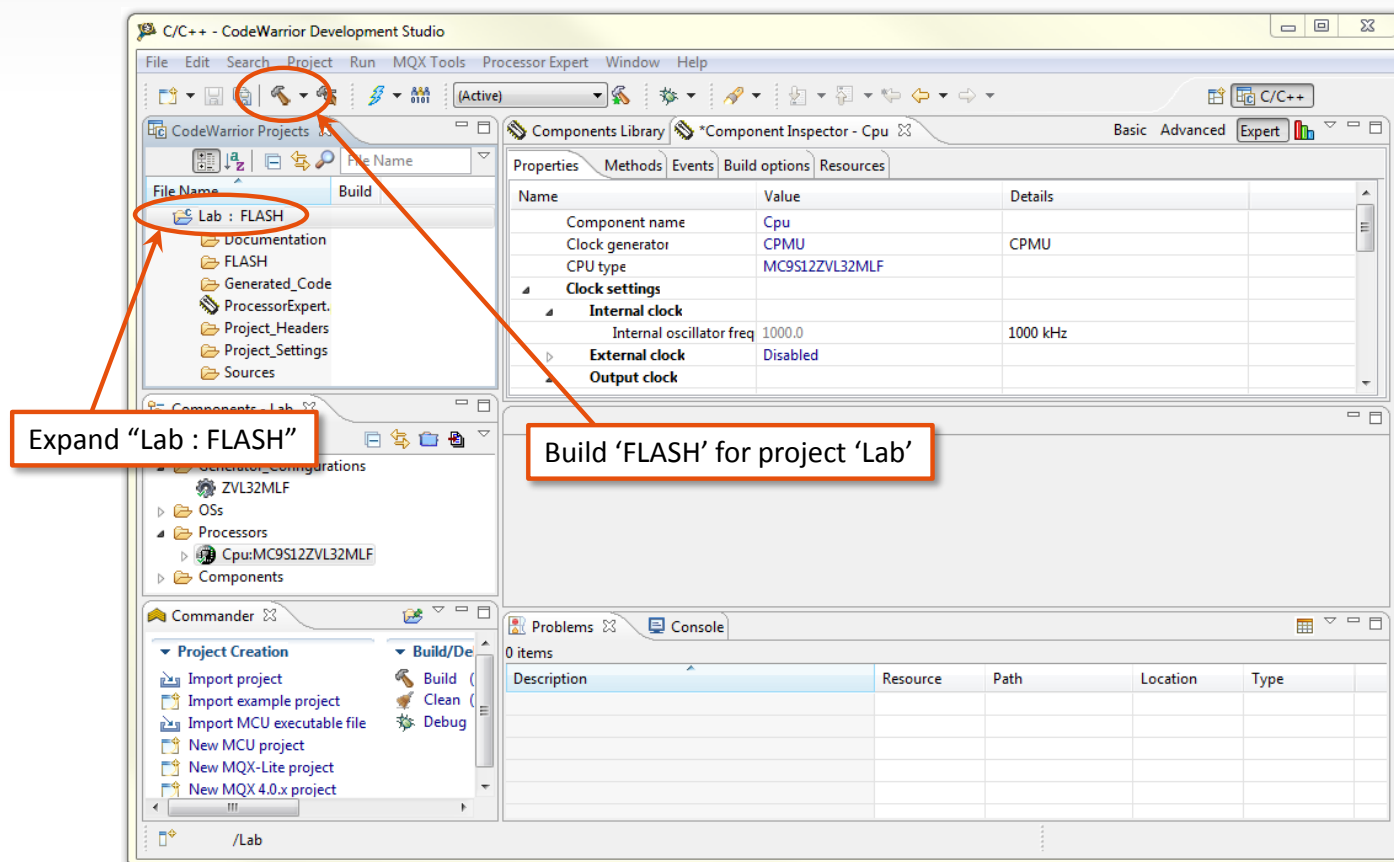


Component Inspector - Cpu

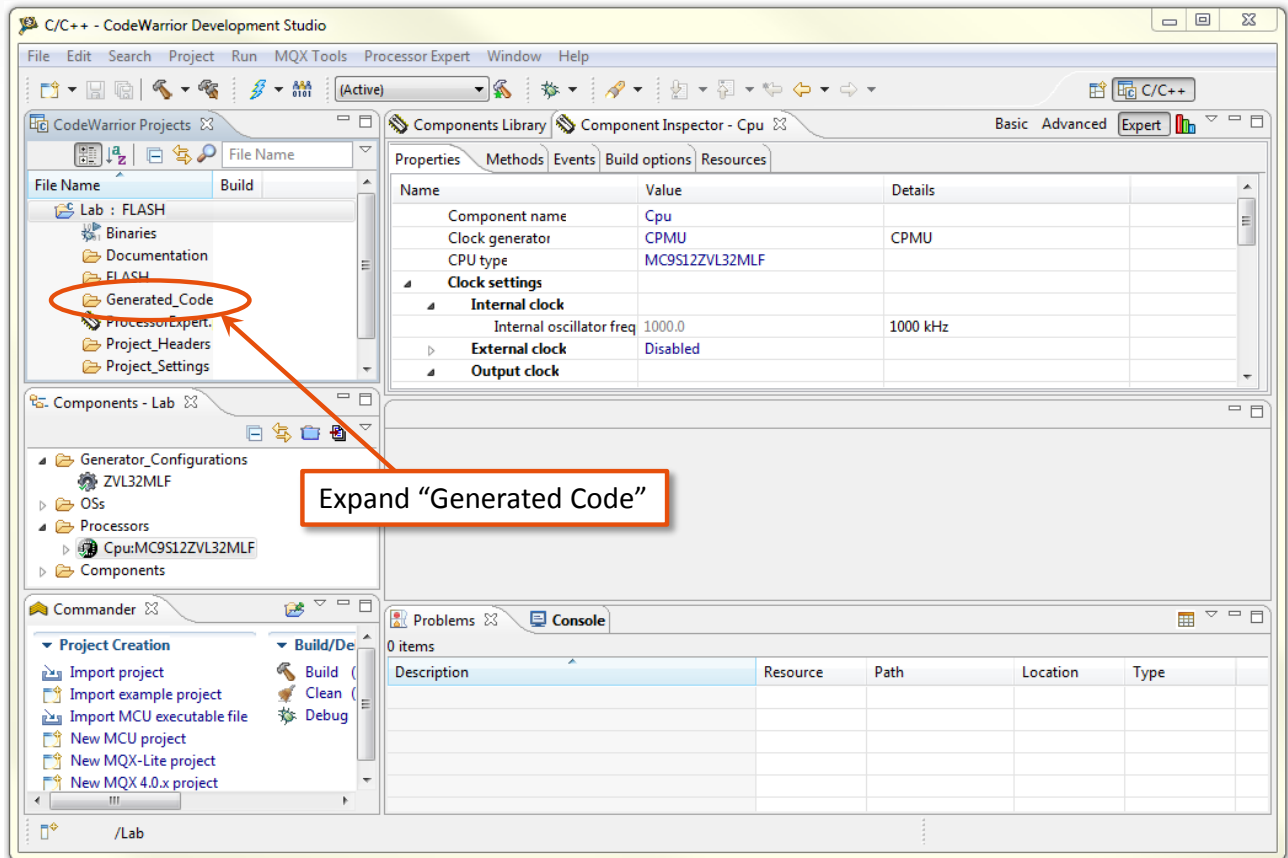
The screenshot shows the CodeWarrior Development Studio interface. The 'Component Inspector - Cpu' tab is selected and highlighted with a red circle. A red arrow points from a callout box saying 'Double-Left-Mouse-Click on "Component Inspector - Cpu" tab' to this tab. Another red circle highlights the 'Internal bus clock' value '25.0' in the 'Enabled speed modes' section, with a callout box saying 'Enter "25" MHz' pointing to it. The table below shows the configuration details for the CPU component.

Name	Value	Details
Component name	Cpu	
Clock generator	CPMU	CPMU
CPU type	MC9S12ZVL32MLF	
Clock settings		
Internal clock		
Internal oscillator freq	1000.0	1000 kHz
External clock	Disabled	
Output clock		
ECLK clock	Disabled	
Low-power modes setti		
Internal resource mapping		
Operating mode settings		
Internal peripherals		
CPU interrupts/resets		
Interrupts initialization		
Enabled speed modes		
High speed mode	Enabled	
High speed clock	Internal clock	50 MHz
Internal bus clock	25.0	25 MHz
PLL clock	Enabled	
Reference divider	Auto select	1
PLL multiplication	Auto select	25
PLL post divider	Auto select	1
VCO clock frequer	50	
Frequency Module	FM off	
Low speed mode	Disabled	
Slow speed mode	Disabled	

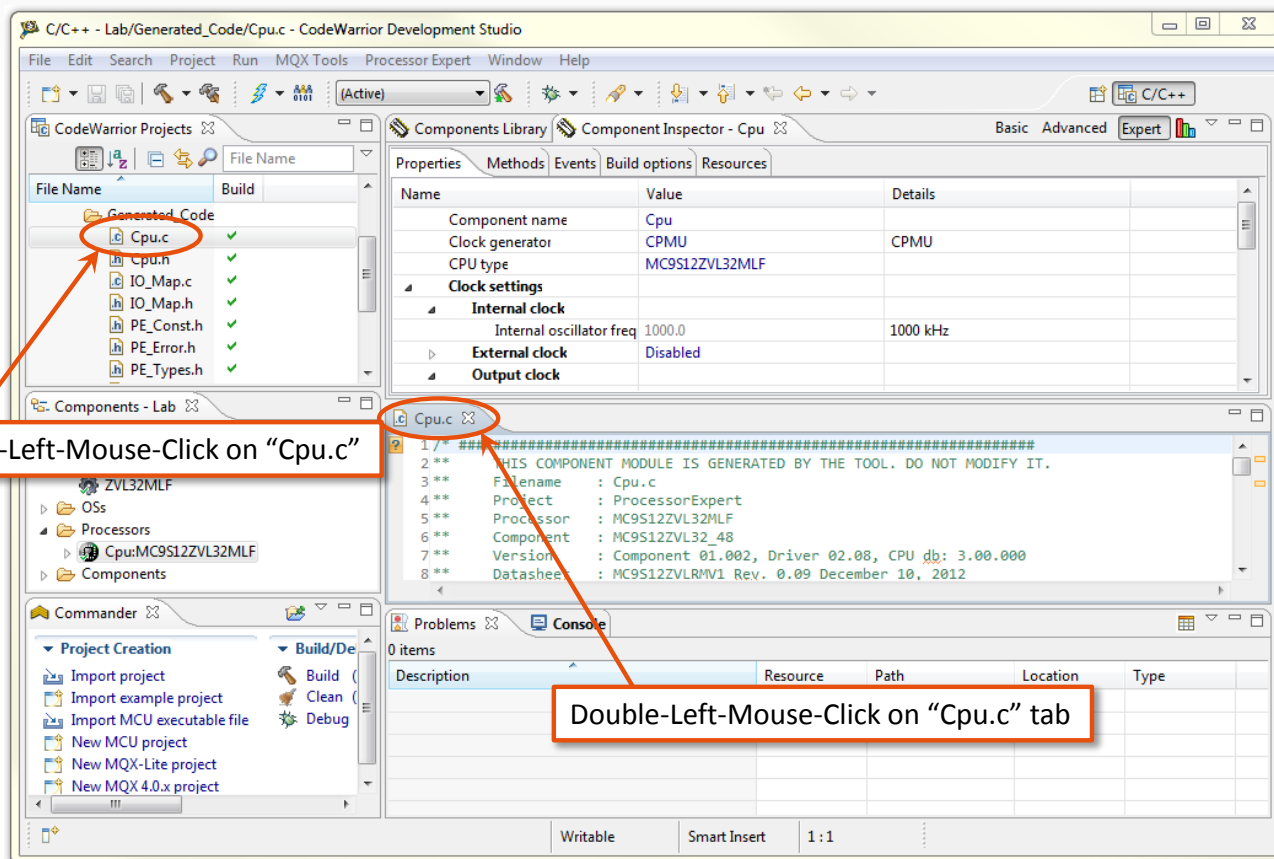
Build Project “Lab”



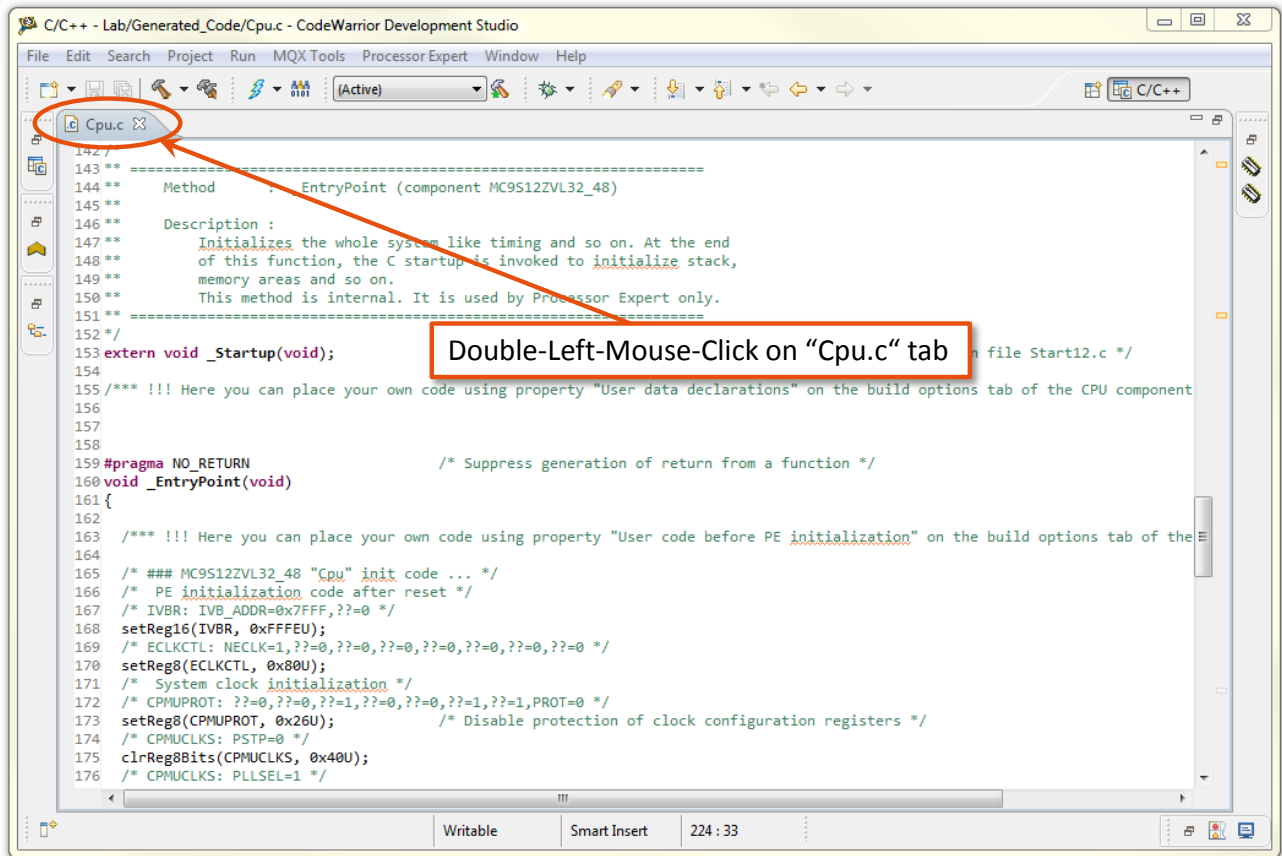
Investigate Processor Expert Generated Code



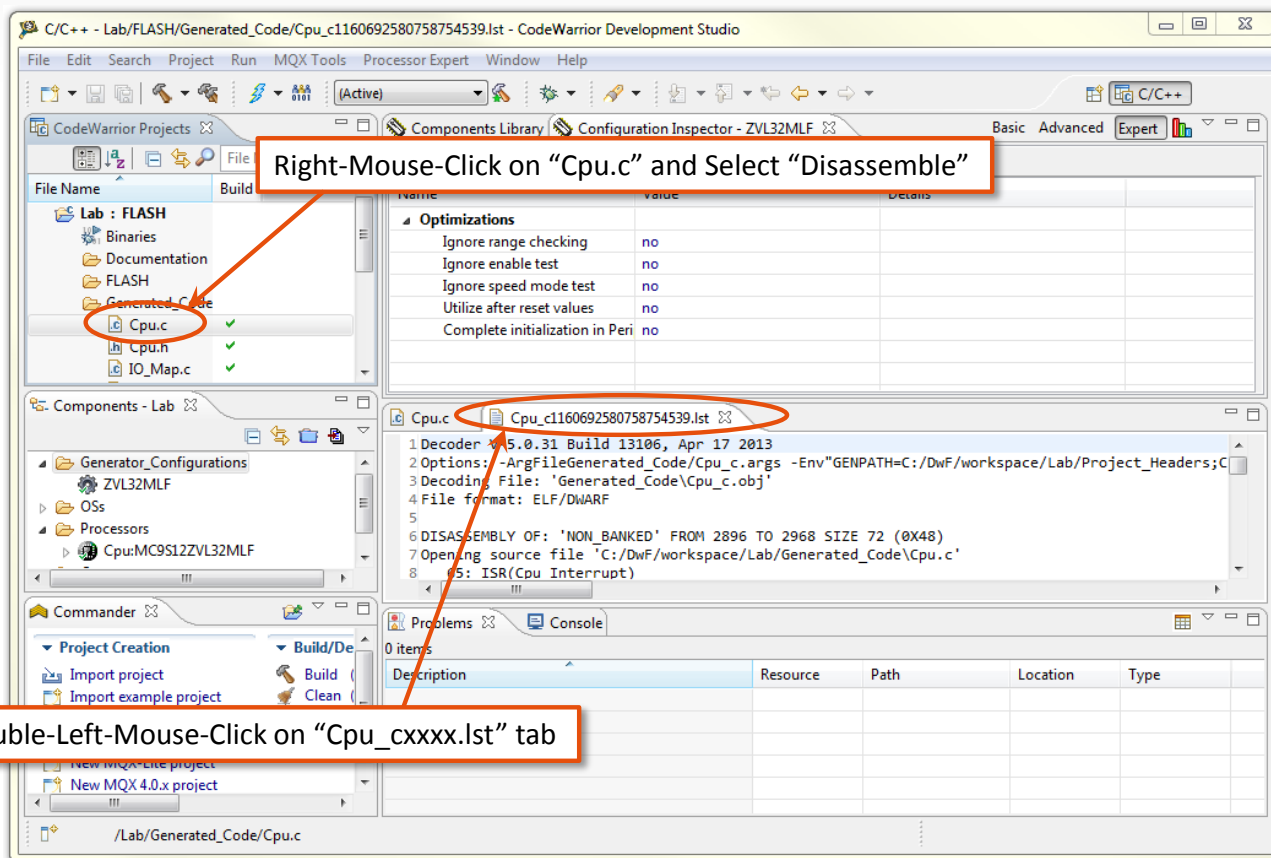
Investigate Processor Expert Generated Code – “Cpu.c”



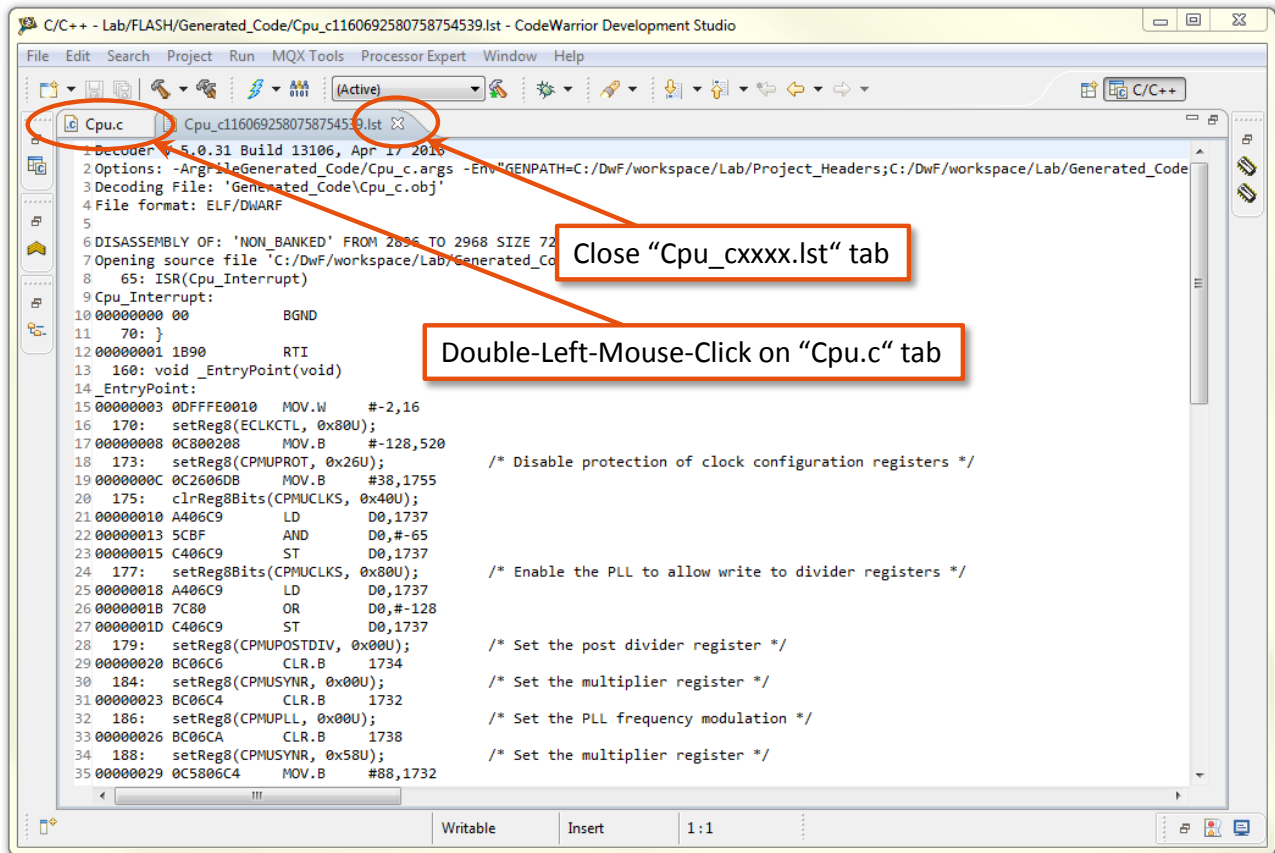
Investigate Processor Expert Generated Code – “Cpu.c”



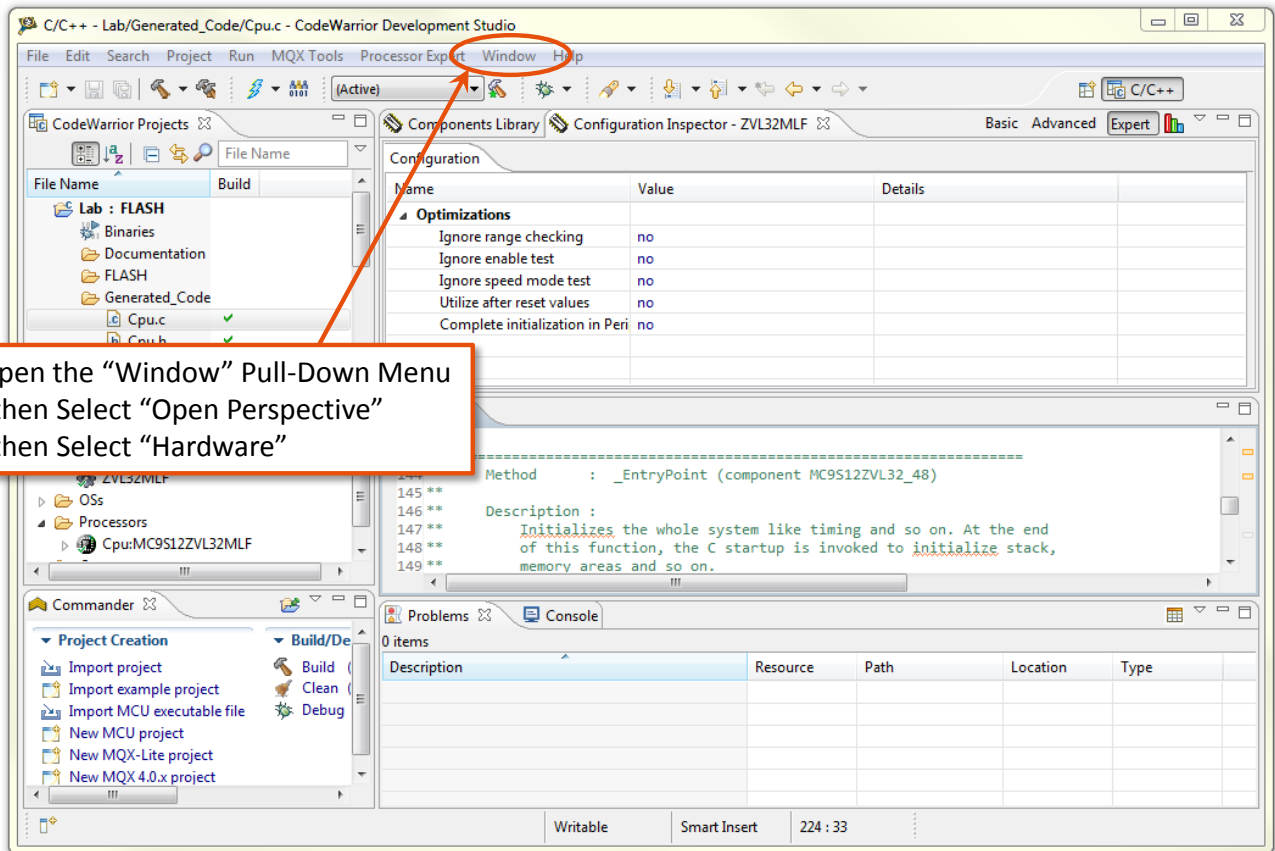
Disassemble “Cpu.c”



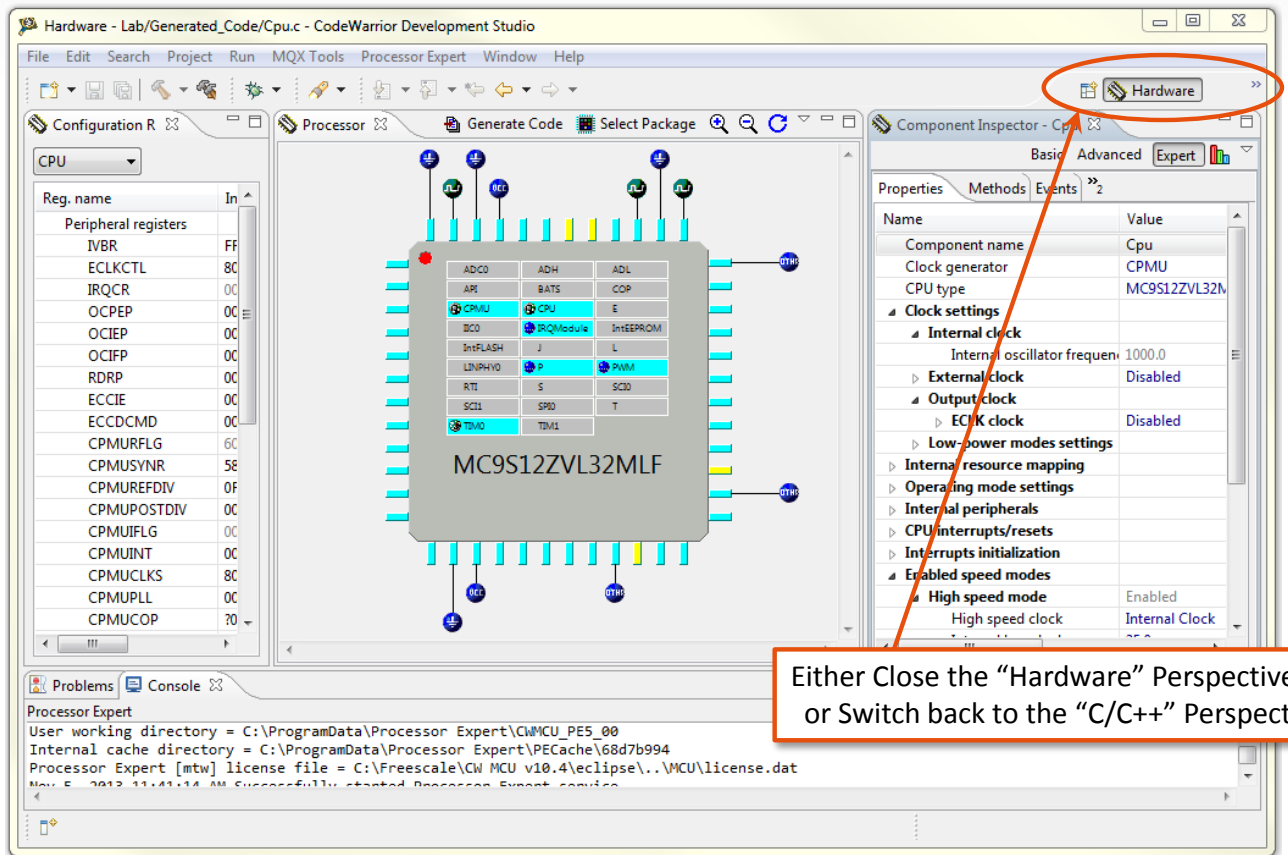
Investigate Assembly Language Code



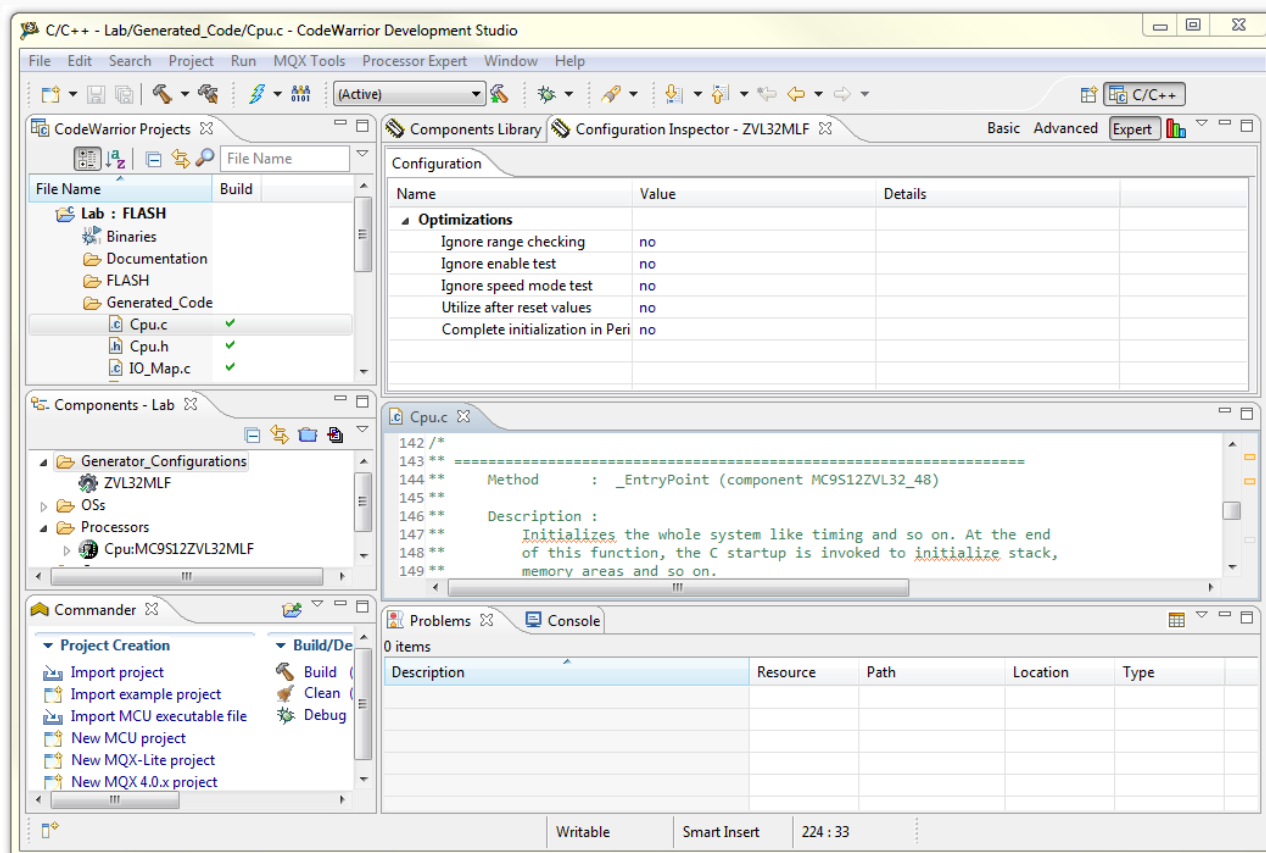
The Hardware Perspective



The Hardware Perspective



Ready for the Next Part of the Lab





Agenda

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- MagniV Solutions and Roadmap
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- **S12Z Enhanced CPU Core**
- S12ZVM for BLDC Motor Control
- S12ZVL for General Purpose LIN
- S12ZVC for General Purpose CAN
- Lab 2 —————
 - Developing a Project for the S12ZVL

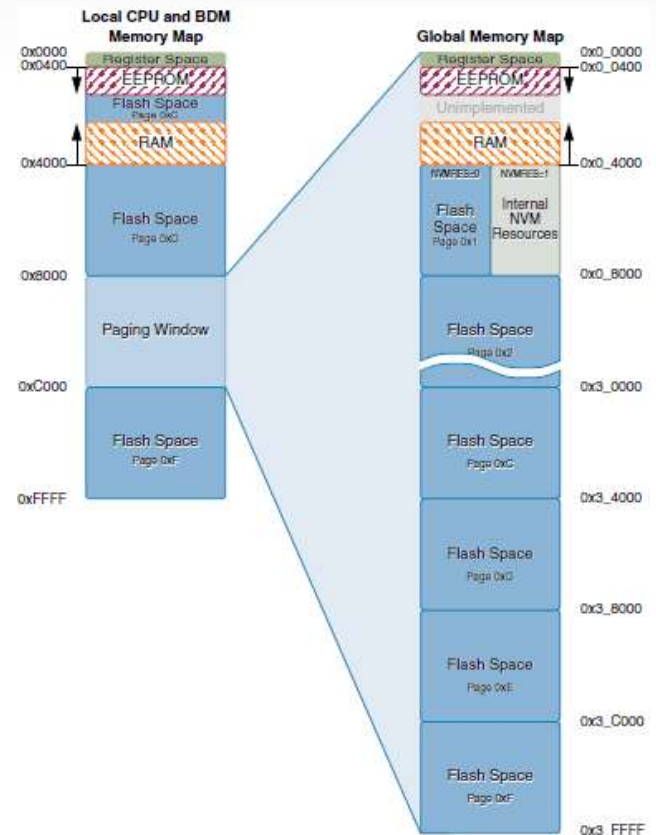
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S12Z Core Overview

- The S12Z CPU is the next generation of CPU in the CPU12 line.
 - High-speed 16-bit processor with an expanded programmers model
 - Improved addressing modes support efficient use of the 16MB (24-bit) linear address space.
 - Improved support for C code-size efficiency and overall performance

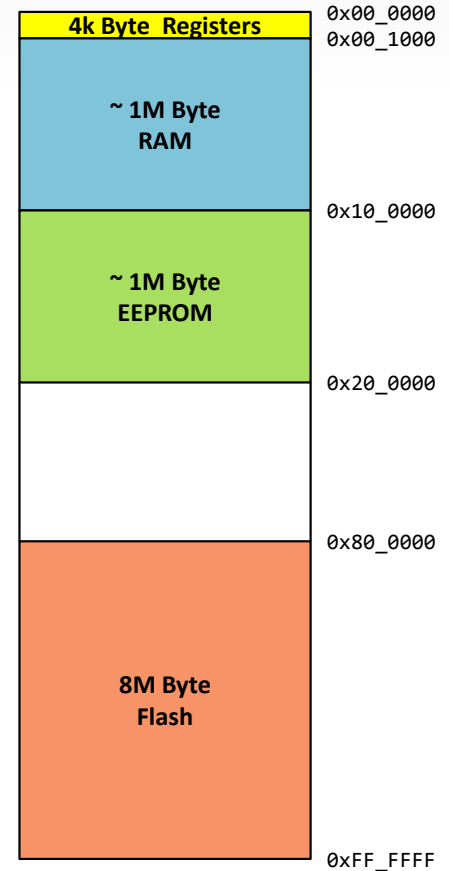
Linear vs. Paged Addressing Mode

- S12 MCUs typical architecture provides 64KB memory space
 - To achieve extended memory sizes, a paging mechanism is needed
 - 256 pages of 16kB each = 4MB maximum
 - Paging is one of the biggest dissatisfiers from customers' perspective

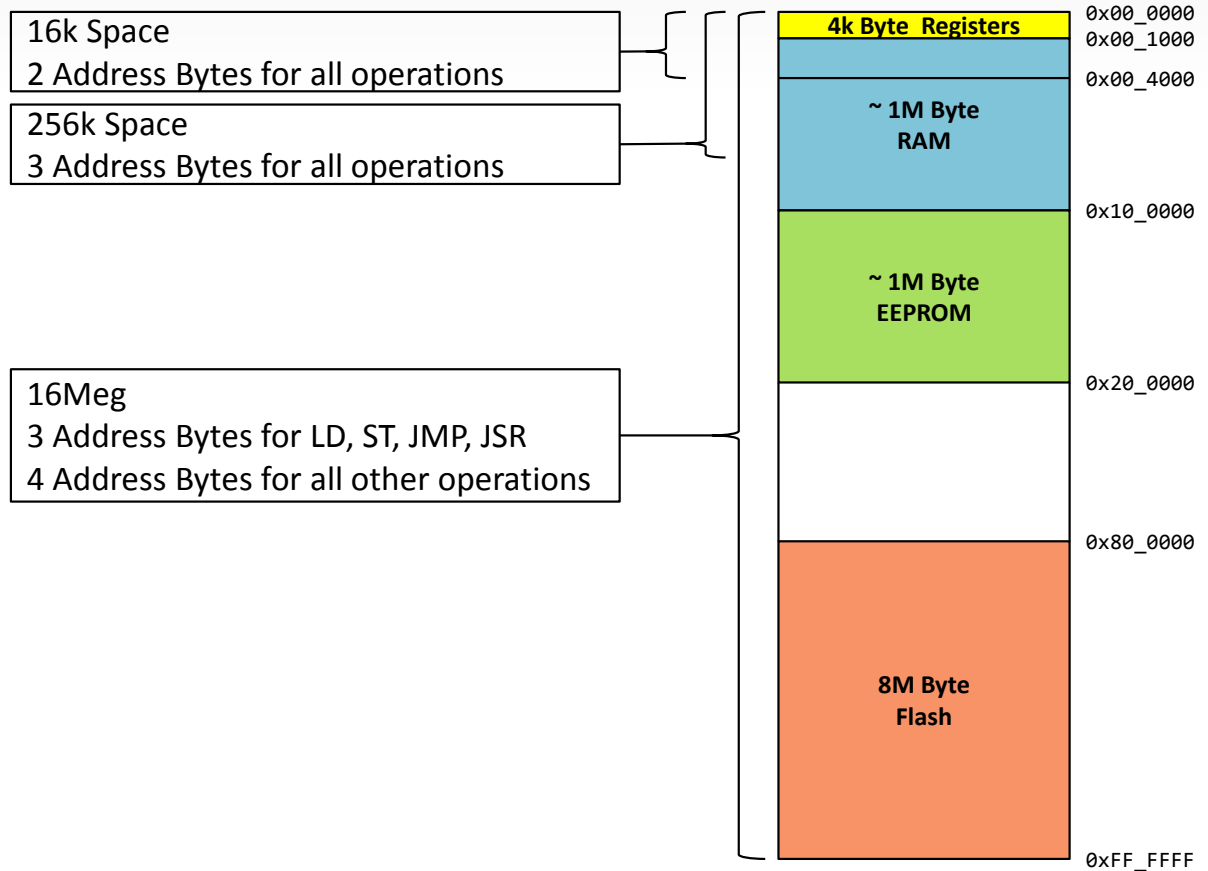


Linear vs. Paged Addressing Mode

- The S12Z CPU includes a 24-bit address bus, which provides up to 16MB memory space
- Linear addressing simplifies memory accesses



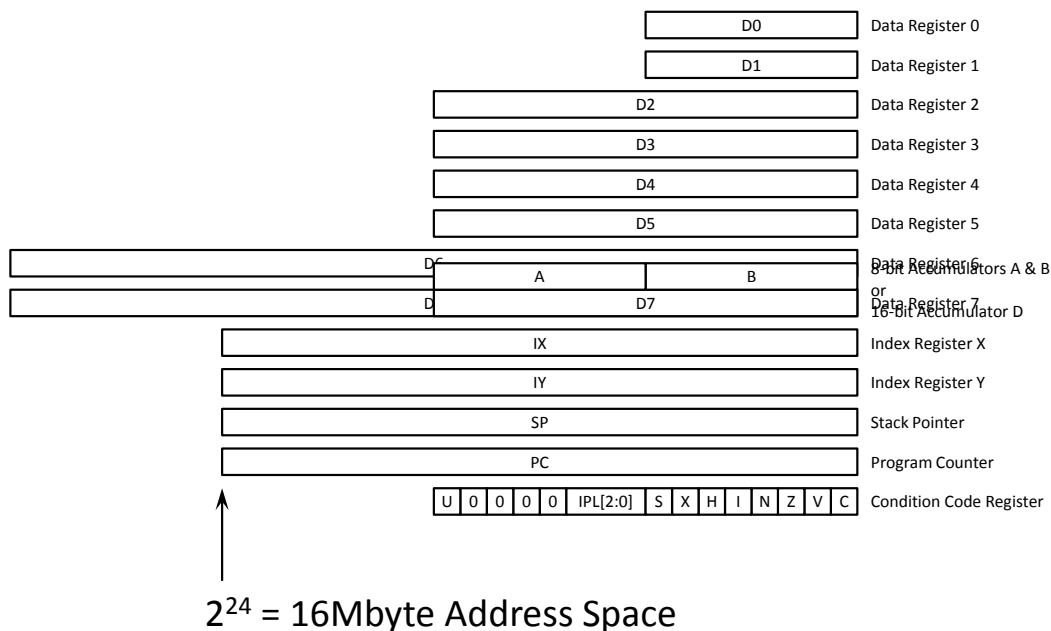
S12Z – Absolute Addressing



S12(X) CPU

A				B				8-bit Accumulators A & B or 16-bit Accumulator D						
D														
IX								Index Register X						
IY								Index Register Y						
SP								Stack Pointer						
PC								Program Counter						
U	0	0	0	0	IPL[2:0]	S	X	H	I	N	Z	V	C	Condition Code Register

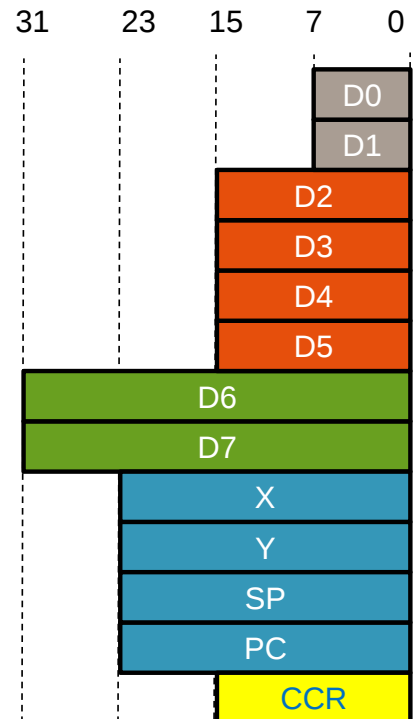
S12Z CPU



S12Z Core Architecture ... a 16-bit MCU?

- It uses **32-Bit** data paths, ALU, Data registers
 - Single-cycle 16x16 multiply (2.5 cycles 32x32)
 - MAC unit 32bit += 32bit*32bit (3.5 cycles)
 - Hardware divider 32bit = 32bit/32bit (18.5 cycles)
 - Single cycle multi-bit shifts (Barrel shifter)
 - Fractional Math support
- It uses a **24-bit** address bus, Stack Pointer, Program Counter and Index registers
- Its native “int” data type is **16-bit**, with 16-bit I/O data path
- It can handle **8-Bit** data and indexes better than S12X
- CPU operates at 100MHz
 - Optimized bus architecture with 100MHz load and store to RAM
 - NVM works with 1 Wait-state => effective 20ns accesses
- Harvard Architecture => parallel code and data access
 - Instructions and addressing modes optimized for C programming and compiler

Expanded programmer's model



S12Z Optimized Opcode Set

- Most used instructions are 8-bit opcodes
 - First Page

LD	ST	MOV	MUL	ADD	SUB	AND	OR	CMP	BSET
Shifts	BCLR	BTGL	INC	DEC	BRA	JMP	JSR		

- Less used opcodes are 16-bit and require the prefix
 - Second Page

MAC	MIN	MAX	ABS	DIV	MOD	ADC	SBC	EOR
-----	-----	-----	-----	-----	-----	-----	-----	-----

Bit Operations

- Bit operations were massively changed
 - BSET, BCLR, BRSET, BRCLR test only a **single bit** to save code space
 - Bit takes a maximum of **5 bits** instead of a mask for 32Bit takes 4 bytes!
 - **>90%** of all codes test/set/clear only one bit!
 - The bit number is either an **immediate** value or defined by an **accumulator**.
 - They can operate on a **memory location** but also on an **accumulator**.
 - The size of a memory operand can be 8, 16 or 32-bits or an accumulator
 - Example:


```
j = 1 << n; => CLR D2; LD D3,#n; BSET D2,D3
```
 - Bitfield operations were added: BFEXT, BFINS can extract or insert a bitfield
 - Example:


```
BFEXT    D7,D6,#7:23    => extracts 7 bits #23 from D6 into D7
```

S12Z – Enhanced Multiplication Instructions

S12(X):

MUL	$(A) \times (B) \rightarrow A:B$
EMUL(S)	$(D) \times (Y) \rightarrow Y:D$

S12Z:

MULU	$(Dj) \times (Dk) \rightarrow Dd$	QMULU	$(Dj) \times (Dk) \rightarrow Dd$
	$(Dj) \times IMM \rightarrow Dd$		$(Dj) \times IMM \rightarrow Dd$
	$(Dj) \times (M) \rightarrow Dd$		$(Dj) \times (M) \rightarrow Dd$
	$(M1) \times (M2) \rightarrow Dd$		$(M1) \times (M2) \rightarrow Dd$
MULS	$(Dj) \times (Dk) \rightarrow Dd$	QMULS	$(Dj) \times (Dk) \rightarrow Dd$
	$(Dj) \times IMM \rightarrow Dd$		$(Dj) \times IMM \rightarrow Dd$
	$(Dj) \times (M) \rightarrow Dd$		$(Dj) \times (M) \rightarrow Dd$
	$(M1) \times (M2) \rightarrow Dd$		$(M1) \times (M2) \rightarrow Dd$

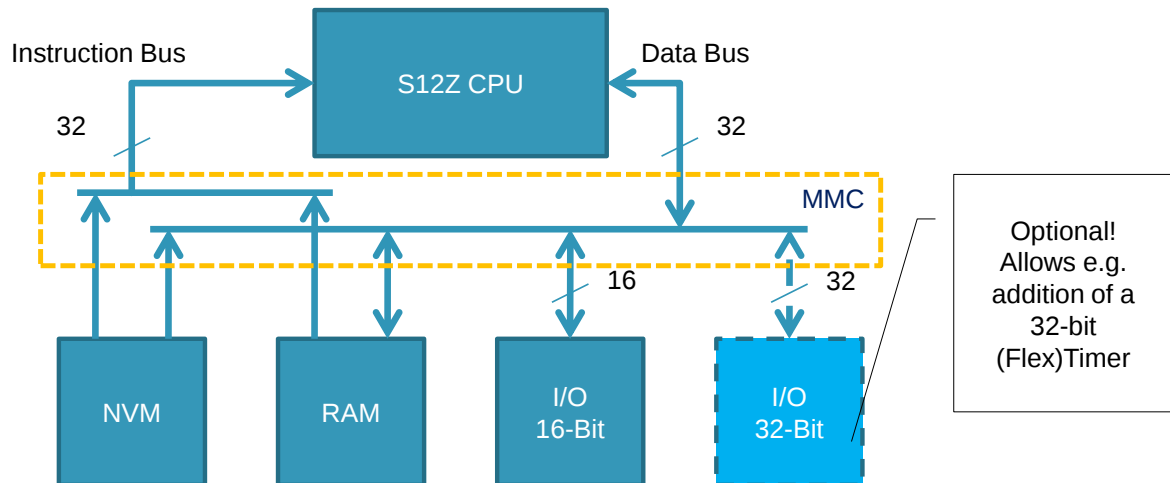
Fractional Math

Fractional Math Support - Instructions

- Fractional Multiply (Signed & Unsigned)
 - Multiplies two signed/unsigned fractional two's complement operands and stores the signed fractional two's complement result to register Dd.
- Saturate
 - Saturate the content of the operand register using the information stored in the overflow (V-) and negative (N-) flags by a previous instruction.
- Count-Leading-Bits
 - Counts the number of leading sign-bits in the source register, decrements this number and then copies the result into the destination register.

S12Z Platform Architecture

- Harvard Architecture (Parallel Data and Code access)



S12Z vs. S12X – Features

Attribute	S12Z	S12XE
Architecture	Harvard	Von Neumann
Address space	16MByte Linear	64KByte Linear (up to 4MByte Paged)
Data Bus Width	32-Bit RAM & Flash, 16-Bit I/O	16-Bit
ALU Width	32-Bit	16-Bit
Data Registers	2 x 8-Bit, 4 x 16-Bit, 2 x 32-Bit	2 x 8-Bit (can be used as a single 16-Bit accumulator)
Pointers	2 x 24-Bit	2 x 16-Bit

S12Z vs. S12X – Performance

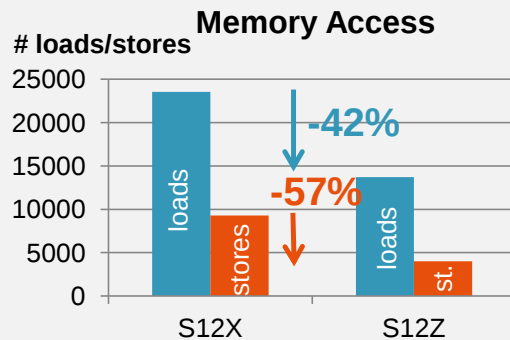
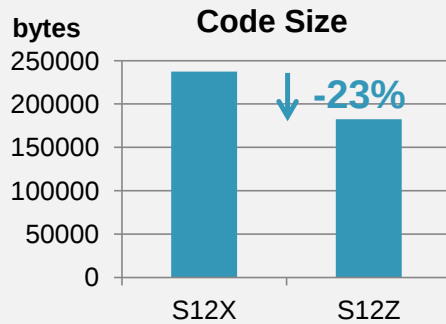
Attribute	S12Z		S12XE	
Bit Shifter	32-bit multi-bit	1 cycle	16-bit single-bit	2cycles
Multiplier	32*32 16*16	2.5cycles 1cycle	16*16	1cycle
Divider	32 = 32/32	18.5cycles	32 = 32/16	11cycles
MAC	32 += 32*32	3.5cycles	32 += 16*16	13cycles
Fractional math support	Yes		No	
Bus speed	50MHz		50MHz	

- CPU operates at up to 100MHz, bus at 50 MHz
 - RAM bus can load and store w/ 100MHz
 - I/O buses @50MHz to reduce power consumption and die area

S12Z Benchmarks Results

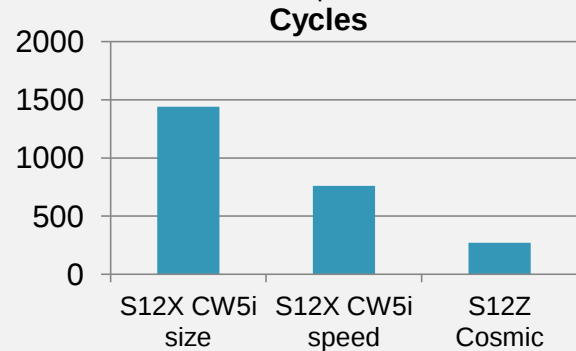
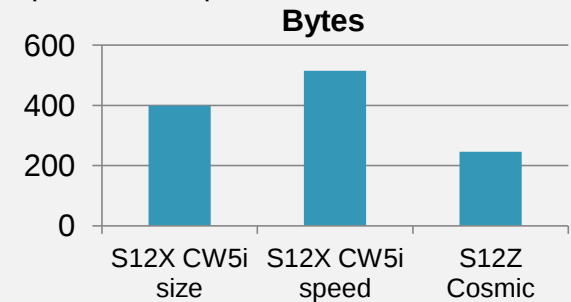
- **S12Z typically saves 20% code size versus S12X**
- **S12Z typically uses 30% less memory accesses than S12X which saves power**

Large Application Code Example:



Digital Filter:

S12Z is faster and denser than any optimization option of S12X



In Depth Code Size Analysis

Feature	S12X	S12Z	Comment
Code Size	237277	182362	-23%
pg1	86.3%	96.9%	Shows well chosen pg1 instructions
Loads	23550	13725	-42%
Stores	9280	4015	-57%
Moves	4347	4332	About equal

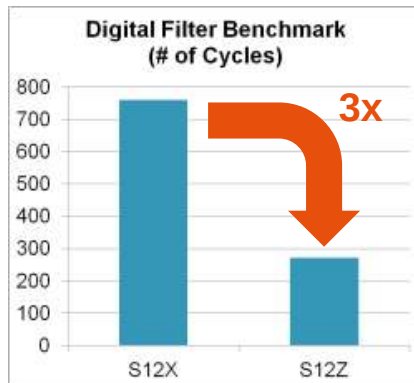
- Code is about 200k byte large Body Application
 - Significant code size savings
 - Large reduction of memory instructions (not accesses!)
 - => Power Savings expected

S12Z Performance Benefits



Improved Performance for Motor Control

- 100 MHz CPU @ 50 MHz bus speed
- Harvard architecture accelerates data handling
- Fractional mat



Improved Software Friendliness

- 24-bit linear address map to ease software development and porting
- Added 8- and 32-bit registers to allow further compiler code size optimization

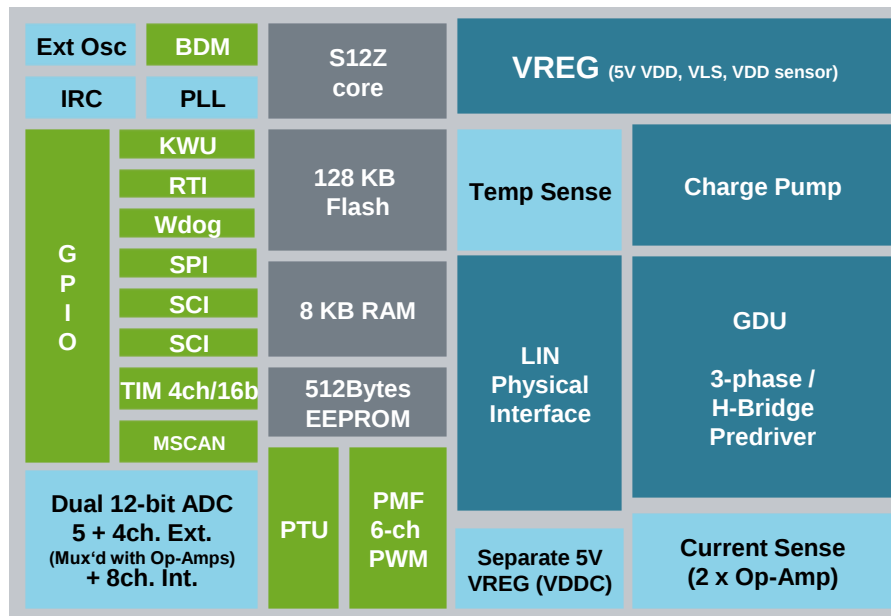
Agenda

- Automotive Body Electronics
- MagniV Solutions and Roadmap
- Lab 1 —————
 - Getting Started with CodeWarrior 10.4
- S12Z Enhanced CPU Core
- **S12ZVM for BLDC Motor Control**
- S12ZVL for General Purpose LIN
- S12ZVC for General Purpose CAN
- Lab 2 —————
 - Developing a Project for the S12ZVL

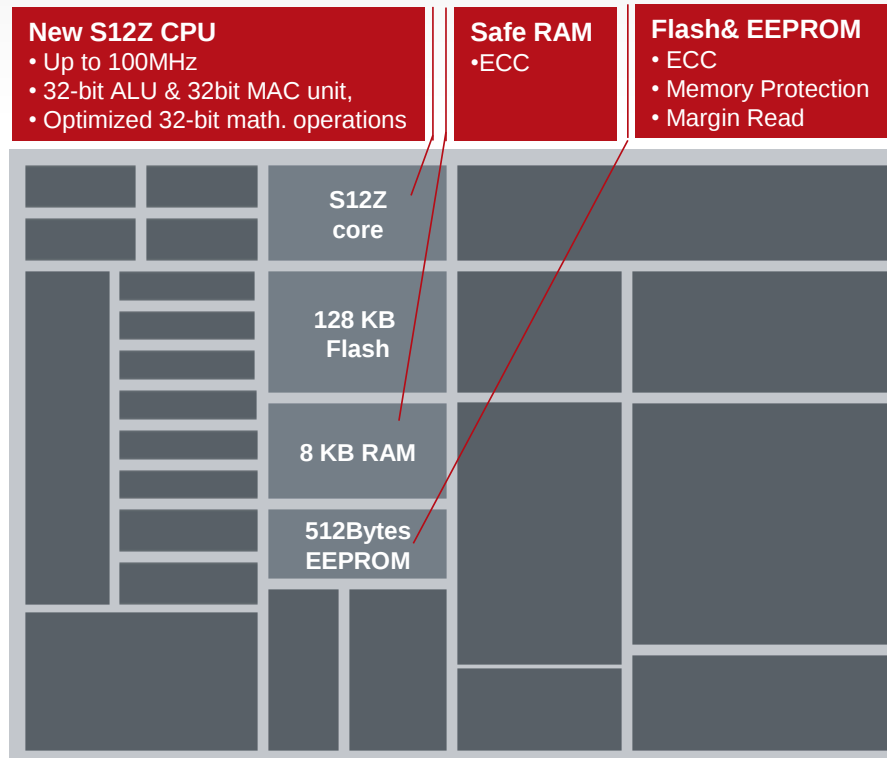


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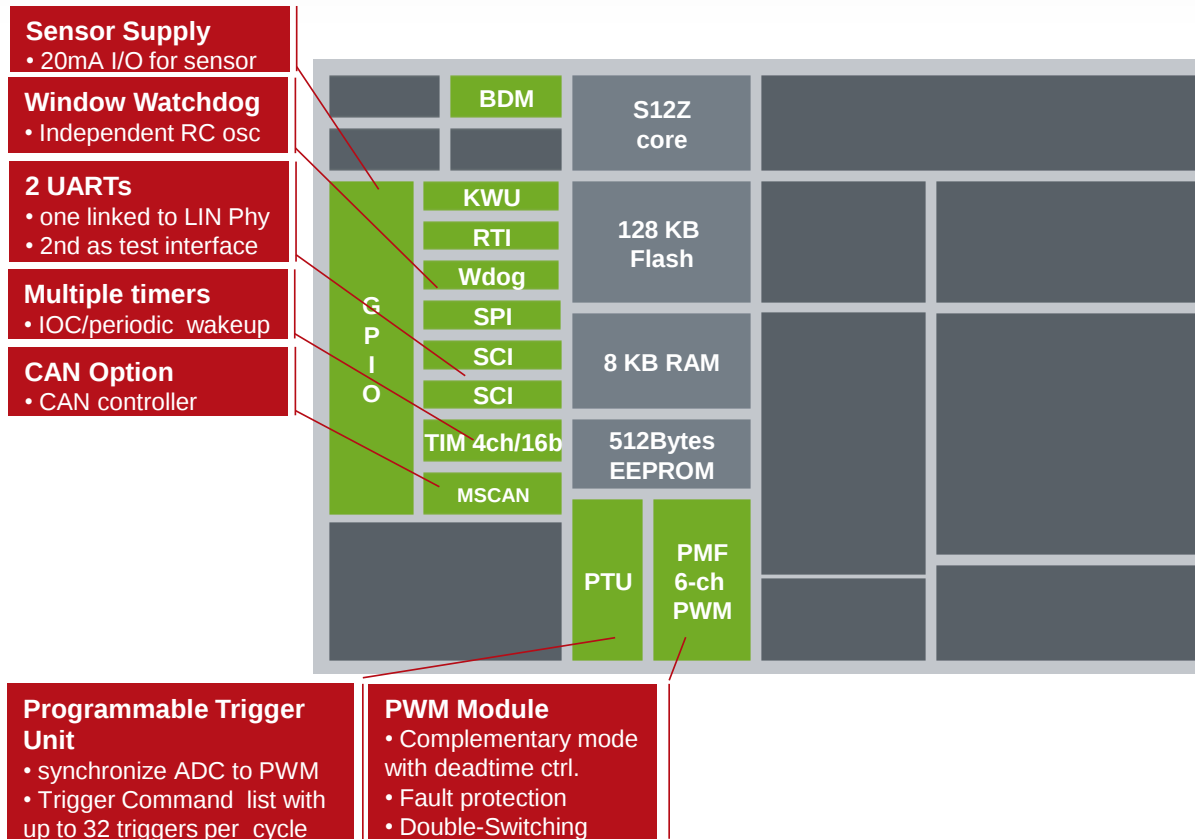
Overview of S12ZVM Feature Set



Overview of S12ZVM Feature Set

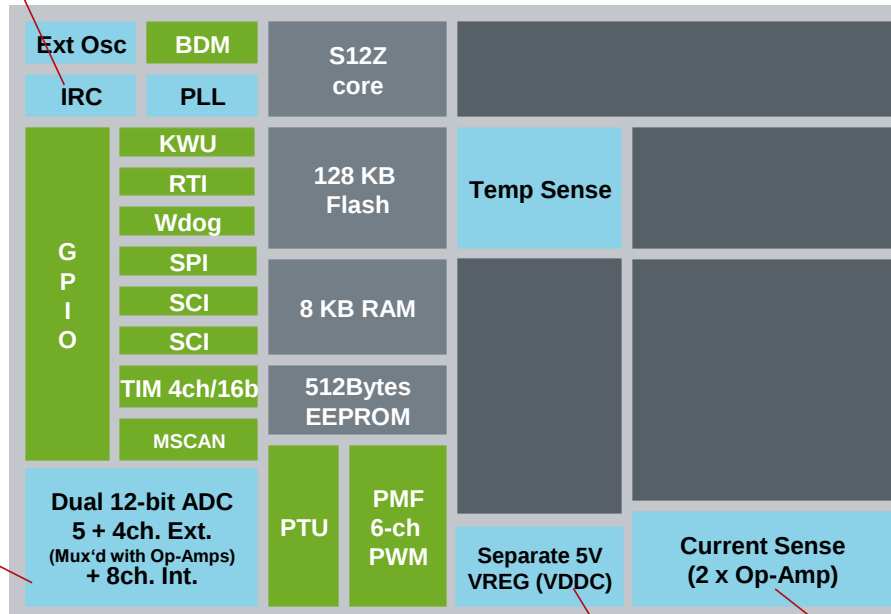


Overview of S12ZVM Feature Set



Overview of S12ZVM Feature Set

Internal RC osc.
• $\pm 1.3\%$ over tmp



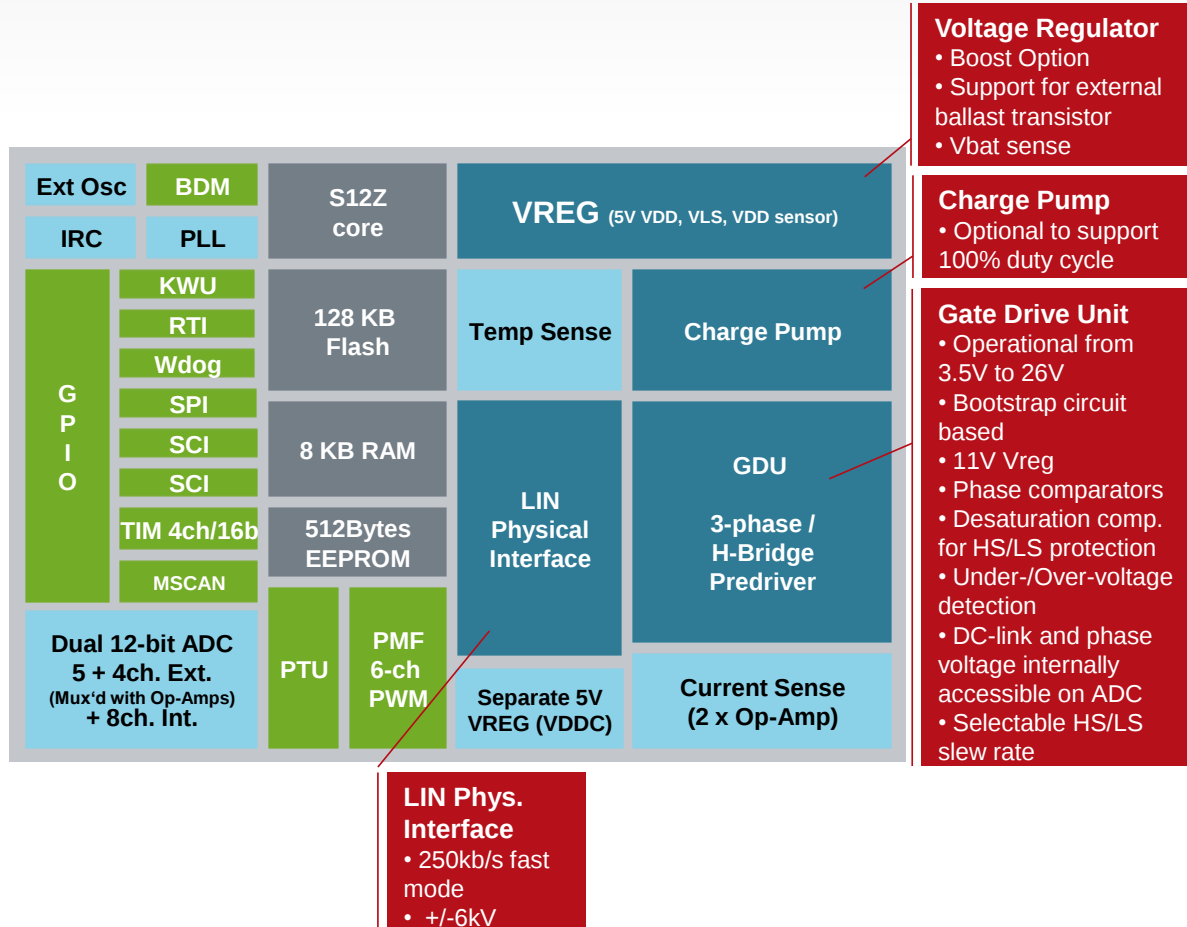
- **Two 12-bit ADC**
- List Based Architecture allows flexible definition of order and number of conversions
- 2.5 μ s conv. time

CAN Support
• 5V Vreg
controller for
external
transceiver

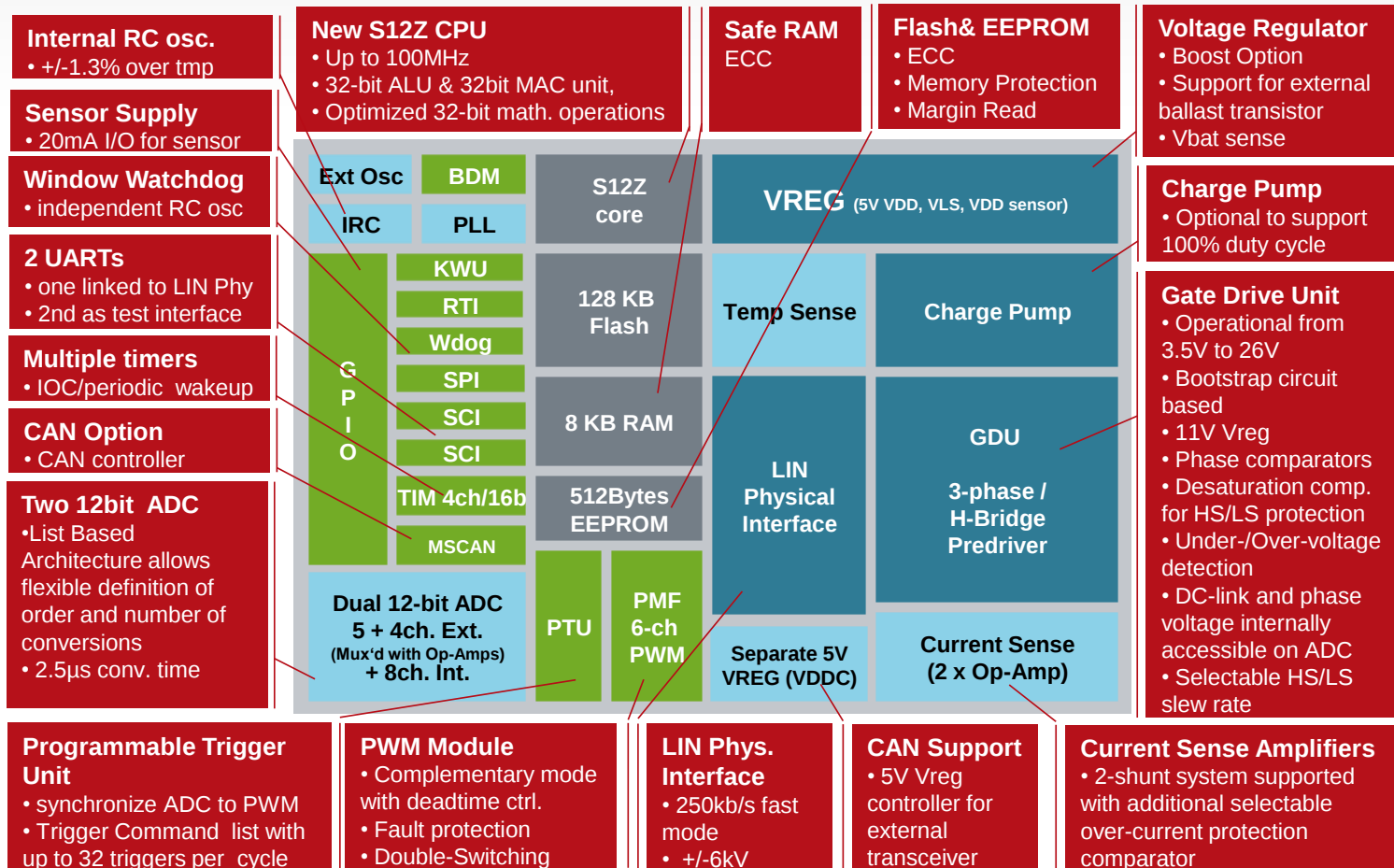
Current Sense Amplifiers

- 2-shunt system supported with additional selectable over-current protection comparator

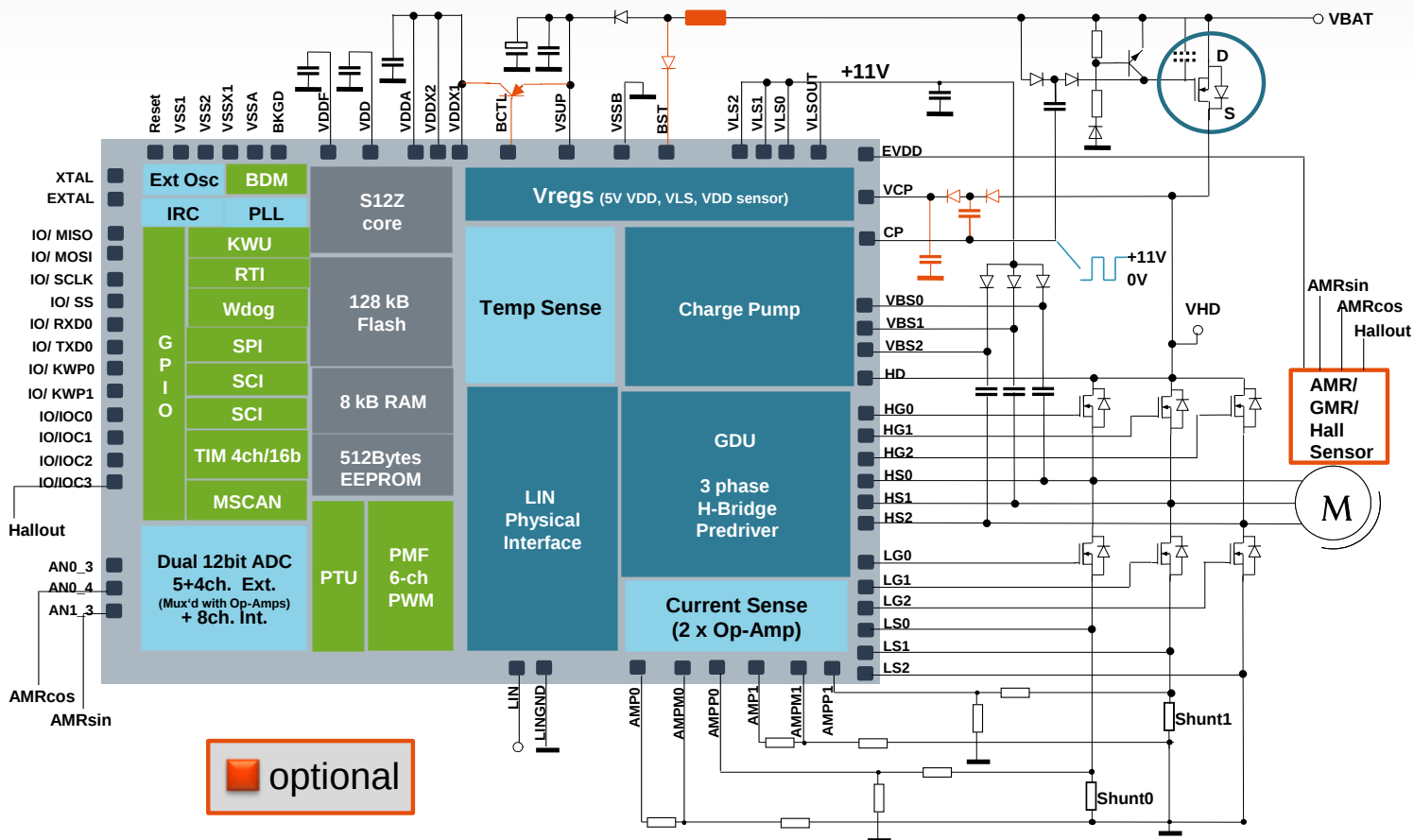
Overview of S12ZVM Feature Set



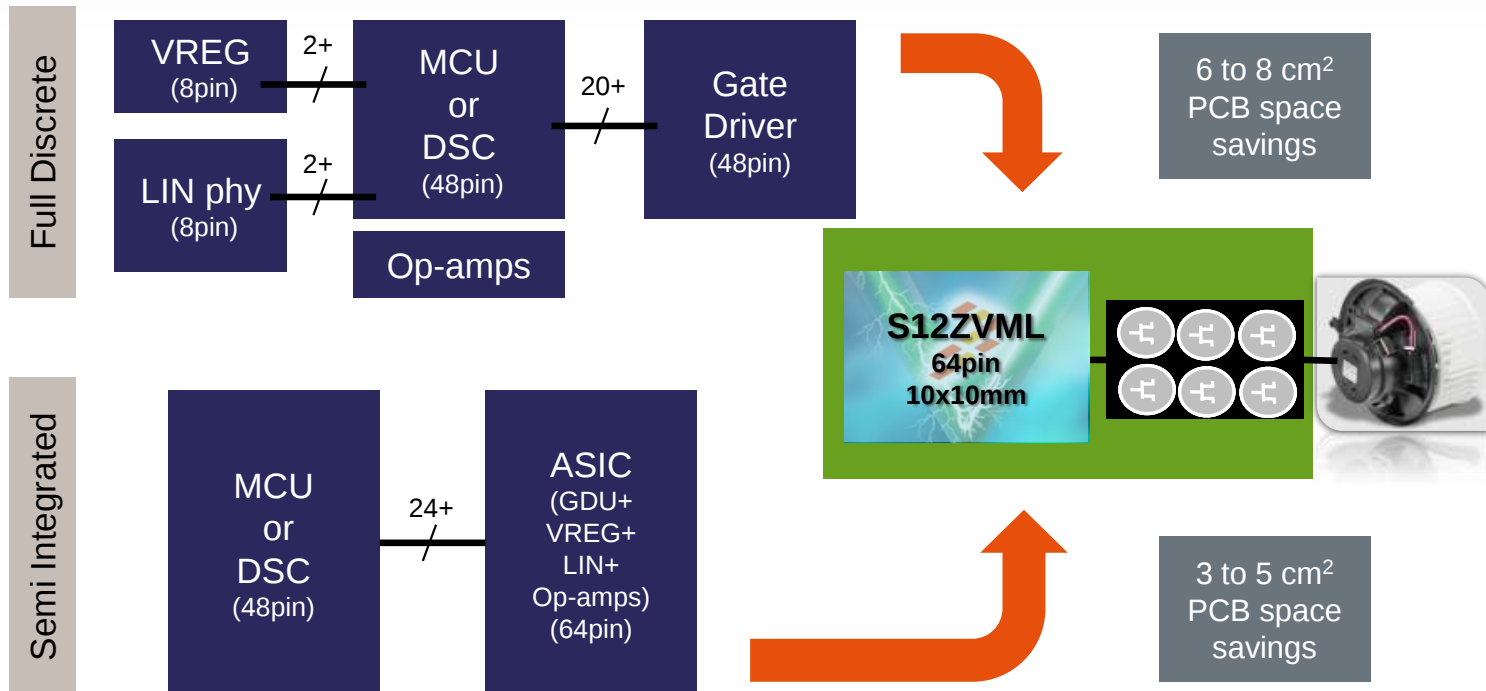
Overview of S12ZVM Feature Set



S12ZVML Application Schematic



Space Savings with S12ZVML



Manufacturing Cost Benefits

Multiple effects of eliminating ICs or passive components:

- Material : PCB space, Cu tracks, test points, soldering
- Pick & place
- Testing at board level
- Inventory management

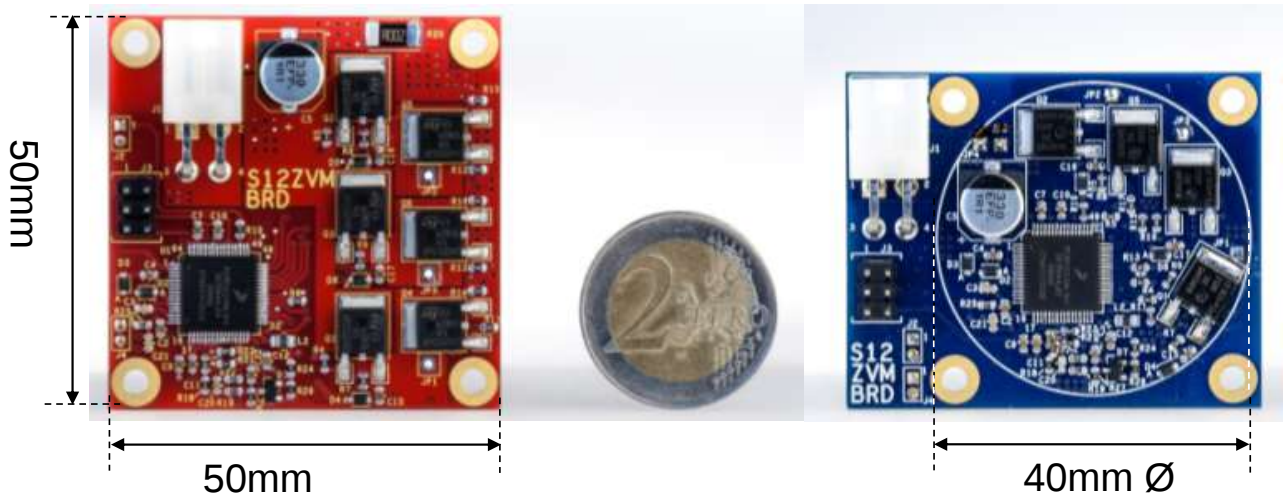


SMTA (Surface Mount Technology Association):

- NMACPCs (Non-Material Assembly Cost Per Component) range from \$0.01 to \$0.15 per component assembled
- NMACPI/O (Non-Material Assembly Cost Per Input/Output) range from \$0.005 to \$0.01 per I/O assembled.

Highest level of Integration

Of your BLDC system:



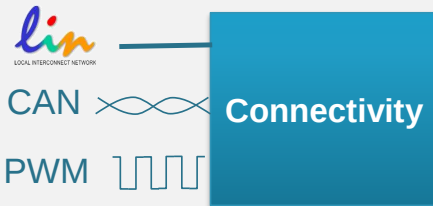


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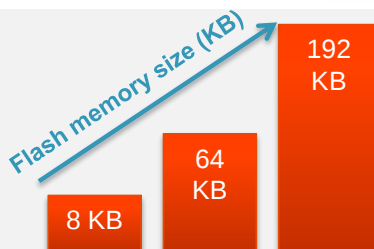
Ultimate Flexibility and Scalability



CAN or LIN support with on-chip physical interface



On-chip 12 V voltage regulator for flexible on- and off-chip supply



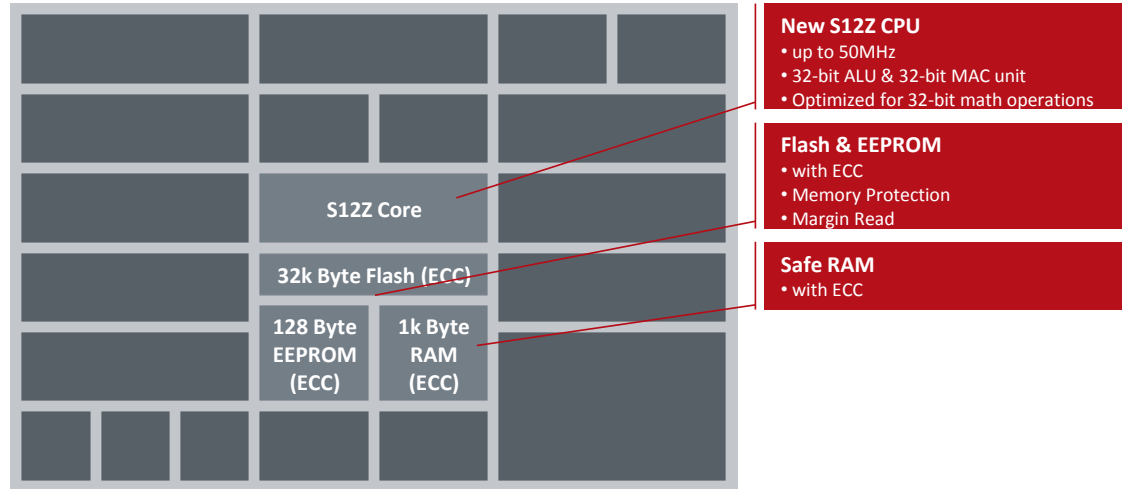
Range of memory options address multiple applications and allow for platform design

True platform solutions through hardware and software reuse

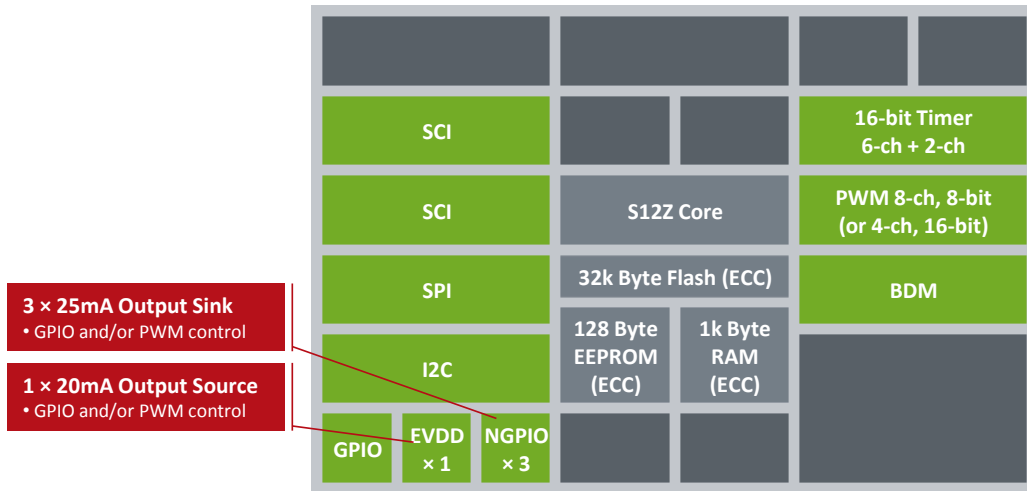
Overview of S12ZVL Feature Set

LIN Physical Interface			Pierce Oscillator		Temp Sense	10-bit ADC
SCI			RC osc ±1.3%	PLL	16-bit Timer 6-ch + 2-ch	
SCI			S12Z Core		PWM 8-ch, 8-bit (or 4-ch, 16-bit)	
SPI			32k Byte Flash (ECC)		BDM	
I2C			128 Byte EEPROM (ECC)	1k Byte RAM (ECC)	VREG for Total Supply: • 70mA • 170mA with ext ballast	
GPIO	EVDD × 1	NGPIO × 3	HVI × 1	V-SUP Sense		

Overview of S12ZVL Feature Set



Overview of S12ZVL Feature Set



Overview of S12ZVL Feature Set

			Pierce Oscillator		Temp Sense	10-bit ADC
SCI			RC osc $\pm 1.3\%$	PLL	16-bit Timer 6-ch + 2-ch	
SCI			S12Z Core		PWM 8-ch, 8-bit (or 4-ch, 16-bit)	
SPI			32k Byte Flash (ECC)		BDM	
I2C			128 Byte EEPROM (ECC)	1k Byte RAM (ECC)		
GPIO	EVDD $\times 1$	NGPIO $\times 3$				

Internal RC oscillator
• $\pm 1.3\%$ over temp

Overview of S12ZVL Feature Set

LIN Physical Interface

- 250kbps Fast Mode
- $\pm 6\text{kV}$ (IEC61000-4-2)

1 × High Voltage Input

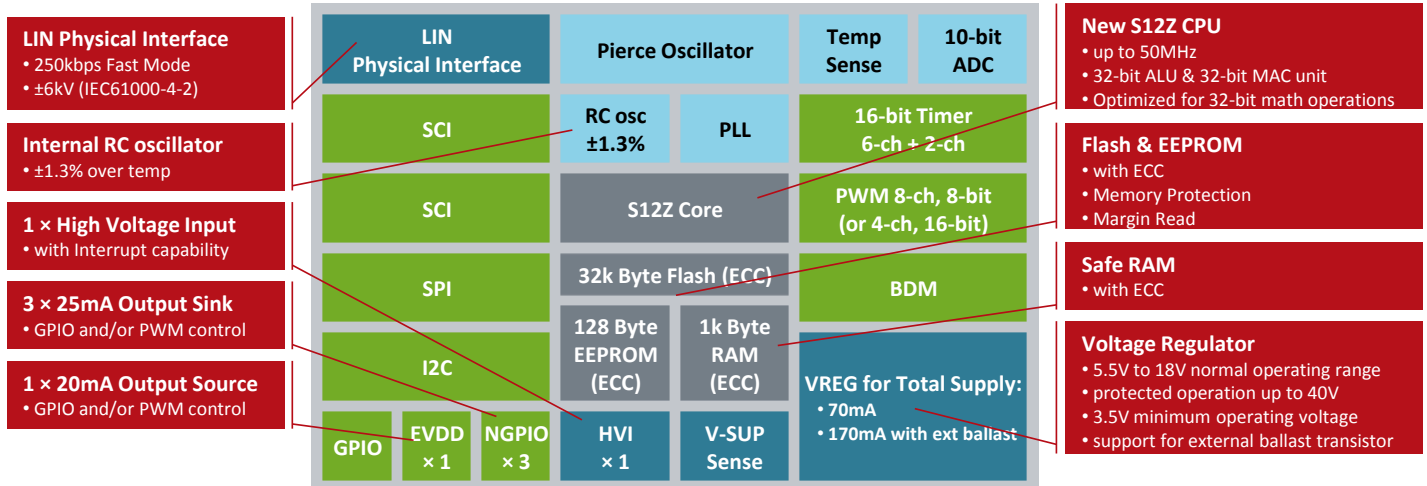
- with Interrupt capability

LIN Physical Interface			Pierce Oscillator		Temp Sense	10-bit ADC
SCI			RC osc $\pm 1.3\%$	PLL	16-bit Timer 6-ch + 2-ch	
SCI			S12Z Core			PWM 8-ch, 8-bit (or 4-ch, 16-bit)
SPI			32k Byte Flash (ECC)			BDM
I2C			128 Byte EEPROM (ECC)	1k Byte RAM (ECC)	VREG for Total Supply: • 70mA • 170mA with ext ballast	
GPIO	EVDD $\times 1$	NGPIO $\times 3$	HVI $\times 1$	V-SUP Sense		

Voltage Regulator

- 5.5V to 18V normal operating range
- protected operation up to 40V
- 3.5V minimum operating voltage
- support for external ballast transistor

Overview of S12ZVL Feature Set



- **Functional Safety – ISO 26262 ASIL A Compliance:**

- Developed in accordance with ISO 26262 as a Safety Element out of Context (SEooC).
- Usable in safety relevant systems classified as ISO 26262 ASIL A.
- MCU development process fulfills ASIL A requirements of ISO 26262.

S12ZVL Key Features



RGB ambient lighting



Sensor (airflow)



Switchpanels / Userinterfaces

LIN Physical Interface			Pierce Oscillator	Temp Sense	10-bit ADC
SCI			RC osc ±1.3%	PLL	16-bit Timer 6-ch + 2-ch
SCI			S12Z Core		PWM 8-ch, 8-bit (or 4-ch, 16-bit)
SPI			32k Byte Flash (ECC)		BDM
I2C			128 Byte EEPROM (ECC)	1k Byte RAM (ECC)	VREG for Total Supply: • 70mA • 170mA with ext ballast
GPIO	EVDD × 1	NGPIO × 3	HVI × 1	V-SUP Sense	

Key Feature`	Benefits
S12Z core, 25 MHz Bus	Improved code-efficiency & core performance vs. S12
8 KB to 32 KB flash	Family-concept, no need for external Flash/EPROM/ROM
Up to 128 Bytes EEPROM	4B erasable page; Easier to use vs. data flash; no need for EE-emul.
all memories (Flash, RAM, EE) with ECC	Error Code Correction provides high reliability
Built-in automotive voltage regulator operating between 3.5 and 40 V	Operates directly from car-battery, no need for extra Voltage-regulator saving PCB-board-space. handles automotive design issues, such as double battery, crank voltage and load dump conditions
Built-in LIN physical layer	No need for an external LIN physical layer device, saving space and design time. Meets automotive OEM specifications for LIN conformance and EMC requirements
NGPIO & EVDD	EVDD able to supply 5V/20 mA offchip; N-GPIO able to sink up to 3 x 25mA off Chip (useful for RGB-LED-drive)
Protected 12V input (HVI)	Allows automotive battery voltage-level inputs (with ADC-capability & ESD-protection)
on Chip RC oscillator trimmed to 1,3% tolerance	Due to accurate on chip clock generation LIN-communication can be done without external Crystal or Resonator and without the need of SW-intense synchronization

Package Options:

- 48 LQFP, 32 LQFP
- 32QFN (5 x 5 mm)

S12ZVC Key Features



Seatbelt pretention



Sensor (Powertrain)



Switchpanels / Userinterfaces

CAN Physical Interface

- High Speed – up to 1Mbps
- ISO 11898-2 & ISO 11898-5

High-Resolution Timer

- 20ns with 25MHz bus

High-Resolution PWM

- 20ns with 25MHz bus

Seperate CAN Supply

- with external ballast transistor

CAN Physical Interface	Pierce Oscillator		Temp Sense	12-bit ADC
MS-CAN	RC osc ±1.3%	PLL	Analog Comparator with DAC	
SCI	S12Z Core		High-Res. Timer 4-ch, 16-bit	
SCI	192k Byte Flash (ECC)		High-Res. PWM 4-ch, 16-bit	
SPI			Timer 8-ch, 16-bit	
I2C	2k Byte EEPROM (ECC)	8k Byte RAM (ECC)	PWM 4-ch, 16-bit	
BDM			VREG for Total Supply: • 70mA • 170mA with ext ballast	
GPIO 4-channel open drain	HVI × 2	V-SUP Sense	CAN Supply: • with ext ballast	

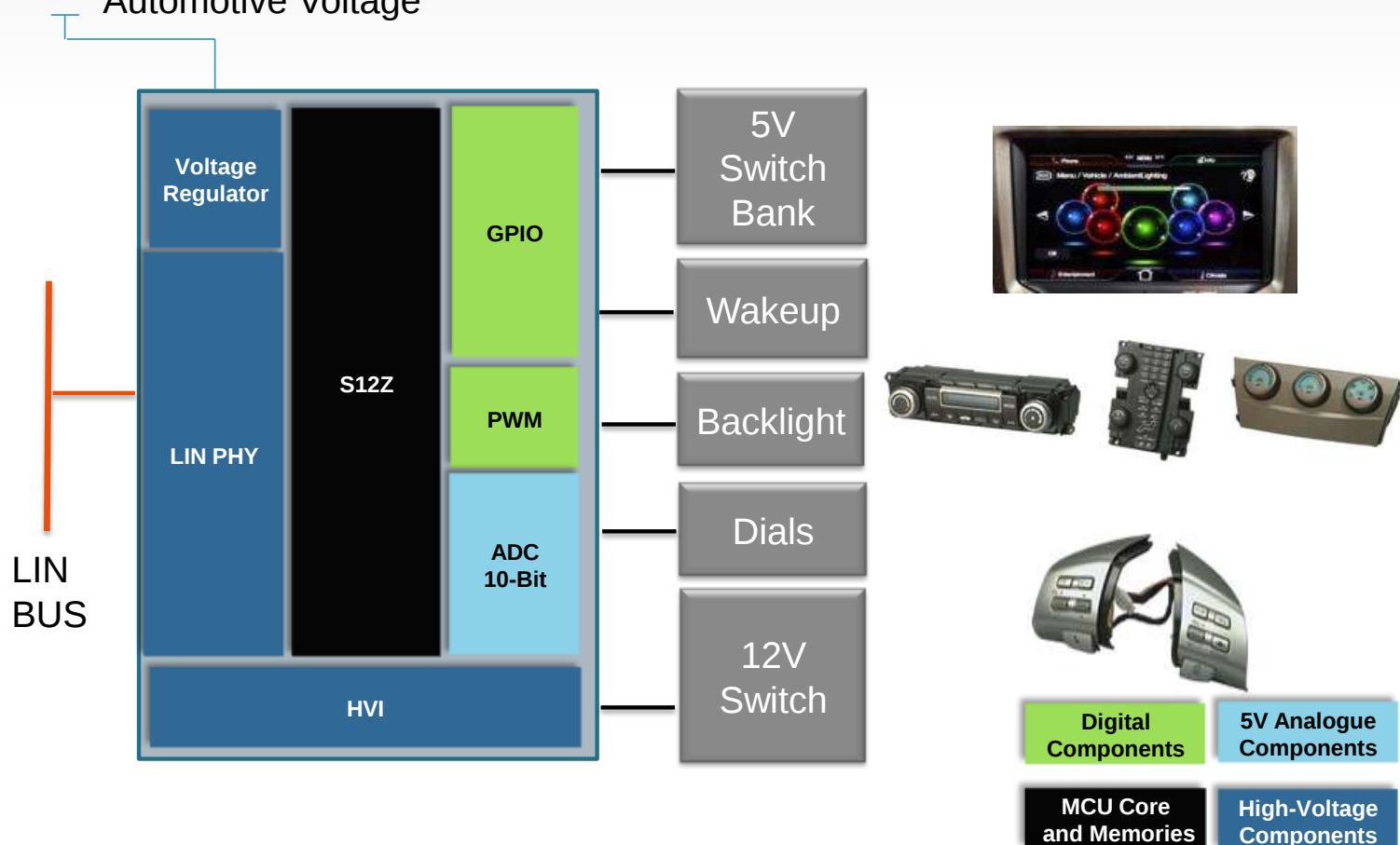
Key Feature	Benefits
S12Z core, 32 MHz Bus	Improved code-efficiency & core performance versus S12
64 KB to 192 KB flash	Family-concept, no need for external Flash/EPROM/ROM
Up to 2k Bytes EEPROM	4B erasable page; Easier to use vs. data flash; no need for EE-emul.
all memories (Flash, RAM, EE) with ECC	Error Code Correction provides high reliability
Built-in automotive voltage regulator operating between 3.5 and 40 V	Operates directly from car battery without the need for extra voltage regulator, saving PCB board space. Handles automotive design issues, such as double battery, crank voltage and load dump conditions
Built-in CAN physical layer	No need for an external CAN physical layer device, saving space as well as time & cost for design & testing. Meets automotive OEM requirements for CAN conformance and EMC.
Analog Comparator with DAC	Allows for fast reaction of ext. signals vs. preprogrammed threshold
Protected 12V input (HVI)	Allows automotive battery voltage-level inputs (with ADC-capability & ESD-protection)
12-Bit ADC; 16ns-Timer/PWM	High resolution mixed signal peripherals for many sensor-applications (e.g. ultrasonic)

Package Options:

- 64 LQFP
- 48 LOFP

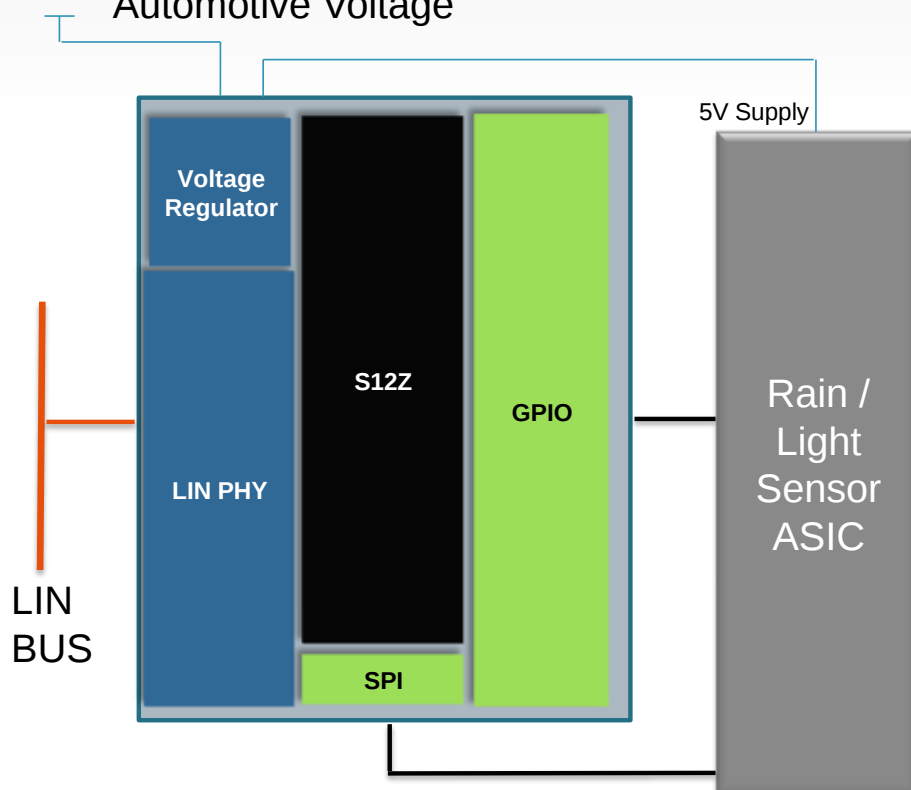
S12ZVL Application Example: Switch Panel

Automotive Voltage



S12ZVL Application Example: Intelligent Sensor

Automotive Voltage



http://www.bmw.com/com/en/insights/technology/technology_guide/articles/rain_sensor.html

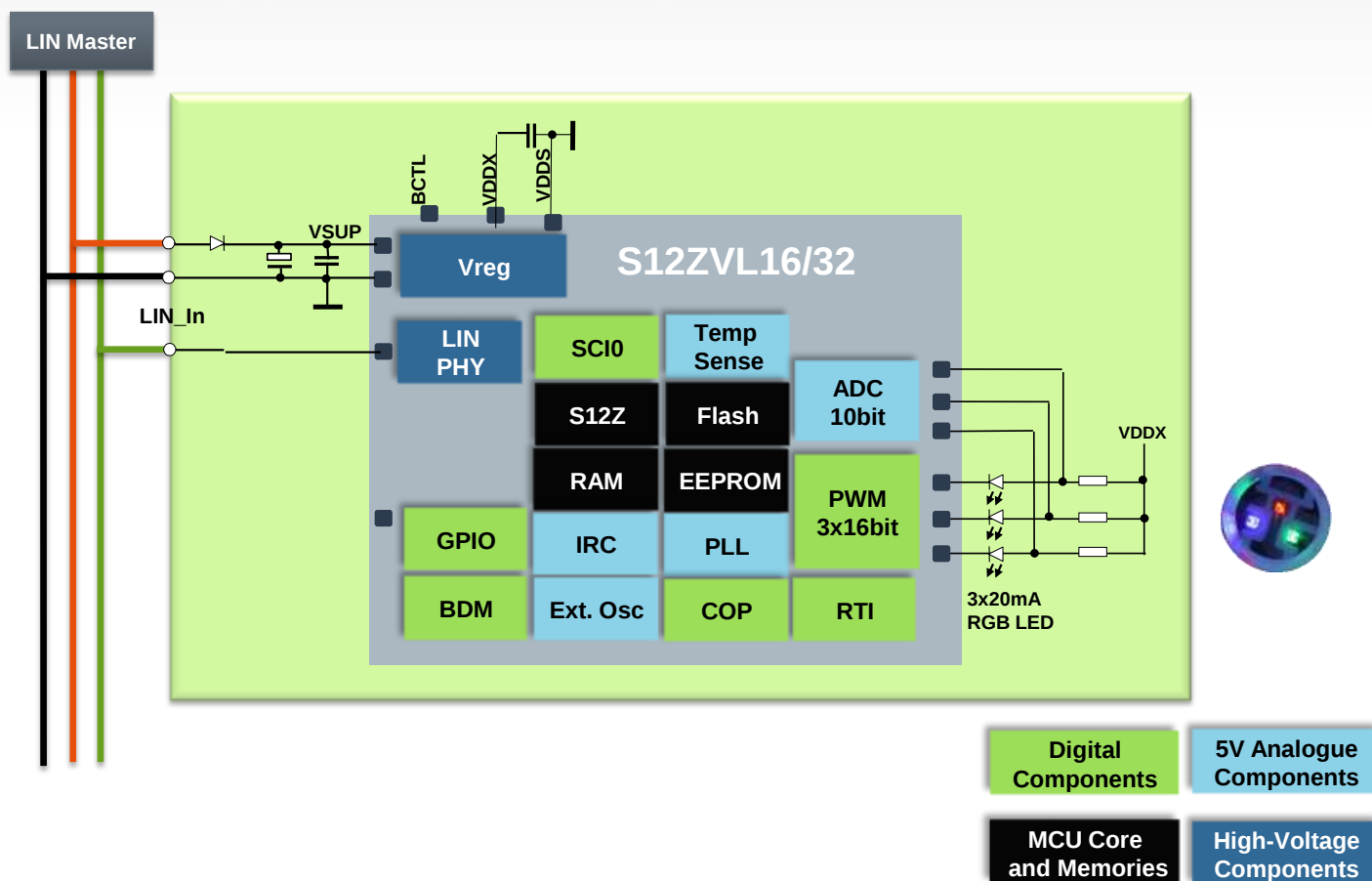
Digital Components

5V Analogue Components

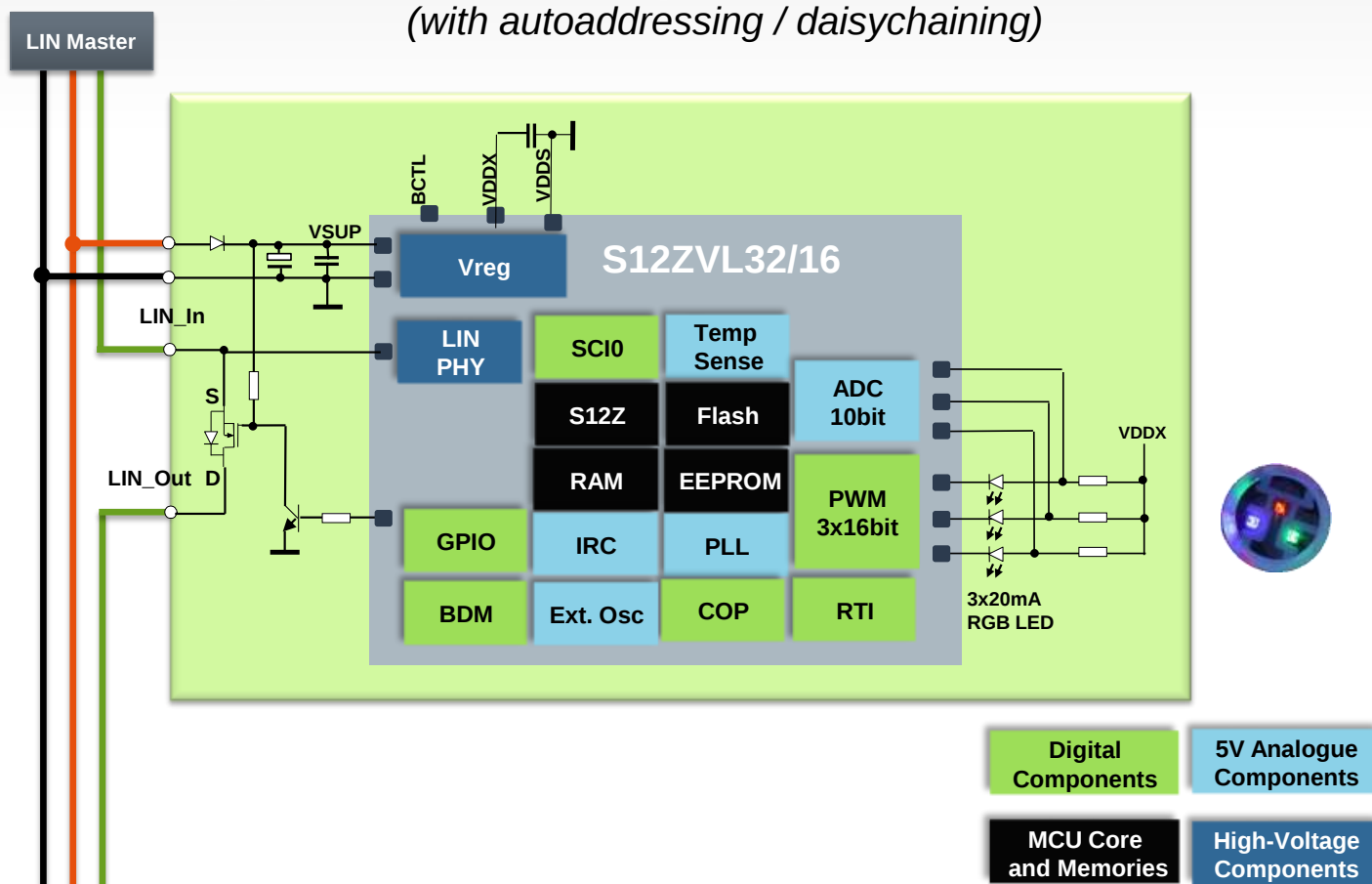
MCU Core and Memories

High-Voltage Components

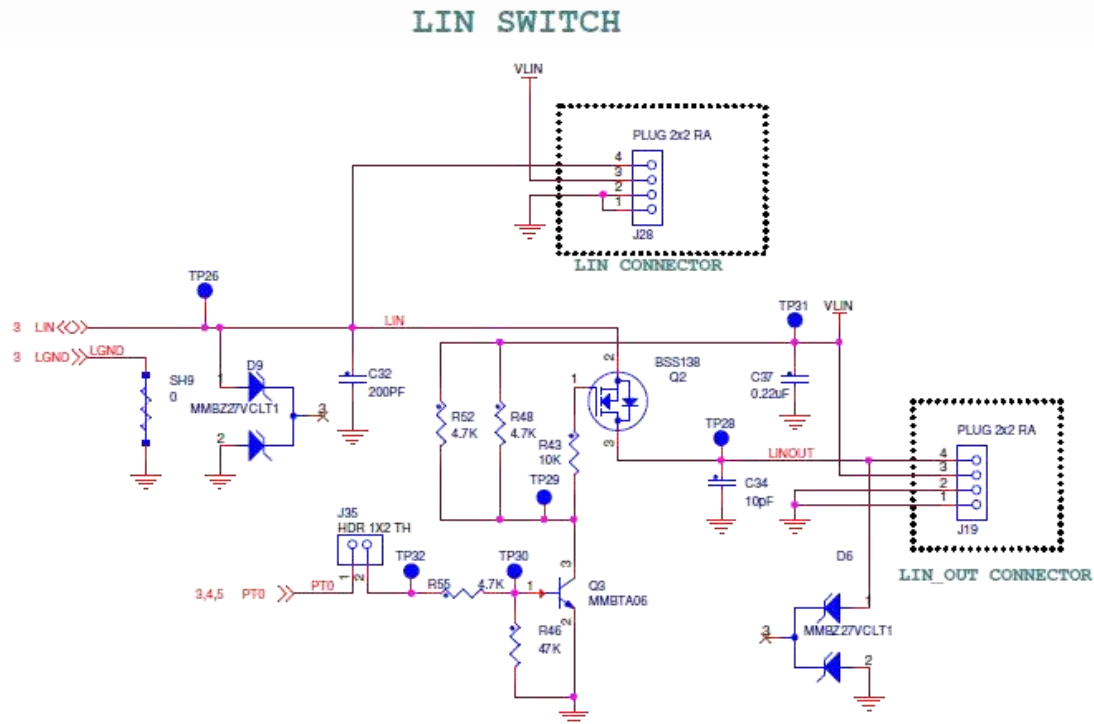
S12ZVL Application Example: LIN RGB LED



S12ZVL Application Example: LIN RGB LED



TRK-S12ZVL: LIN Daisychain



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[S12ZVL](#)

S12ZVL: S12 MagniV Mixed-Signal MCU for LIN Applications

[Overview](#)
[Documentation](#)
[Software & Tools](#)

[Application Notes](#)

PREPRODUCTION

The S12ZVL platform, part of the S12 MagniV mixed-signal MCU family, offers a low-cost, highly integrated solution that enables the design of smallest possible automotive LIN nodes, while the family concept provides scalability for platform design. The S12ZVL integrates a sophisticated S12Z core together with a 12V to 5V voltage regulator and a LIN physical layer for automotive applications such as sensors, actuators switch panels or lighting.

This page contains information on a preproduction product. Specifications and information herein are subject to change without notice.

For additional information and sample availability, contact your local [Freescale Sales Office](#).

Features

- Enhanced S12Z core at 25 MHz bus speed
- Up to 32 KB Flash (with ECC)
- 128B EEPROM (with ECC)
- Up to 1 KB RAM (with ECC)
- Vreg for 3.5 to 20-volt operating range, scalable in supply for on- and off-chip systems
- LIN physical layer
- On-chip RC-oscillator 1.3% accurate

Related Products

S12VR: S12 MagniV Mixed-Signal MCU for Relay Driven Motor Applications

S12ZVC: S12 MagniV Mixed-Signal MCU for CAN Applications

S12ZVH: S12 MagniV Mixed-Signal Microcontroller for Automotive Instrument Cluster Applications

S12ZVL Family Block Diagram

Core and Memories Digital Peripherals HV Analing S-V Analog

Featured Documentation

S12ZVLFS: S12 MagniV S12ZVL Family - Fact Sheet

BODYELECTRWP: Future Advances in Body Electronics - White Paper

Target Applications

- Automotive
 - Heating Ventilation and Air Conditioning (HVAC)
 - Lighting
 - Doors, Window Lift and Seat Control
 - Steering Wheel Controllers
 - Watchdog Controller for Chassis/Safety/Powertrain
 - LIN Nodes
 - LIN User Interface
 - LIN Switch Panel
 - LIN Actuators, Sensors
- Industrial
 - Ambient Lighting Control

Functional Safety

SAFE ASSURE

SafeAssure Functional Safety Program Solutions targeted to help meet IEC 61508 and ISO 26262 functional safety compliance

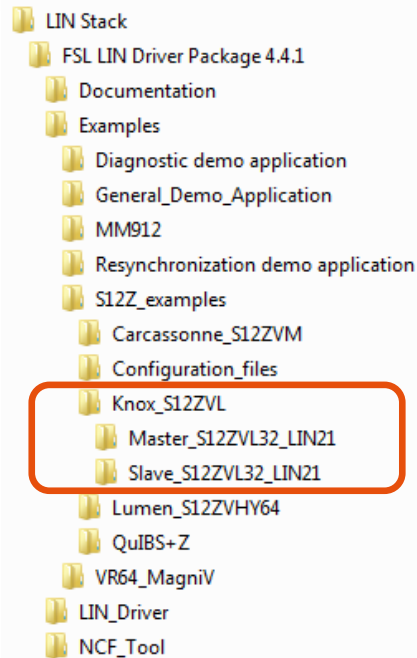
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freescale.com/MagniV

Freescall LIN 2.1 Driver (version 4.4.1)



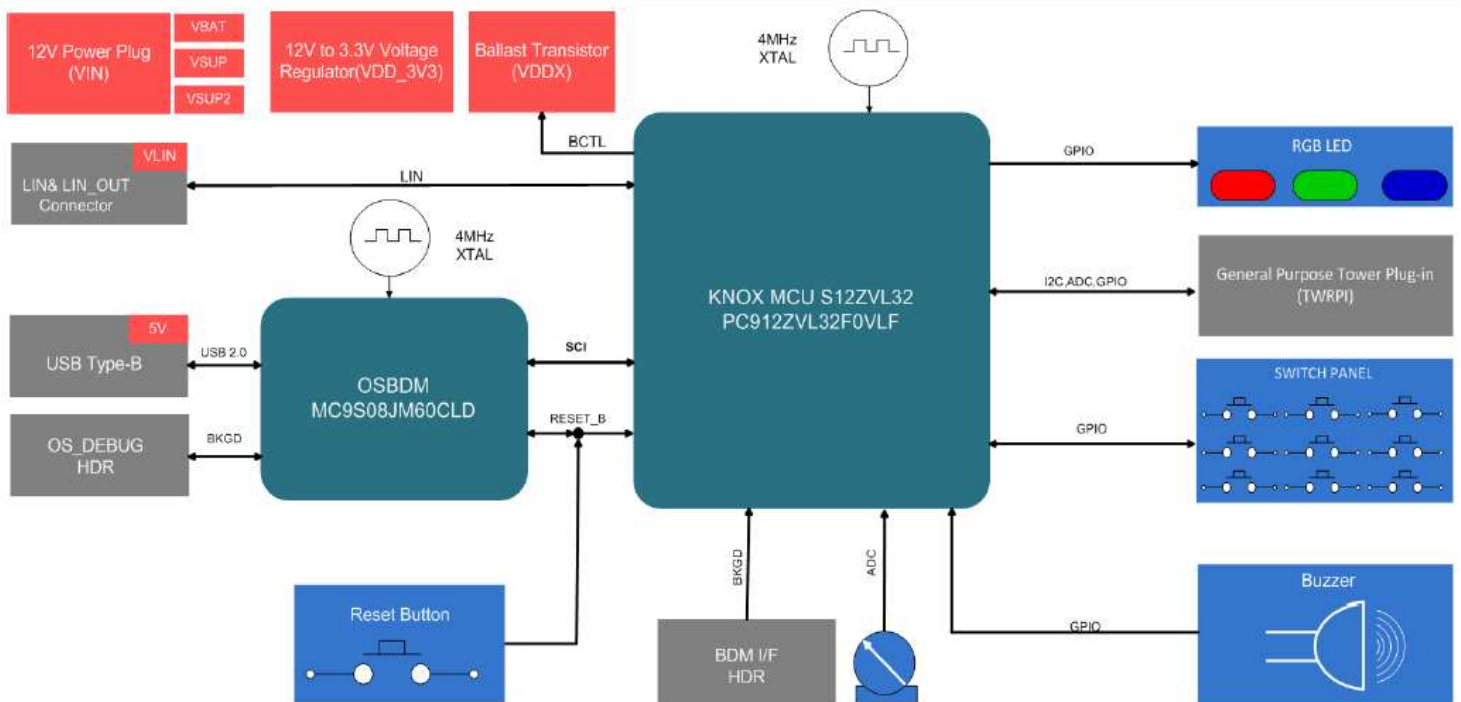
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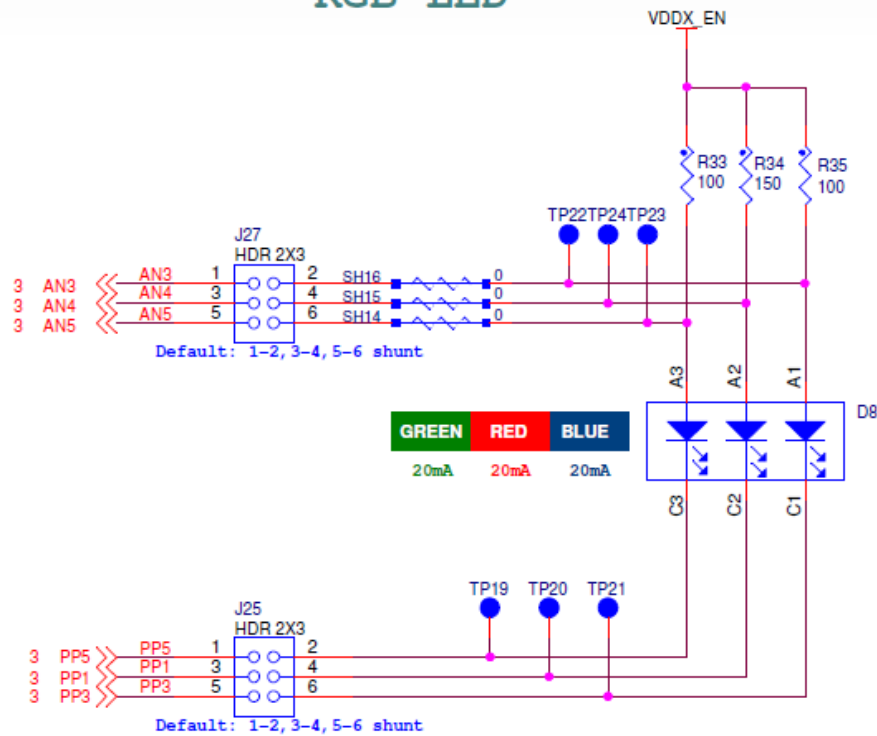


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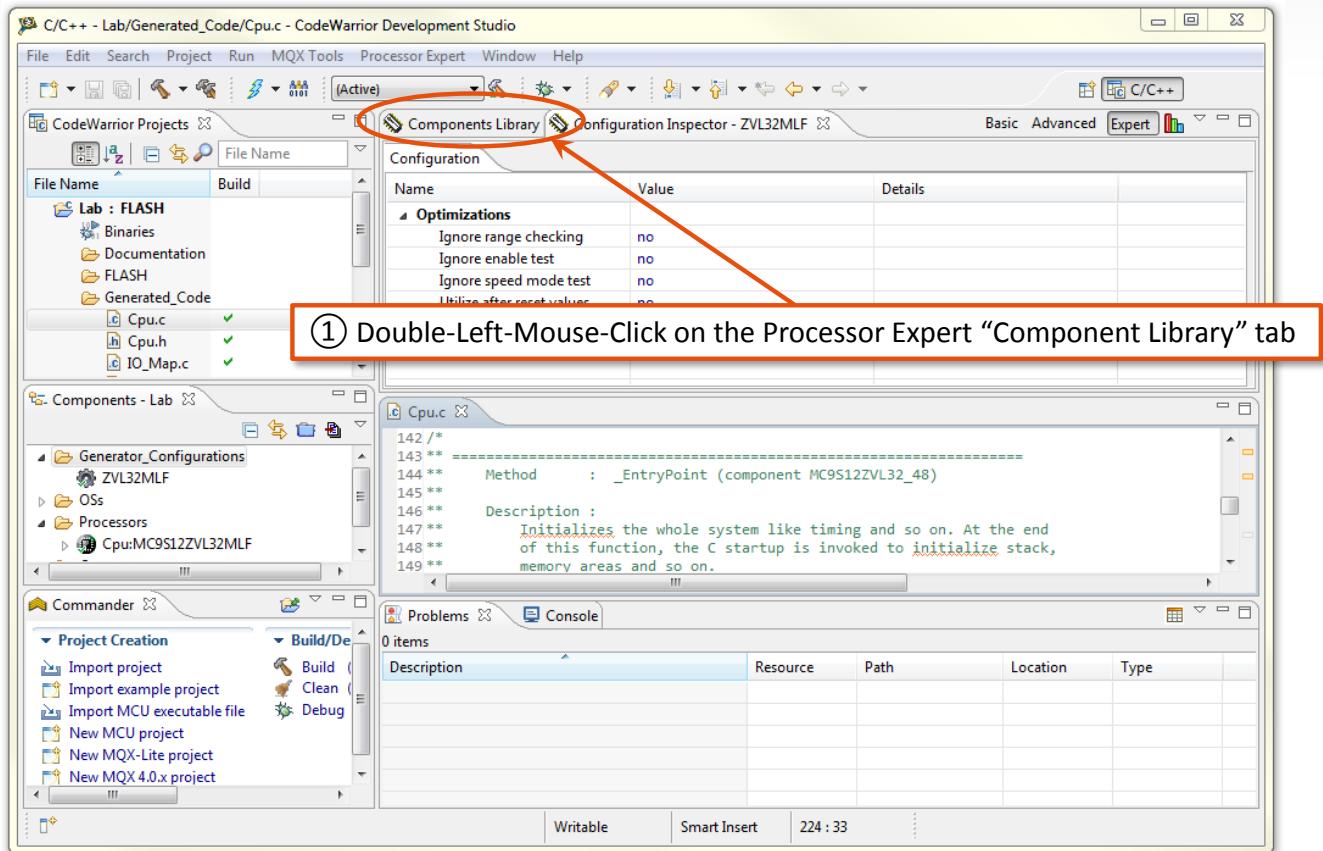
TRK-S12ZVL Block Diagram



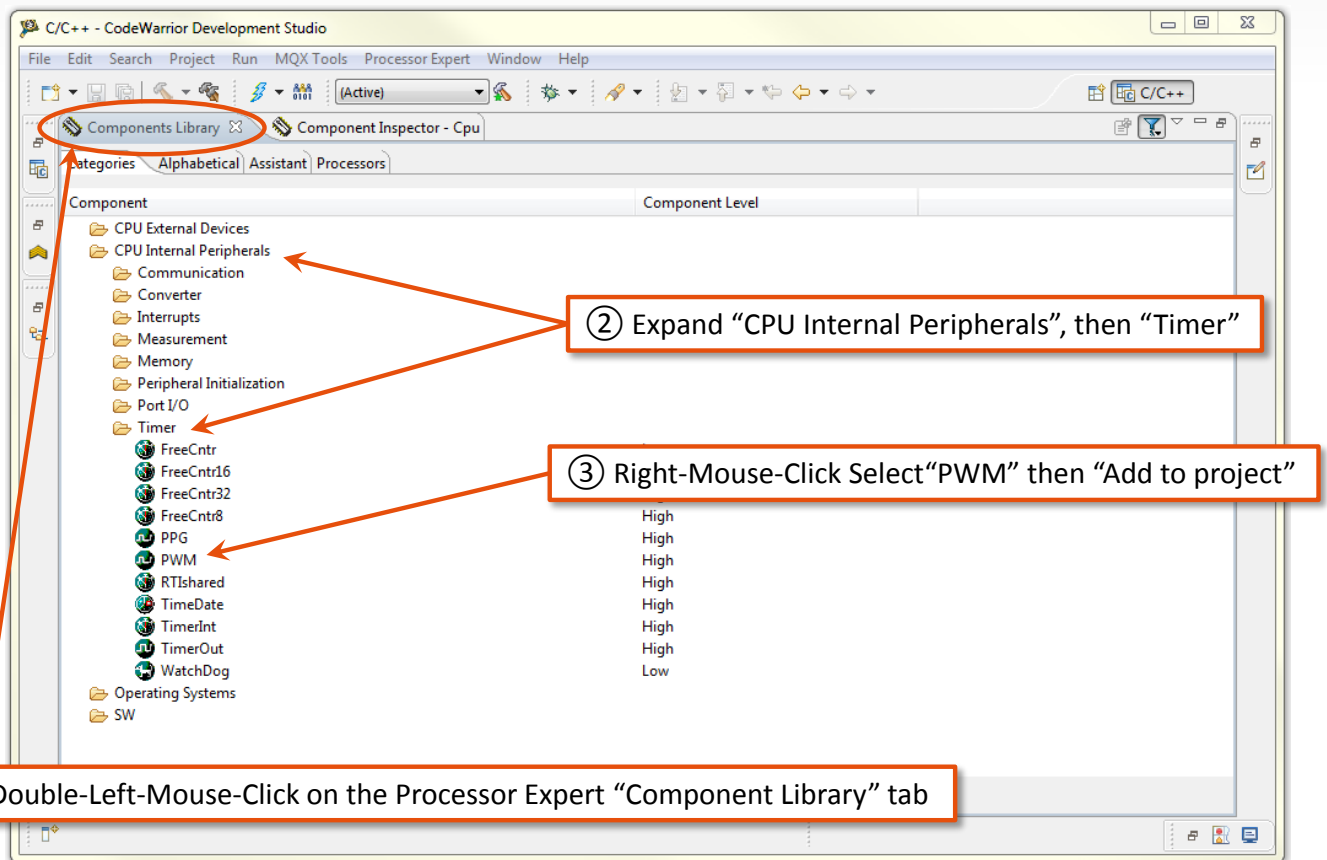
RGB LED



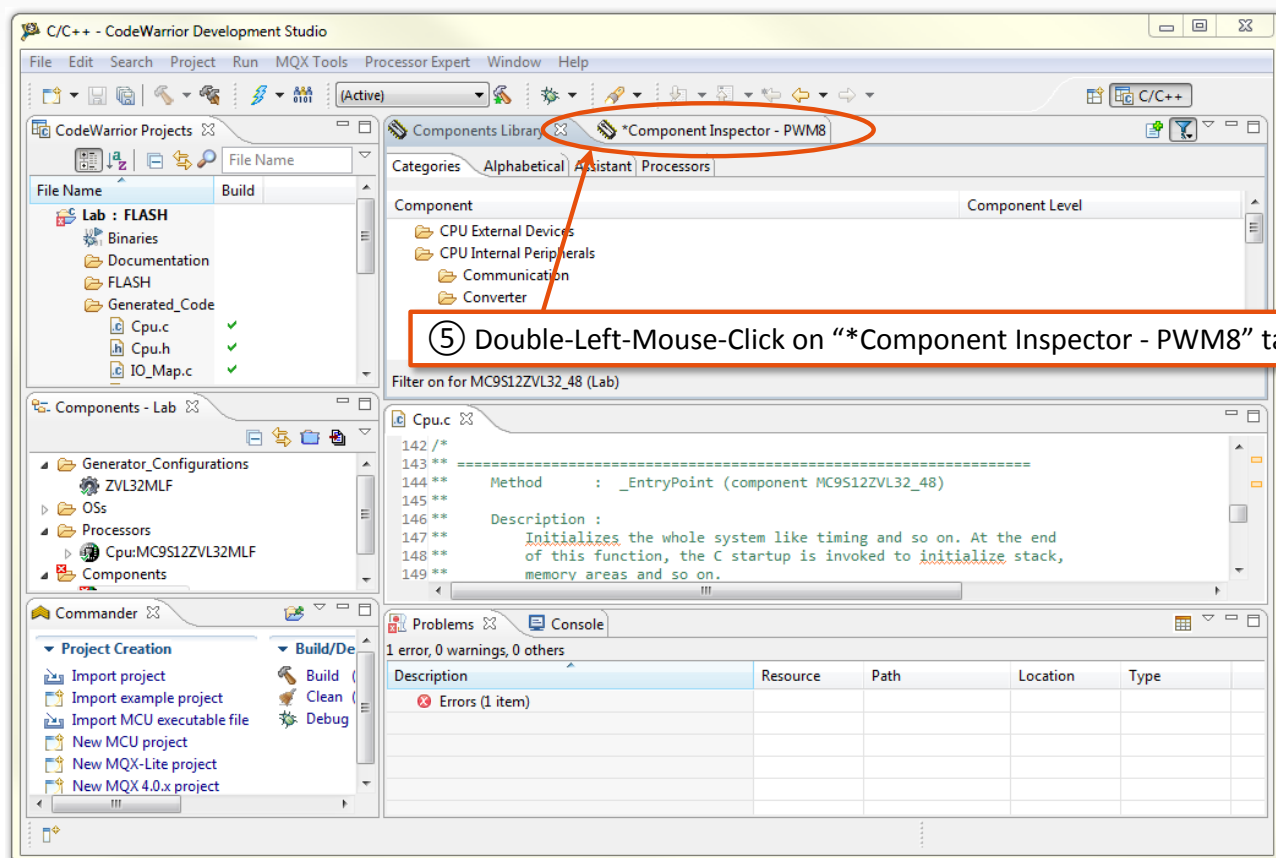
Lab Part 2: PWM LED Control



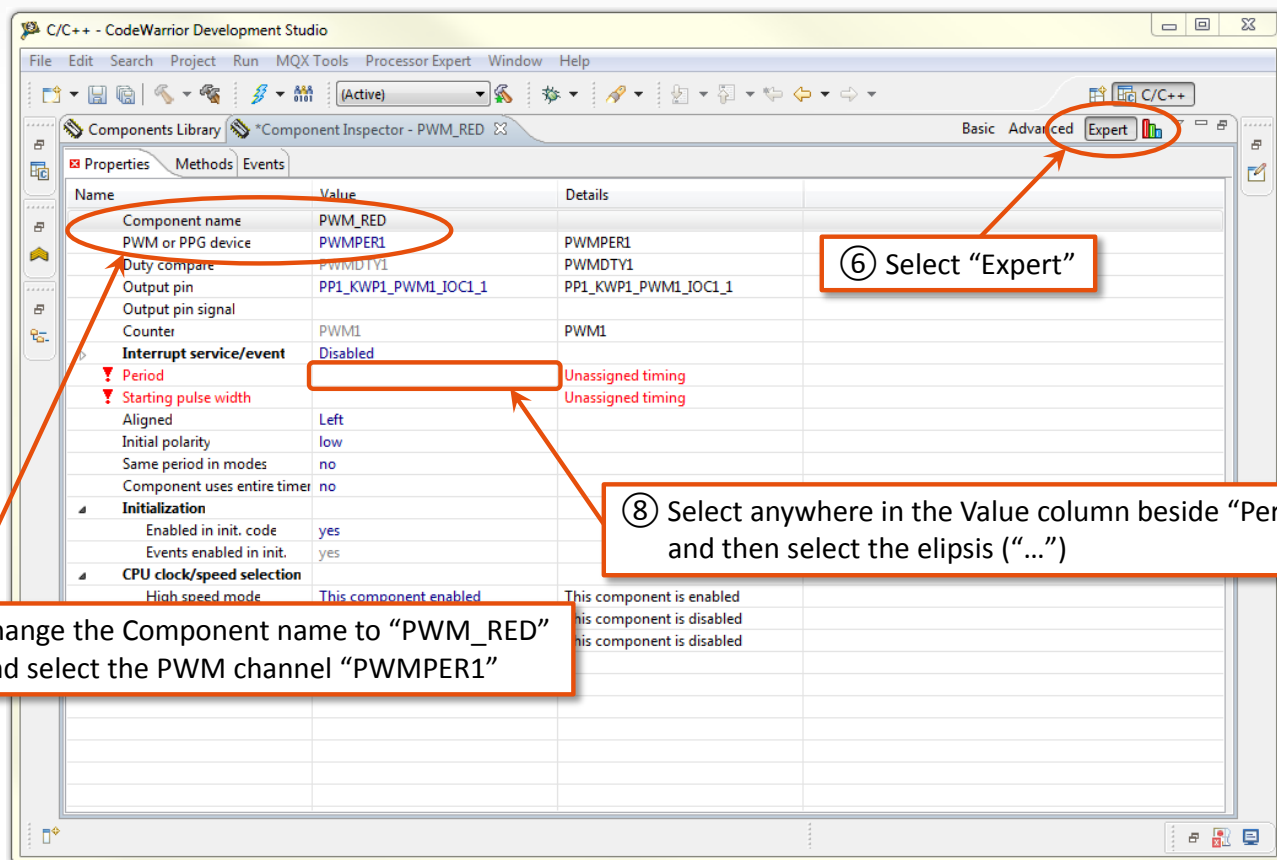
Add a PWM Component to the Project



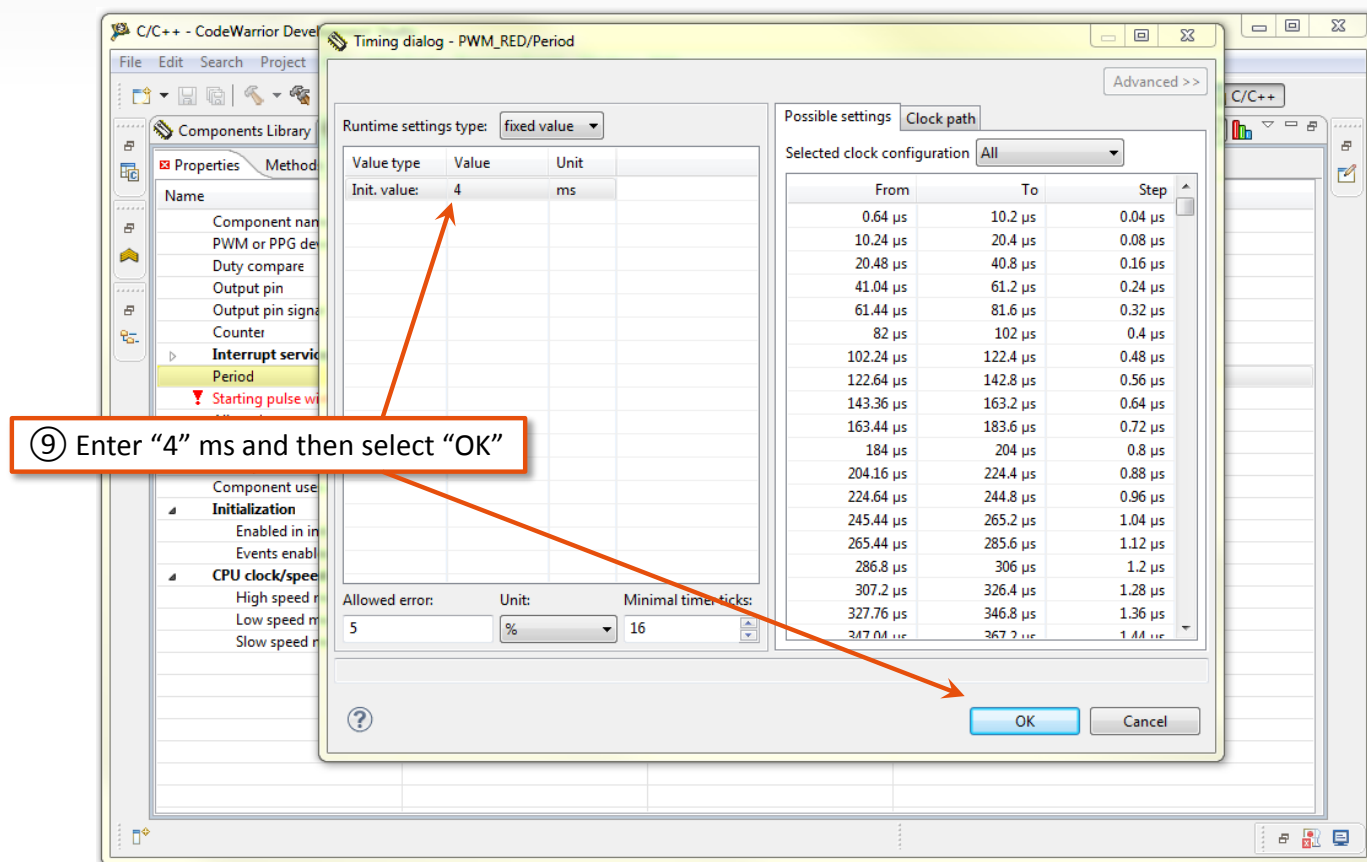
Change PWM Component Properties



Change PWM Component Properties



Change PWM Component Properties

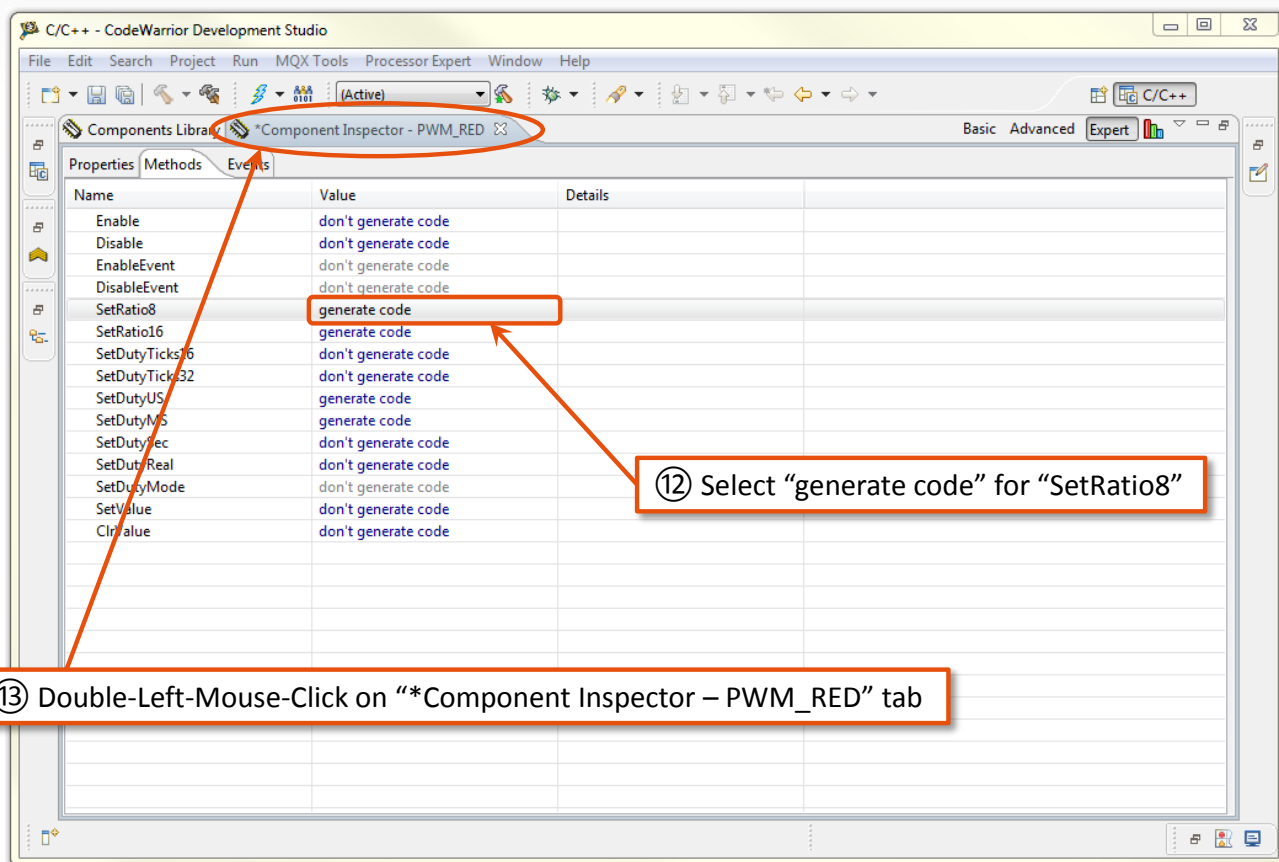


Change PWM Component Properties

The screenshot shows the CodeWarrior Development Studio interface. The 'Components Library' pane on the left shows the 'PWM_RED' component selected. The 'Methods' tab is active, displaying a table of properties and values. The 'Starting pulse width' is set to '0 ms'. Two annotations are present: a red circle around the 'Methods' tab with an arrow pointing to it and the text '11 Select the "Methods" tab', and a red circle around the 'Starting pulse width' value with an arrow pointing to it and the text '10 Repeat with the "Starting pulse width" by making it "0"ms.'

Name	Value	Details
Component name	PWM_RED	
PWM or PPG device	PWMPER1	PWMPER1
Duty compare	PWMDTY1	PWMDTY1
Output pin	PP1_KWP1_PWM1_IOC1_1	PP1_KWP1_PWM1_IOC1_1
Output pin signal		
Counter	PWM1	PWM1
Interrupt service/event	Disabled	
Period	4 ms	3.815 ms
Starting pulse width	0 ms	0 ms
Aligned	Left	
Initial polarity	low	
Same period in modes	no	
Component uses entire timer	no	
Initialization		
Enabled in init. code	yes	
Events enabled in init.	yes	
CPU clock/speed selection		
	ent enabled	This component is enabled
	ent disabled	This component is disabled
	ent disabled	This component is disabled

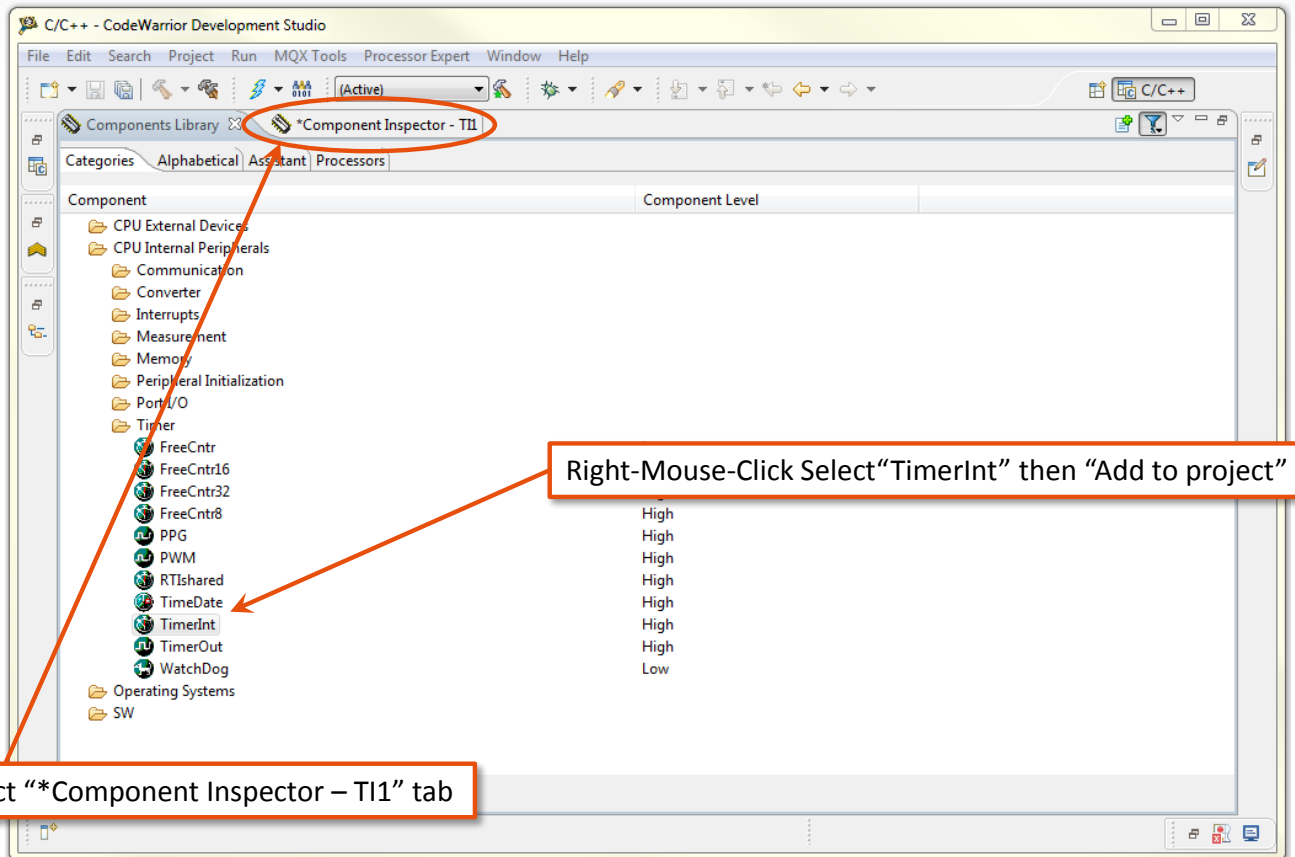
Change PWM Component Properties



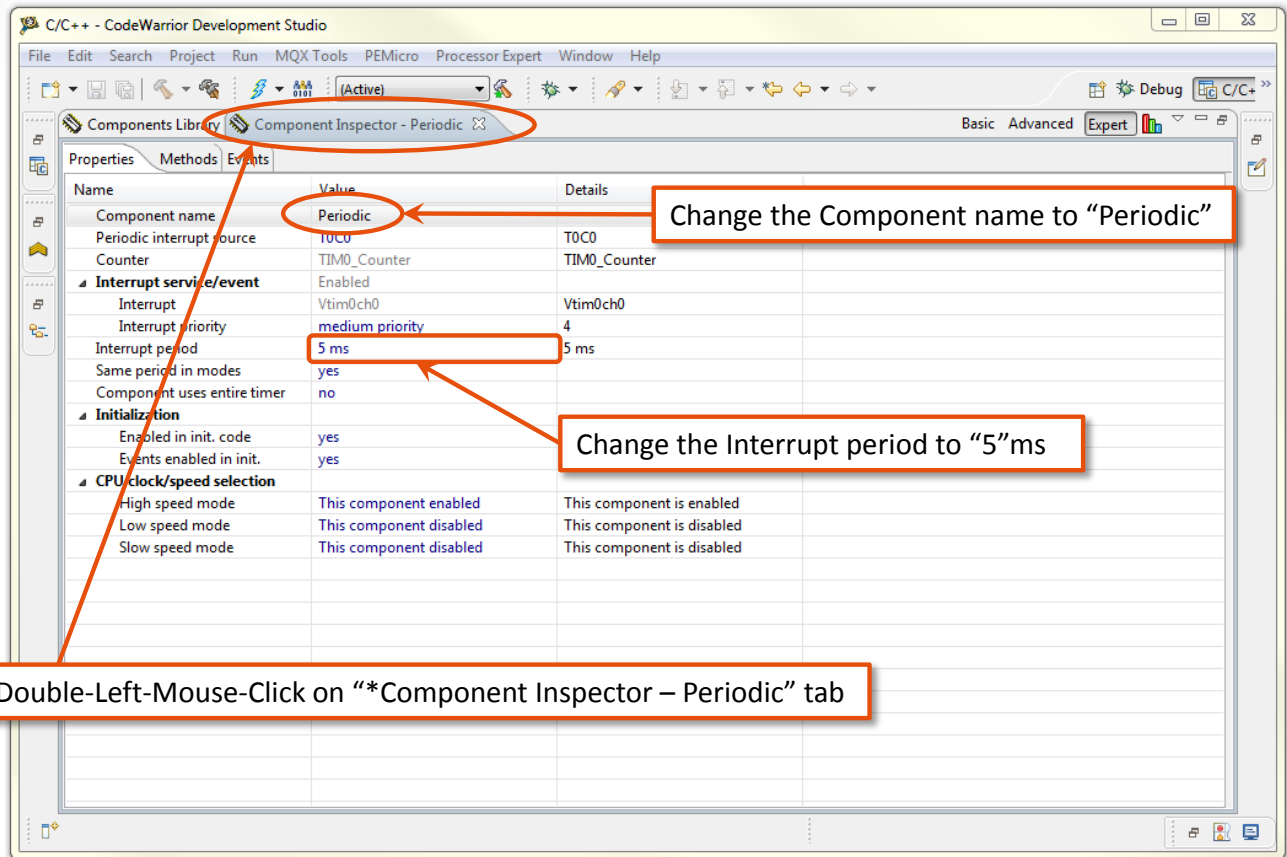
Create a PWM Component for Each LED Colour

- Repeat the previous steps ① through ⑬ two more times creating separate identical PWM channels for:
 - “PWM_GREEN” on “PWMPER5”
 - on Output pin “PP5_XIRQ_KWP5_PWM5”
 - “PWM_BLUE” on “PWMPER3”
 - on Output pin “PP3_IRQ_KWP3_PWM3”

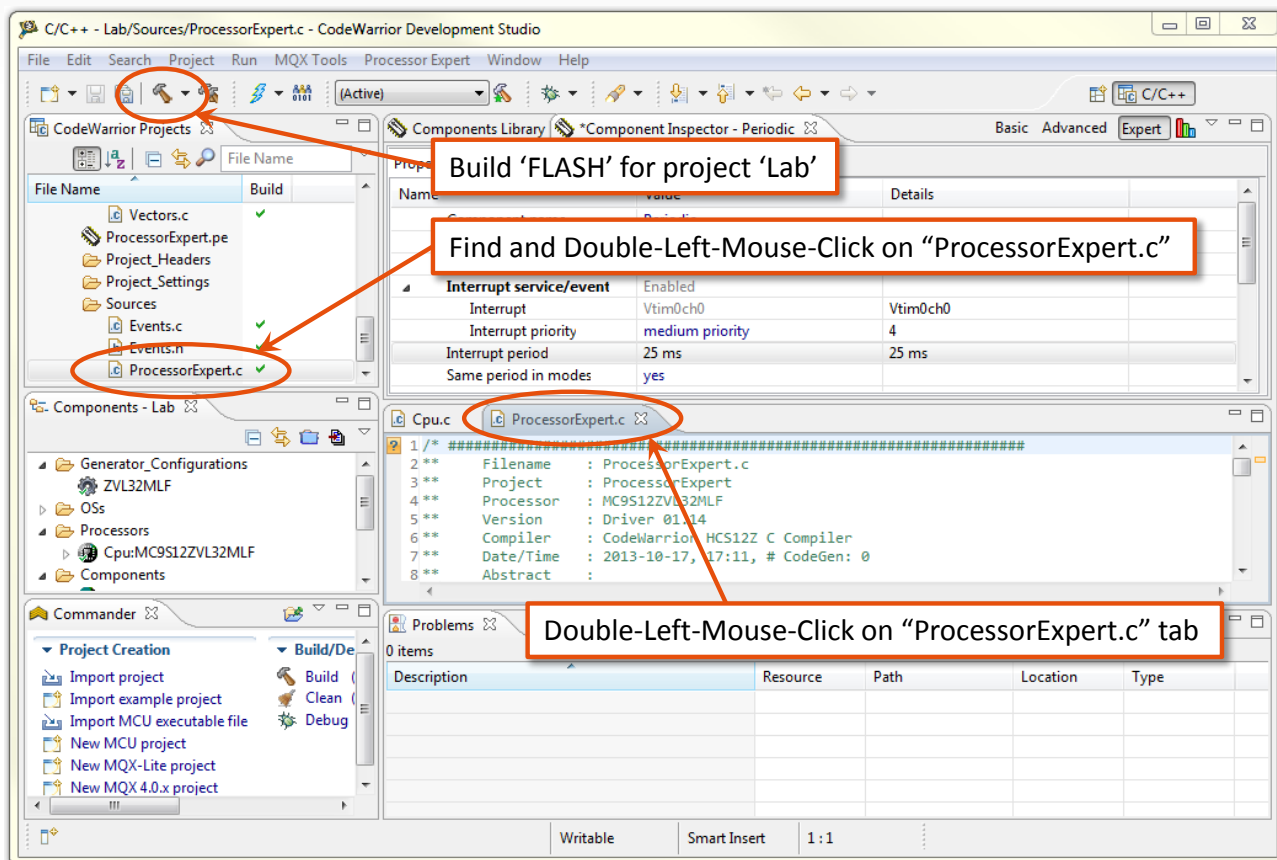
Add a Periodic Timer Component to the Project



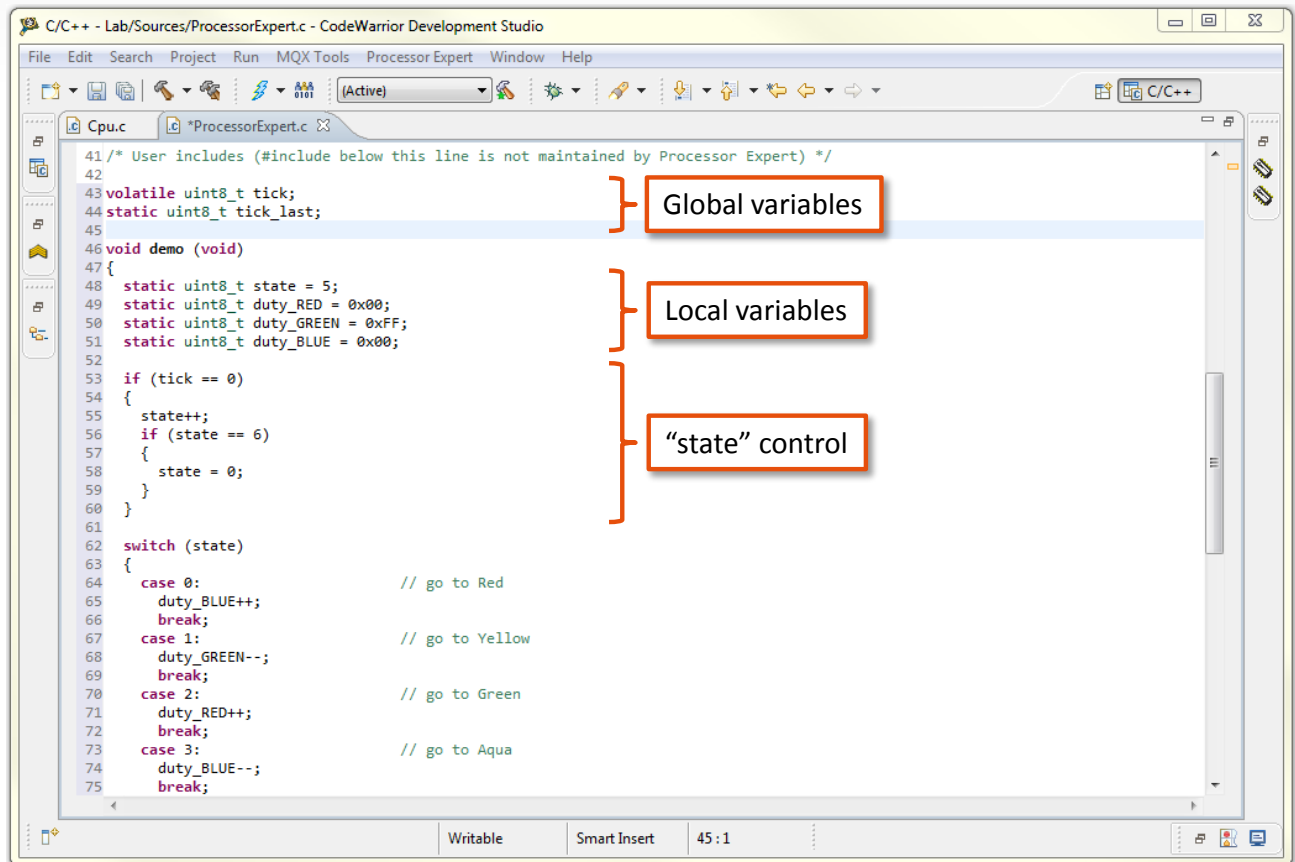
Change Periodic Timer Component Properties



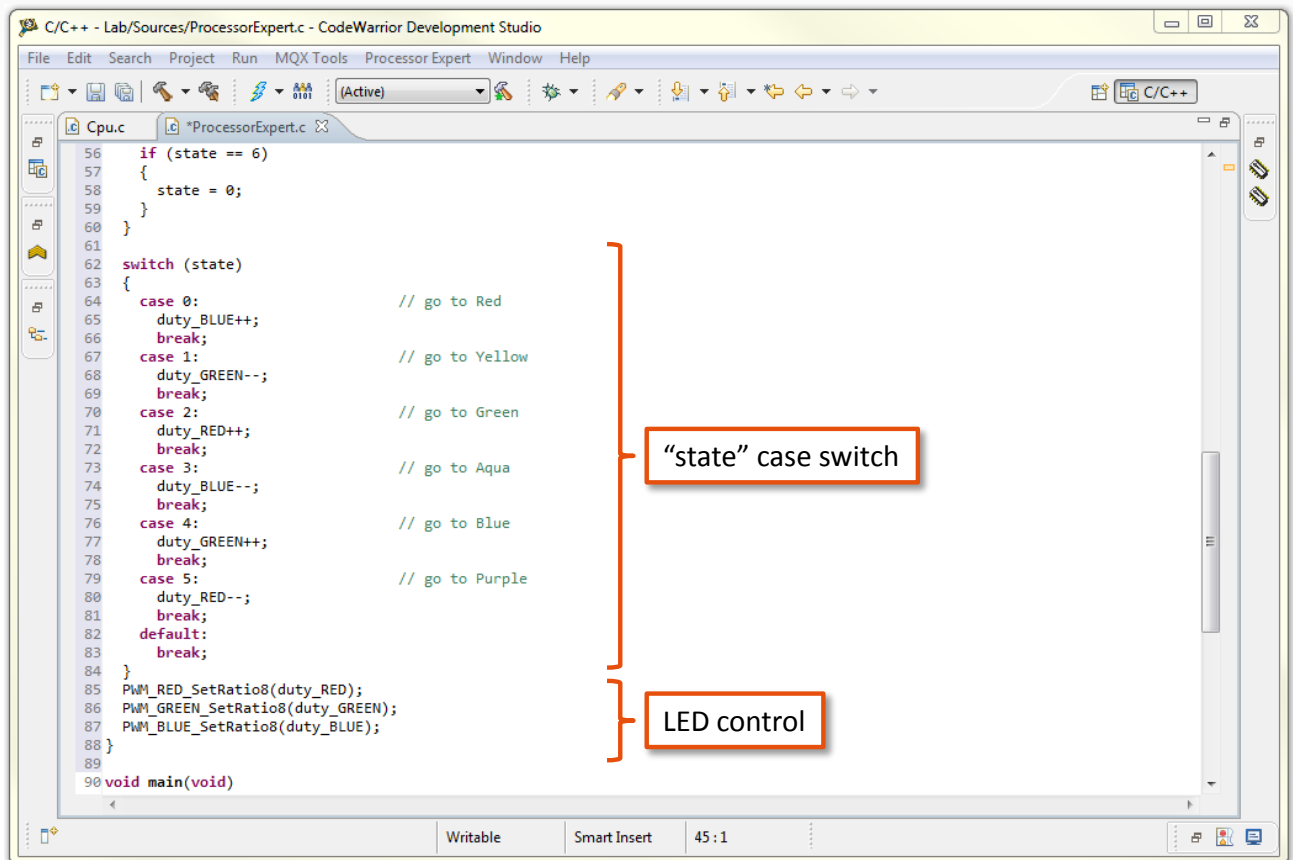
Build the Processor Expert Components



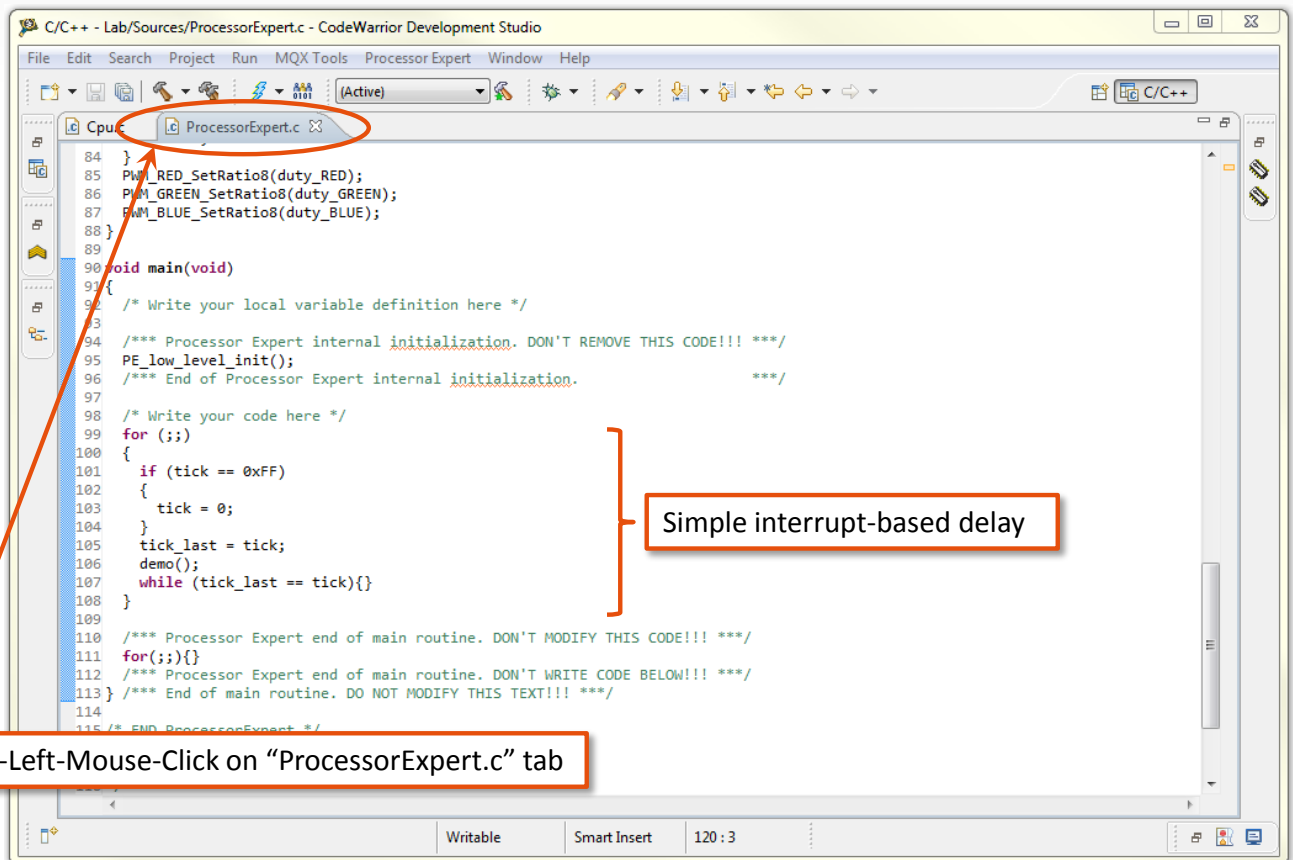
Add Code to ProcessorExpert.c



Add Code to ProcessorExpert.c



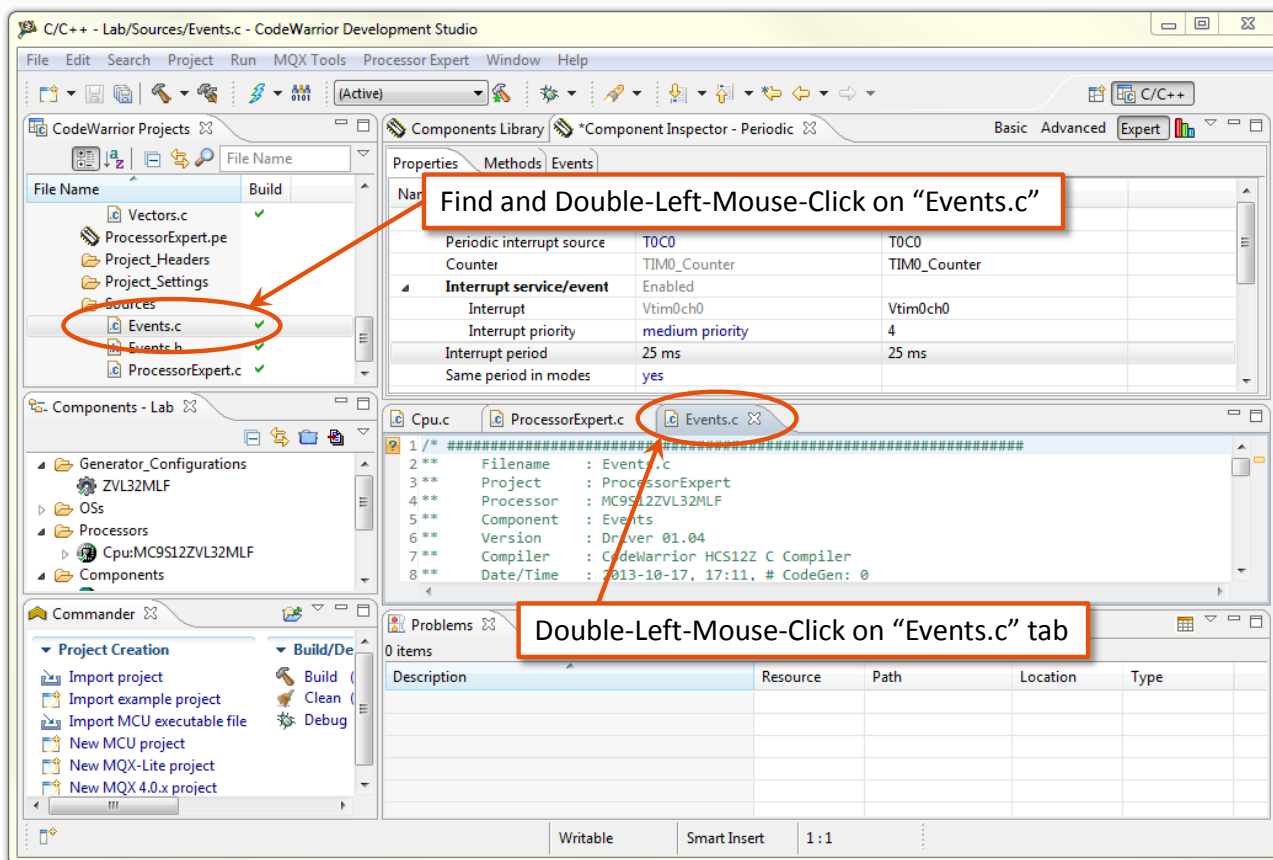
Add Code to ProcessorExpert.c



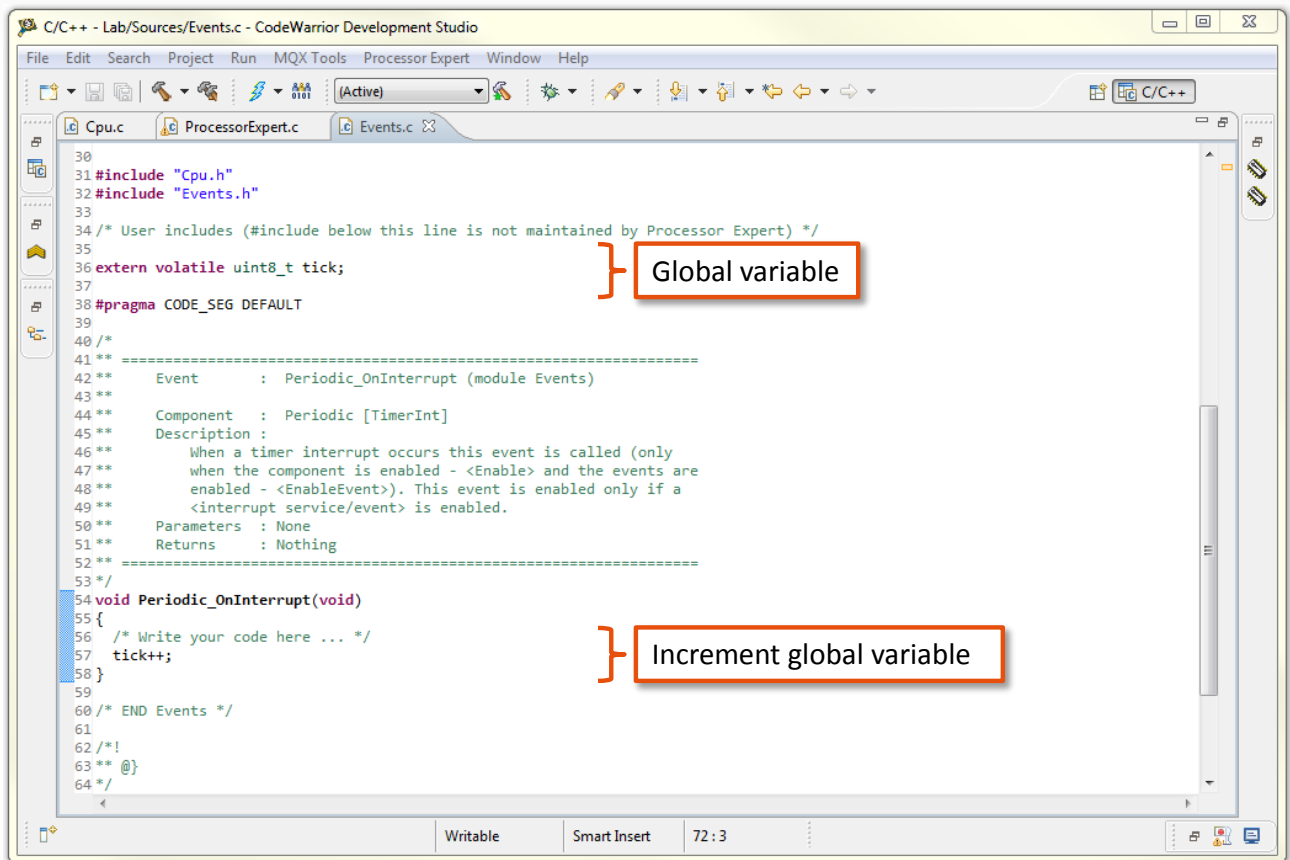
Double-Left-Mouse-Click on “ProcessorExpert.c” tab

Simple interrupt-based delay

Add Code to Events.c

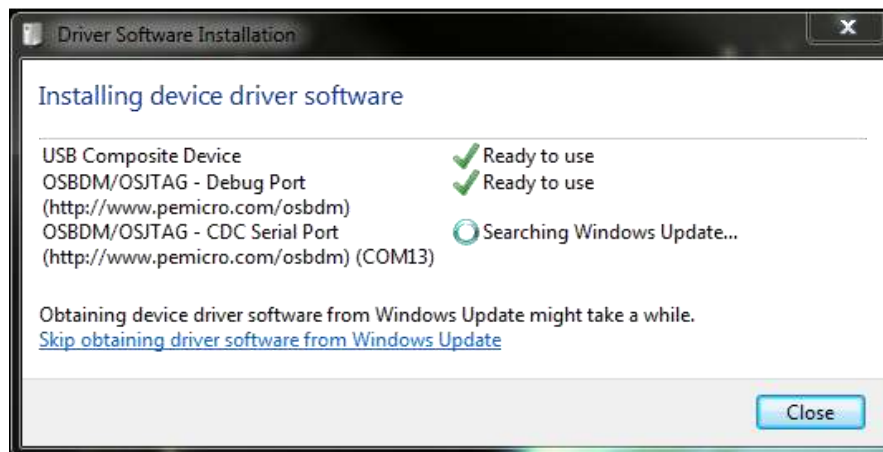


Add Code to Events.c



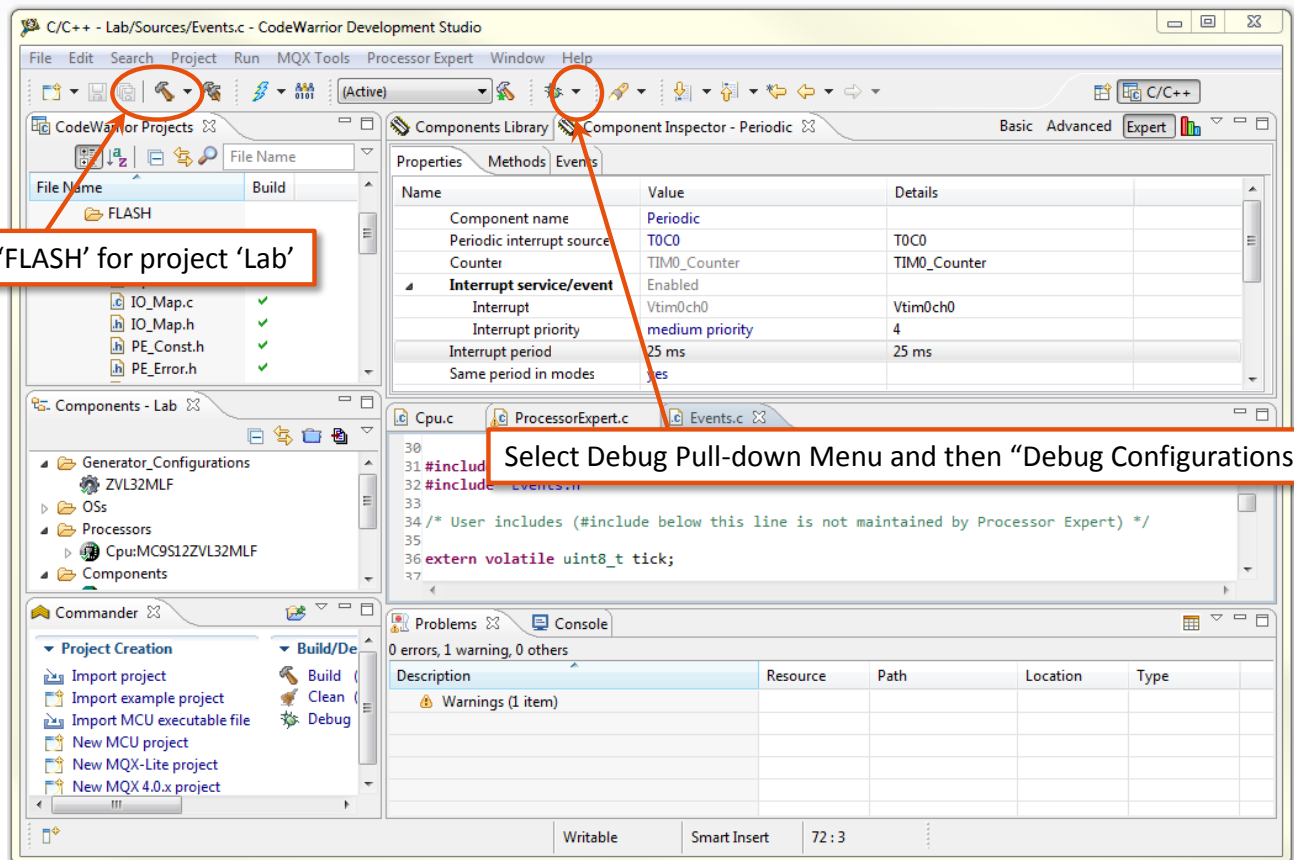
Prepare the Hardware

- Connect USB cable to the TRK-S12ZVL Evaluation Board

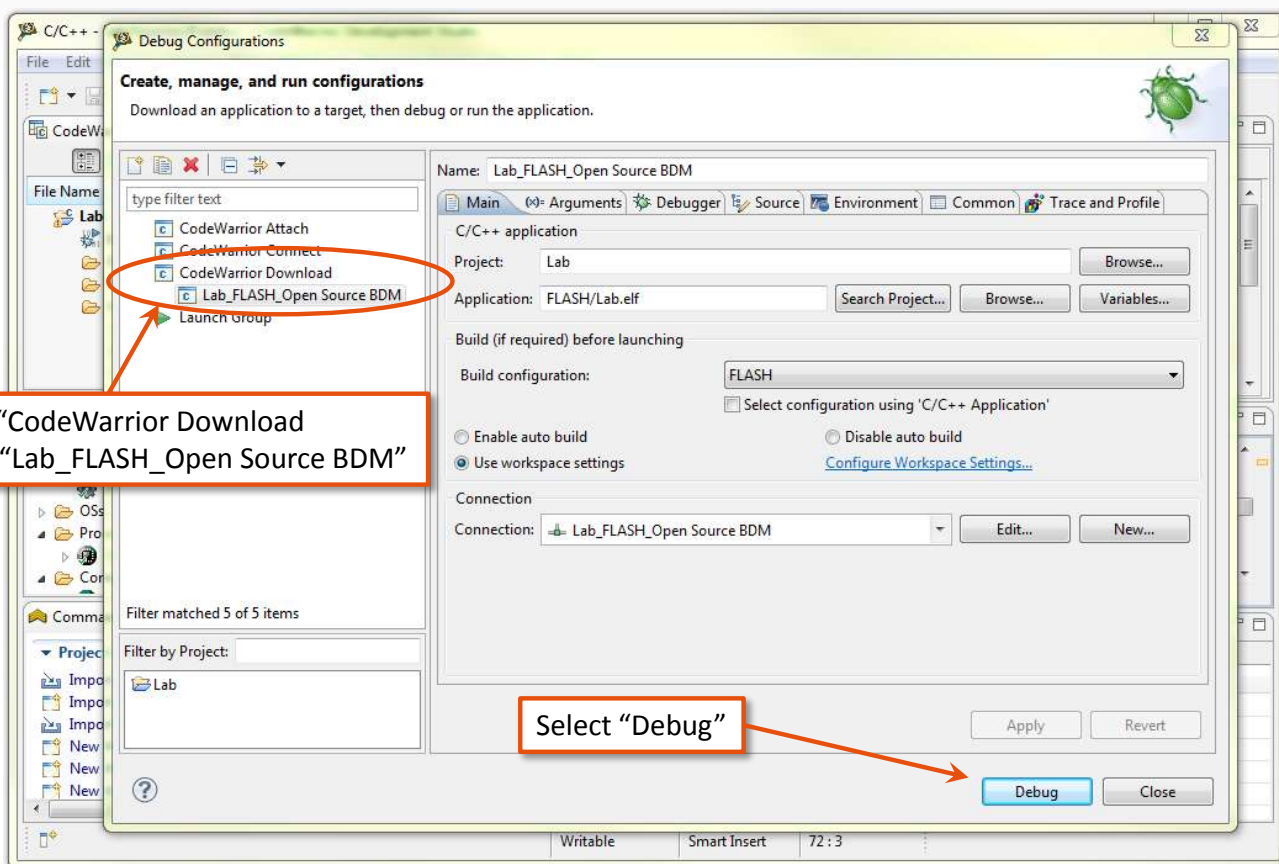


- Connect 12V Power Supply

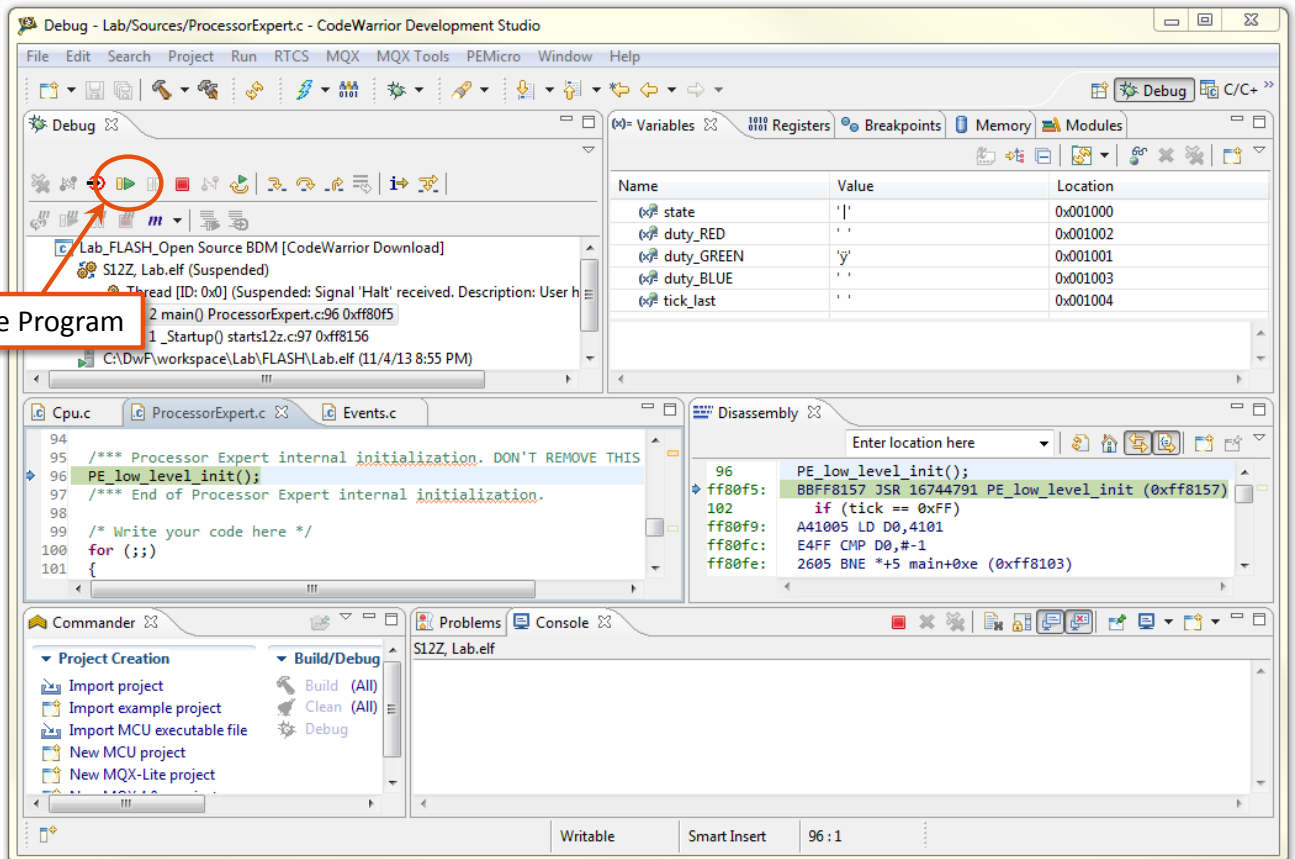
Build and Prepare to Debug



Select the Debug Configuration



Run the Program





Agenda

- Automotive Body Electronics
- MagniV Solutions and Roadmap
- Lab 1 —————
 - Getting Started with CodeWarrior 10.4
- S12Z Enhanced CPU Core
- S12ZVM for BLDC Motor Control
- S12ZVL for General Purpose LIN
- S12ZVC for General Purpose CAN
- Lab 2 —————
 - Developing a Project for the S12ZVL

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