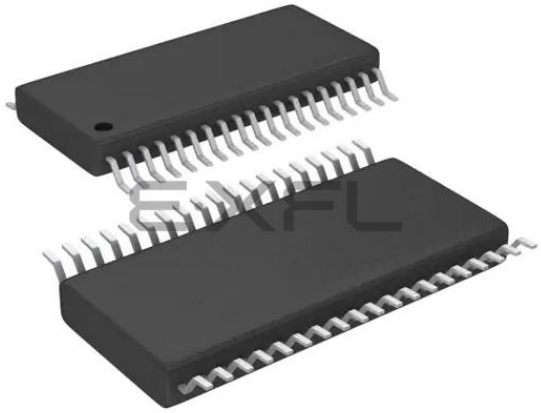

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Applications of "Embedded - Microcontrollers"

Details	
Product Status	Obsolete
Core Processor	XC800
Core Size	8-Bit
Speed	86MHz
Connectivity	LINbus, SSI, UART/USART
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	19
Program Memory Size	4KB (4K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	768 x 8
Voltage - Supply (Vcc/Vdd)	4.5V ~ 5.5V
Data Converters	A/D 8x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	38-TFSOP (0.173", 4.40mm Width)
Supplier Device Package	PG-TSSOP-38
Purchase URL	https://www.e-xfl.com/product-detail/infineon-technologies/saf-xc866l-1fra-ab

XC866

8-Bit Single-Chip Microcontroller

Microcontrollers

Never stop thinking

2 General Device Information

2.1 Block Diagram

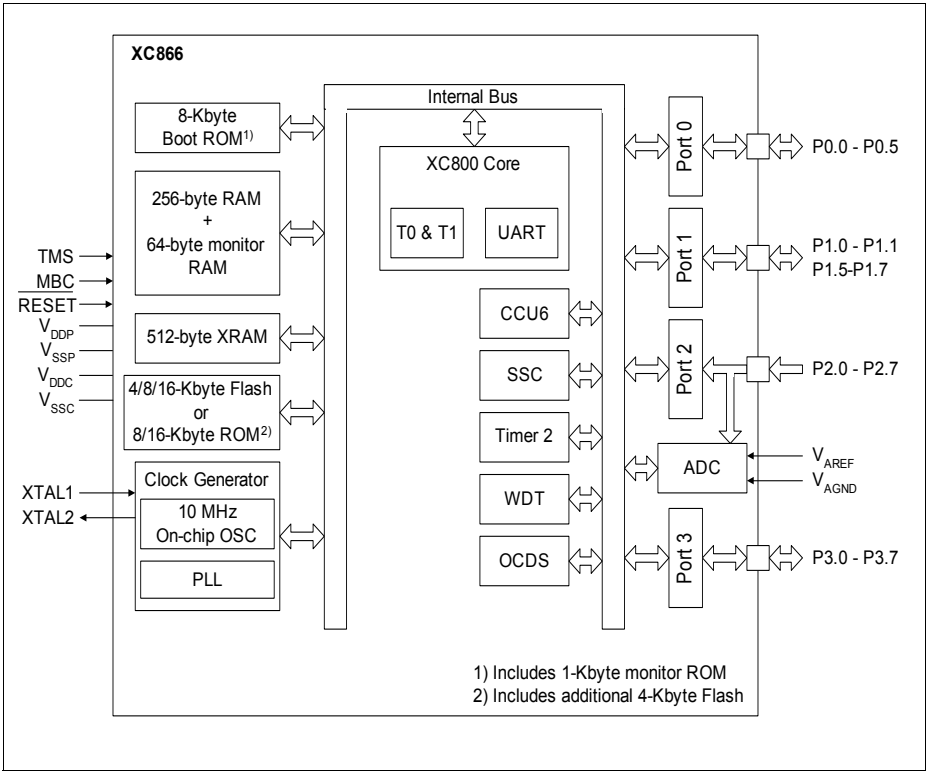


Figure 2 XC866 Block Diagram

2.4 Pin Definitions and Functions

Table 3 Pin Definitions and Functions

Symbol	Pin Number	Type	Reset State	Function
P0		I/O		**Port 0** Port 0 is a 6-bit bidirectional general purpose I/O port. It can be used as alternate functions for the JTAG, CCU6, UART, and the SSC.
P0.0	12		Hi-Z	TCK_0 JTAG Clock Input T12HR_1 CCU6 Timer 12 Hardware Run Input CC61_1 Input/Output of Capture/Compare channel 1 CLKOUT Clock Output RXDO_1 UART Transmit Data Output
P0.1	14		Hi-Z	TDI_0 JTAG Serial Data Input T13HR_1 CCU6 Timer 13 Hardware Run Input RXD_1 UART Receive Data Input COUT61_1 Output of Capture/Compare channel 1 EXF2_1 Timer 2 External Flag Output
P0.2	13		PU	$\overline{\text{CTRAP}}$_2 CCU6 Trap Input TDO_0 JTAG Serial Data Output TXD_1 UART Transmit Data Output/ Clock Output
P0.3	2		Hi-Z	SCK_1 SSC Clock Input/Output COUT63_1 Output of Capture/Compare channel 3
P0.4	3		Hi-Z	MTSR_1 SSC Master Transmit Output/ Slave Receive Input CC62_1 Input/Output of Capture/Compare channel 2
P0.5	4		Hi-Z	MRST_1 SSC Master Receive Input/ Slave Transmit Output EXINT0_0 External Interrupt Input 0 COUT62_1 Output of Capture/Compare channel 2

Table 3 Pin Definitions and Functions (cont'd)

Symbol	Pin Number	Type	Reset State	Function
P2		I		**Port 2** Port 2 is an 8-bit general purpose input-only port. It can be used as alternate functions for the digital inputs of the JTAG and CCU6. It is also used as the analog inputs for the ADC.
P2.0	15		Hi-Z	CCPOS0_0 CCU6 Hall Input 0 EXINT1 External Interrupt Input 1 T12HR_2 CCU6 Timer 12 Hardware Run Input TCK_1 JTAG Clock Input CC61_3 Input of Capture/Compare channel 1 AN0 Analog Input 0
P2.1	16		Hi-Z	CCPOS1_0 CCU6 Hall Input 1 EXINT2 External Interrupt Input 2 T13HR_2 CCU6 Timer 13 Hardware Run Input TDI_1 JTAG Serial Data Input CC62_3 Input of Capture/Compare channel 2 AN1 Analog Input 1
P2.2	17		Hi-Z	CCPOS2_0 CCU6 Hall Input 2 CTRAP_1 CCU6 Trap Input CC60_3 Input of Capture/Compare channel 0 AN2 Analog Input 2
P2.3	20		Hi-Z	AN3 Analog Input 3
P2.4	21		Hi-Z	AN4 Analog Input 4
P2.5	22		Hi-Z	AN5 Analog Input 5
P2.6	23		Hi-Z	AN6 Analog Input 6
P2.7	26		Hi-Z	AN7 Analog Input 7

3 Functional Description

3.1 Processor Architecture

The XC866 is based on a high-performance 8-bit Central Processing Unit (CPU) that is compatible with the standard 8051 processor. While the standard 8051 processor is designed around a 12-clock machine cycle, the XC866 CPU uses a 2-clock machine cycle. This allows fast access to ROM or RAM memories without wait state. Access to the Flash memory, however, requires an additional wait state (one machine cycle). The instruction set consists of 45% one-byte, 41% two-byte and 14% three-byte instructions.

The XC866 CPU provides a range of debugging features, including basic stop/start, single-step execution, breakpoint support and read/write access to the data memory, program memory and SFRs.

Figure 5 shows the CPU functional blocks.

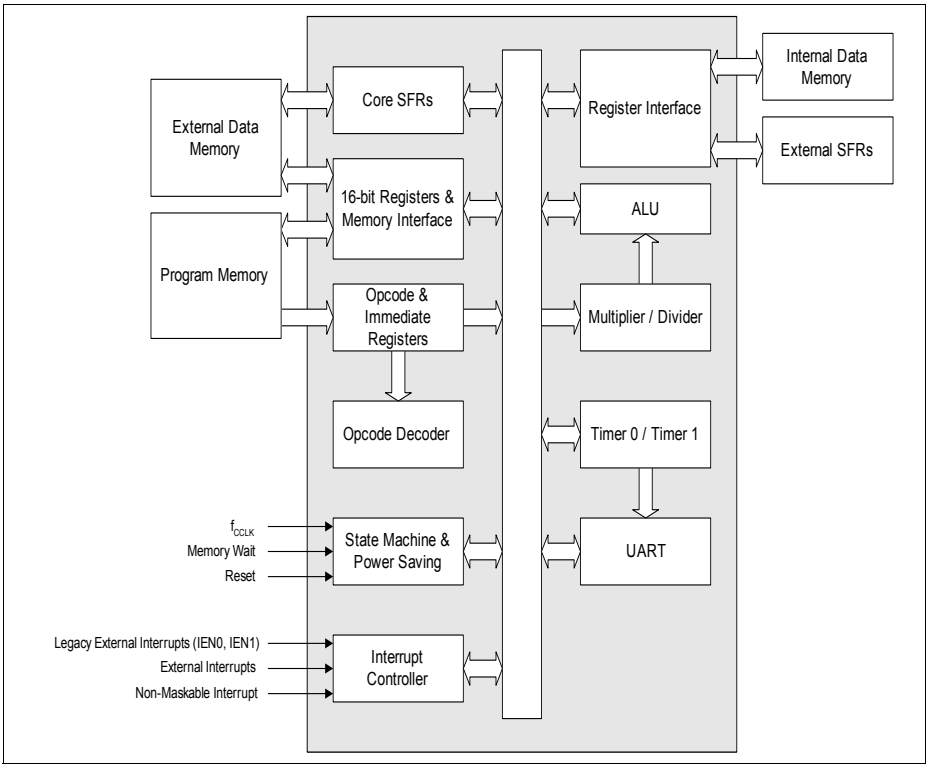


Figure 5 CPU Block Diagram

3.2.1 Memory Protection Strategy

The XC866 memory protection strategy includes:

- Read-out protection: The Flash Memory can be enabled for read-out protection and ROM memory is always protected.
- Program and erase protection: The Flash memory in all devices can be enabled for program and erase protection.

Flash memory protection is available in two modes:

- Mode 0: Only the P-Flash is protected; the D-Flash is unprotected
- Mode 1: Both the P-Flash and D-Flash are protected

The selection of each protection mode and the restrictions imposed are summarized in **Table 4**.

Table 4 Flash Protection Modes

Mode	0	1
Activation	Program a valid password via BSL mode 6	
Selection	MSB of password = 0	MSB of password = 1
P-Flash contents can be read by	Read instructions in the P-Flash	Read instructions in the P-Flash or D-Flash
P-Flash program and erase	Not possible	Not possible
D-Flash contents can be read by	Read instructions in any program memory	Read instructions in the P-Flash or D-Flash
D-Flash program	Possible	Not possible
D-Flash erase	Possible, on the condition that bit DFLASHEN in register MISC_CON is set to 1 prior to each erase operation	Not possible

BSL mode 6, which is used for enabling Flash protection, can also be used for disabling Flash protection. Here, the programmed password must be provided by the user. A password match triggers an automatic erase of the read-protected Flash contents, see **Table 5** and **Table 6**, and the programmed password is erased. The Flash protection is then disabled upon the next reset.

For XC866-2FR and XC866-4FR devices:

The selection of protection type is summarized in **Table 5**.

Table 5 Flash Protection Type for XC866-2FR and XC866-4FR devices

PASSWORD	Type of Protection	Flash Banks to Erase when Unprotected
$1XXXXXXX_B$	Flash Protection Mode 1	All Banks
$0XXXXXXX_B$	Flash Protection Mode 0	P-Flash Bank

For XC866-1FR device and ROM devices:

The selection of protection type is summarized in **Table 6**.

Table 6 Flash Protection Type for XC866-1FR device and ROM devices

PASSWORD	Type of Protection (Applicable to the whole Flash)	Sectors to Erase when Unprotected	Comments
$1XXXXXXX_B$	Read/Program/Erase	All Sectors	Compatible to Protection mode 1
$00001XXX_B$	Erase	Sector 0	
$00010XXX_B$	Erase	Sector 0 and 1	
$00011XXX_B$	Erase	Sector 0 to 2	
$00100XXX_B$	Erase	Sector 0 to 3	
$00101XXX_B$	Erase	Sector 0 to 4	
$00110XXX_B$	Erase	Sector 0 to 5	
$00111XXX_B$	Erase	Sector 0 to 6	
$01000XXX_B$	Erase	Sector 0 to 7	
$01001XXX_B$	Erase	Sector 0 to 8	
$01010XXX_B$	Erase	All Sectors	
Others	Erase	None	

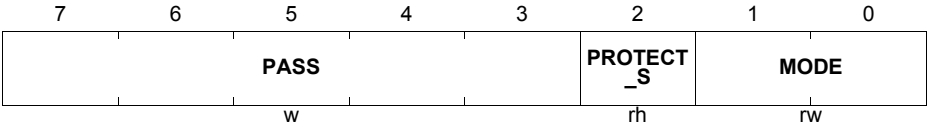
Although no protection scheme can be considered infallible, the XC866 memory protection strategy provides a very high level of protection for a general purpose microcontroller.

3.2.3 Bit Protection Scheme

The bit protection scheme prevents direct software writing of selected bits (i.e., protected bits) using the PASSWD register. When the bit field MODE is 11_B, writing 10011_B to the bit field PASS opens access to writing of all protected bits, and writing 10101_B to the bit field PASS closes access to writing of all protected bits. In both cases, the value of the bit field MODE is not changed even if PASSWD register is written with 98_H or $A8_H$. It can only be changed when bit field PASS is written with 11000_B, for example, writing $D0_H$ to PASSWD register disables the bit protection scheme.

The access is opened for maximum 32 CCLKs if the “close access” password is not written. If “open access” password is written again before the end of 32 CCLK cycles, there will be a recount of 32 CCLK cycles. The protected bits include NDIV, WDTEN, PD, and SD.

PASSWD
Password Register **Reset Value: 07_H**



Field	Bits	Type	Description
MODE	[1:0]	rw	**Bit Protection Scheme Control bits** 00 Scheme Disabled 11 Scheme Enabled (default) Others: Scheme Enabled These two bits cannot be written directly. To change the value between 11_B and 00_B, the bit field PASS must be written with 11000_B; only then, will the MODE[1:0] be registered.
PROTECT_S	2	rh	**Bit Protection Signal Status bit** This bit shows the status of the protection. 0 Software is able to write to all protected bits. 1 Software is unable to write to any protected bits.
PASS	[7:3]	w	**Password bits** The Bit Protection Scheme only recognizes three patterns. 11000_B Enables writing of the bit field MODE. 10011_B Opens access to writing of all protected bits. 10101_B Closes access to writing of all protected bits.

3.3.2 Flash Programming Width

For the P-Flash banks, a programmed wordline (WL) must be erased before it can be reprogrammed as the Flash cells can only withstand one gate disturb. This means that the entire sector containing the WL must be erased since it is impossible to erase a single WL.

For the D-Flash bank, the same WL can be programmed twice before erasing is required as the Flash cells are able to withstand two gate disturbs. Hence, it is possible to program the same WL, for example, with 16 bytes of data in two times (see **Figure 12**).

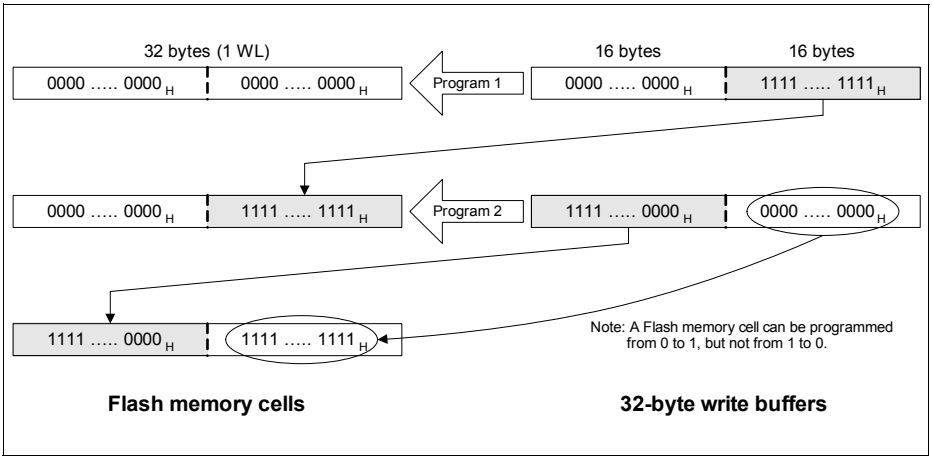


Figure 12 D-Flash Programming

Note: When programming a D-Flash WL the second time, the previously programmed Flash memory cells (whether 0s or 1s) should be reprogrammed with 0s to retain its original contents and to prevent “over-programming”.

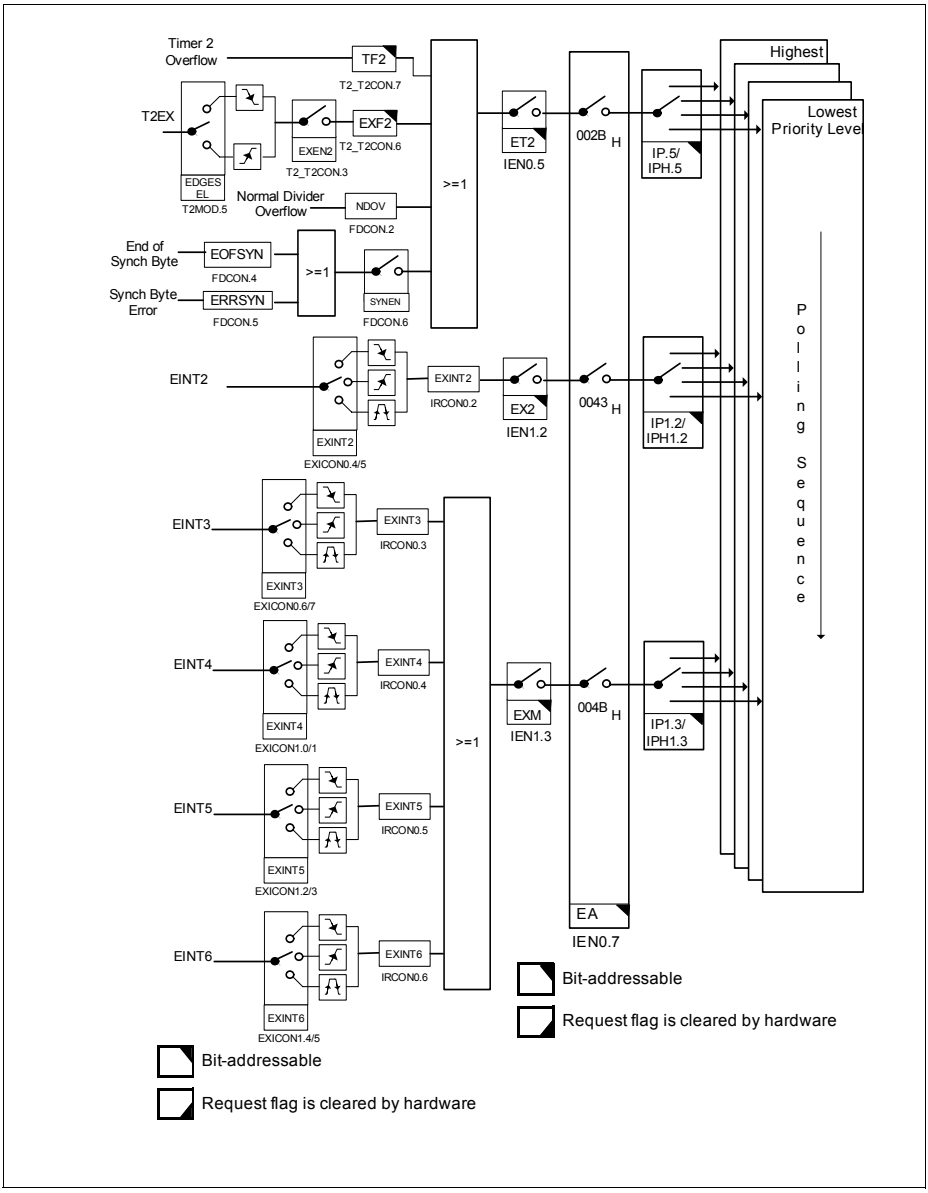


Figure 15 Interrupt Request Sources (Part 2)

3.5 Parallel Ports

The XC866 has 27 port pins organized into four parallel ports, Port 0 (P0) to Port 3 (P3). Each pin has a pair of internal pull-up and pull-down devices that can be individually enabled or disabled. Ports P0, P1 and P3 are bidirectional and can be used as general purpose input/output (GPIO) or to perform alternate input/output functions for the on-chip peripherals. When configured as an output, the open drain mode can be selected. Port P2 is an input-only port, providing general purpose input functions, alternate input functions for the on-chip peripherals, and also analog inputs for the Analog-to-Digital Converter (ADC).

Bidirectional Port Features:

- Configurable pin direction
- Configurable pull-up/pull-down devices
- Configurable open drain mode
- Transfer of data through digital inputs and outputs (general purpose I/O)
- Alternate input/output for on-chip peripherals

Input Port Features:

- Configurable input driver
- Configurable pull-up/pull-down devices
- Receive of data through digital input (general purpose input)
- Alternate input for on-chip peripherals
- Analog input for ADC module

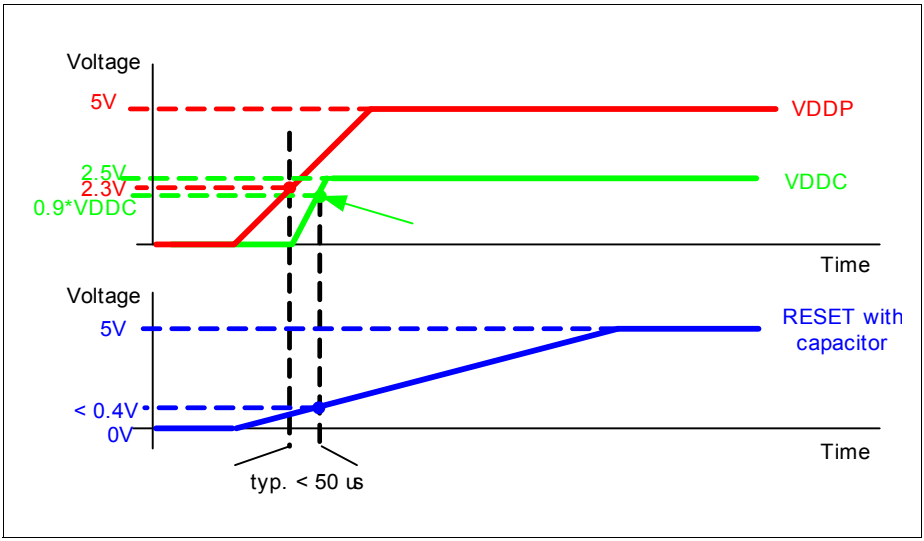


Figure 22 V_{DDP}, V_{DDC} and V_{RESET} during Power-on Reset

The second type of reset in XC866 is the hardware reset. This reset function can be used during normal operation or when the chip is in power-down mode. A reset input pin $\overline{\text{RESET}}$ is provided for the hardware reset. To ensure the recognition of the hardware reset, pin $\overline{\text{RESET}}$ must be held low for at least 100 ns.

The Watchdog Timer (WDT) module is also capable of resetting the device if it detects a malfunction in the system.

Another type of reset that needs to be detected is a reset while the device is in power-down mode (wake-up reset). While the contents of the static RAM are undefined after a power-on reset, they are well defined after a wake-up reset from power-down mode.

3.7.1 Module Reset Behavior

Table 19 shows how the functions of the XC866 are affected by the various reset types. A "■" means that this function is reset to its default state.

Table 19 Effect of Reset on Device Functions

Module/ Function	Wake-Up Reset	Watchdog Reset	Hardware Reset	Power-On Reset	Brownout Reset
CPU Core	■	■	■	■	■
Peripherals	■	■	■	■	■
On-Chip Static RAM	Not affected, reliable	Not affected, reliable	Not affected, reliable	Affected, un-reliable	Affected, un-reliable
Oscillator, PLL	■	Not affected	■	■	■
Port Pins	■	■	■	■	■
EVR	The voltage regulator is switched on	Not affected	■	■	■
FLASH	■	■	■	■	■
NMI	Disabled	Disabled	■	■	■

3.7.2 Booting Scheme

When the XC866 is reset, it must identify the type of configuration with which to start the different modes once the reset sequence is complete. Thus, boot configuration information that is required for activation of special modes and conditions needs to be applied by the external world through input pins. After power-on reset or hardware reset, the pins MBC, TMS and P0.0 collectively select the different boot options. Table 20 shows the available boot options in the XC866.

Table 20 XC866 Boot Selection

MBC	TMS	P0.0	Type of Mode	PC Start Value
1	0	x	User Mode; on-chip OSC/PLL non-bypassed	0000_H
0	0	x	BSL Mode; on-chip OSC/PLL non-bypassed	0000_H
0	1	0	OCDS Mode[1]; on-chip OSC/PLL non-bypassed	0000_H
1	1	0	Standalone User (JTAG) Mode[2]; on-chip OSC/PLL non-bypassed (normal)	0000_H

1) The OCDS mode is not accessible if Flash is protected.
2) Normal user mode with standard JTAG (TCK,TDI,TDO) pins for hot-attach purpose.

For power saving purposes, the clocks may be disabled or slowed down according to Table 23.

Table 23 System frequency (f_{sys} = 80 MHz)

Power Saving Mode	Action
Idle	Clock to the CPU is disabled.
Slow-down	Clocks to the CPU and all the peripherals, including CCU6, are divided by a common programmable factor defined by bit field CMCON.CLKREL.
Power-down	Oscillator and PLL are switched off.

- 8-bit reload value (BR_VALUE) for the baud rate timer defined by register BG

The following formulas calculate the final baud rate without and with the fractional divider respectively:

$$\text{baud rate} = \frac{f_{PCLK}}{16 \times 2^{BRPRE} \times (BR\_VALUE + 1)} \quad \text{where} \quad 2^{BRPRE} \times (BR\_VALUE + 1) > 1$$

$$\text{baud rate} = \frac{f_{PCLK}}{16 \times 2^{BRPRE} \times (BR\_VALUE + 1)} \times \frac{STEP}{256}$$

The maximum baud rate that can be generated is limited to $f_{PCLK}/32$. Hence, for a module clock of 26.7 MHz, the maximum achievable baud rate is 0.83 MBaud.

Standard LIN protocal can support a maximum baud rate of 20kHz, the baud rate accuracy is not critical and the fractional divider can be disabled. Only the prescaler is used for auto baud rate calculation. For LIN fast mode, which supports the baud rate of 20kHz to 115.2kHz, the higher baud rates require the use of the fractional divider for greater accuracy.

Table 26 lists the various commonly used baud rates with their corresponding parameter settings and deviation errors. The fractional divider is disabled and a module clock of 26.7 MHz is used.

Table 26 Typical Baud rates for UART with Fractional Divider disabled

Baud rate	Prescaling Factor (2^{BRPRE})	Reload Value (BR_VALUE + 1)	Deviation Error
19.2 kBaud	1 (BRPRE=000_B)	87 (57_H)	-0.22 %
9600 Baud	1 (BRPRE=000_B)	174 (AE_H)	-0.22 %
4800 Baud	2 (BRPRE=001_B)	174 (AE_H)	-0.22 %
2400 Baud	4 (BRPRE=010_B)	174 (AE_H)	-0.22 %

The fractional divider allows baud rates of higher accuracy (lower deviation error) to be generated. **Table 27** lists the resulting deviation errors from generating a baud rate of

3.13 LIN Protocol

The UART can be used to support the Local Interconnect Network (LIN) protocol for both master and slave operations. The LIN baud rate detection feature provides the capability to detect the baud rate within LIN protocol using Timer 2. This allows the UART to be synchronized to the LIN baud rate for data transmission and reception.

LIN is a holistic communication concept for local interconnected networks in vehicles. The communication is based on the SCI (UART) data format, a single-master/multiple-slave concept, a clock synchronization for nodes without stabilized time base. An attractive feature of LIN is self-synchronization of the slave nodes without a crystal or ceramic resonator, which significantly reduces the cost of hardware platform. Hence, the baud rate must be calculated and returned with every message frame.

The structure of a LIN frame is shown in **Figure 30**. The frame consists of the:

- header, which comprises a Break (13-bit time low), Synch Byte (55_H), and ID field
- response time
- data bytes (according to UART protocol)
- checksum

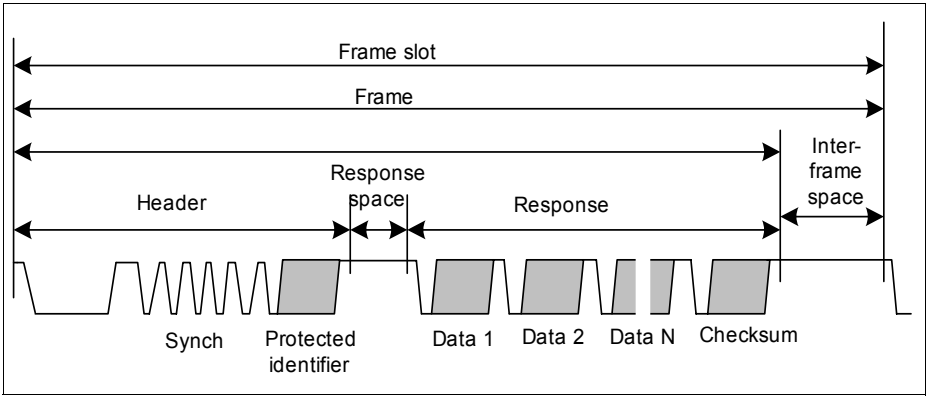


Figure 30 Structure of LIN Frame

3.13.1 LIN Header Transmission

LIN header transmission is only applicable in master mode. In the LIN communication, a master task decides when and which frame is to be transferred on the bus. It also identifies a slave task to provide the data transported by each frame. The information needed for the handshaking between the master and slave tasks is provided by the master task through the header portion of the frame.

The header consists of a break and synch pattern followed by an identifier. Among these three fields, only the break pattern cannot be transmitted as a normal 8-bit UART data.

Data is transmitted or received on lines TXD and RXD, which are normally connected to the pins MTSR (Master Transmit/Slave Receive) and MRST (Master Receive/Slave Transmit). The clock signal is output via line MS_CLK (Master Serial Shift Clock) or input via line SS_CLK (Slave Serial Shift Clock). Both lines are normally connected to the pin SCLK. Transmission and reception of data are double-buffered.

Figure 31 shows the block diagram of the SSC.

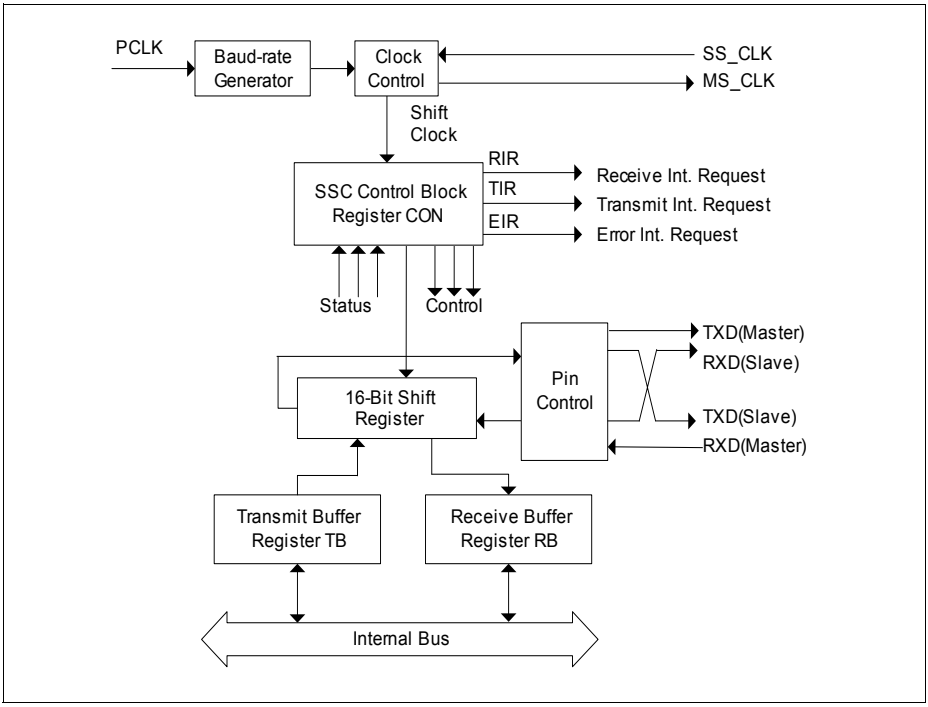


Figure 31 SSC Block Diagram

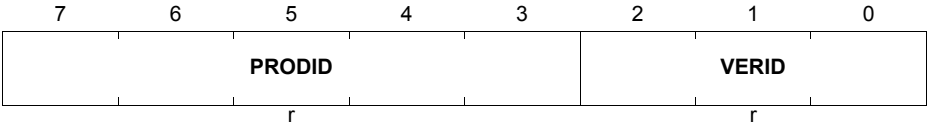
Table 31 JTAG ID Summary

ROM	XC866L-4RR	1013 9083$_H$
	XC866-4RR	1013 9083$_H$
	XC866L-2RR	1013 9083$_H$
	XC866-2RR	1013 9083$_H$

3.20 Identification Register

The XC866 identity register is located at Page 1 of address B3$_H$.

ID
Identity Register **Reset Value: 0000 0010$_B$**



Field	Bits	Type	Description
VERID	[2:0]	r	**Version ID** 010$_B$
PRODID	[7:3]	r	**Product ID** 00000$_B$

4.2.3 ADC Characteristics

The values in the table below are given for an analog power supply between 4.5 V to 5.5 V. The ADC can be used with an analog power supply down to 3 V. But in this case, the analog parameters may show a reduced performance. All ground pins (V_{SS}) must be externally connected to one single star point in the system. The voltage difference between the ground pins must not exceed 200mV.

Table 36 ADC Characteristics (Operating Conditions apply; V_{DDP} = 5V Range)

Parameter	Symbol	Limit Values			Unit	Test Conditions/ Remarks
		min.	typ .	max.		
Analog reference voltage	V_{AREF} SR	V_{AGND} + 1	V_{DDP}	V_{DDP} + 0.05	V	
Analog reference ground	V_{AGND} SR	V_{SS} - 0.05	V_{SS}	V_{AREF} - 1	V	
Analog input voltage range	V_{AIN} SR	V_{AGND}	–	V_{AREF}	V	
ADC clocks	f_{ADC}	–	20	40	MHz	module clock
	f_{ADCI}	–	–	10	MHz	internal analog clock See **Figure 33**
Sample time	t_S CC	(2 + INPCR0.STC) × t_{ADCI}			µs	
Conversion time	t_C CC	See **Section 4.2.3.1**			µs	
Total unadjusted error	TUE[1] CC	–	–	±1	LSB	8-bit conversion.[2]
		–	–	±2	LSB	10-bit conversion.
Differential Nonlinearity	DNL CC	–	±1	–	LSB	10-bit conversion[2]
Integral Nonlinearity	INL CC	–	±1	–	LSB	10-bit conversion[2]
Offset	OFF CC	–	±1	–	LSB	10-bit conversion[2]
Gain	GAIN CC	–	±1	–	LSB	10-bit conversion[2]
Switched capacitance at the reference voltage input	C_{AREFSW} CC	–	10	20	pF	[2][3]

Table 36 ADC Characteristics (Operating Conditions apply; V_{DDP} = 5V Range)

Parameter	Symbol	Limit Values			Unit	Test Conditions/ Remarks
		min.	typ .	max.		
Switched capacitance at the analog voltage inputs	C_{AINSW} CC	–	5	7	pF	2)4)
Input resistance of the reference input	R_{AREF}CC	–	1	2	kΩ	2)
Input resistance of the selected analog channel	R_{AIN} CC	–	1	1.5	kΩ	2)

1) TUE is tested at V_{AREF} = 5.0 V, V_{AGND} = 0 V , V_{DDP} = 5.0 V.

2) Not subject to production test, verified by design/characterization.

3) This represents an equivalent switched capacitance. This capacitance is not switched to the reference voltage at once. Instead of this, smaller capacitances are successively switched to the reference voltage.

4) The sampling capacity of the conversion C-Network is pre-charged to V_{AREF}/2 before connecting the input to the C-Network. Because of the parasitic elements, the voltage measured at ANx is lower than V_{AREF}/2.