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GENERAL DESCRIPTION

The 73S1215F is a versatile and economical CMOS System-on-Chip device intended for smart card reader applications. The circuit features an ISO 7816 / EMV interface, an USB 2.0 interface (full-speed 12Mbps device) and a 5x6 PINpad interface. Maximum design flexibility is supported with additional features such as 9 user I/Os, multiple interrupt options, up to 4 programmable current outputs (to drive external LEDs), and 1 analog voltage input (suitable for DC voltage monitoring such as battery level detection). Other built-in hardware interfaces include an asynchronous serial UART and an I²C interface.

The System-on-Chip is built around an 80515 high performance core. Its feature and instruction set is compatible with the industry standard 8051, while offering one clock-cycle per instruction processing power (most instructions) with a CPU clock running up to 24MHz, it results in up to 20 MIPS available that meets the requirements of various encryption needs such as AES, DES / 3-DES and even RSA (for PIN encryption for instance). The circuit requires a single crystal, which frequency can be between 6MHz and 12MHz. In addition, a 32768 Hz sub-system oscillator (optional) with an independent real-time-clock counter enables stand-alone applications to access an RTC value. The respective 73S1215F embedded memories are; 64KB Flash program memory, 2KB user XRAM memory, and 256B IIRAM memory. In addition to these memories are independent FIFOs dedicated to the ISO7816 UART and to the USB interface. Overall, the 73S1215F offers a cost effective solution to implement hand-held PINpad smart card readers - USB connected, serial connected, standalone or combo – as well as turnkey smart card reader modules, USB or ExpressCard® type.

Embedded Flash memory is in-system programmable and lockable by means of on-silicon fuses. This makes the Teridian 73S1215F suitable for both development and production phases.

Teridian Semiconductor Corporation offers with its 73S1215F a very comprehensive set of software libraries, including the smart card and USB protocol layers that are pre-approved against USB, Microsoft WHQL and EMV, as well as a CCID reference design. Refer to the *73S12xxF Software User's Guide* for a complete description of the Application Programming Interface (API Libraries) and related software modules.

A complete array of development and programming tools, libraries and demonstration boards enable rapid development and certification of smart card readers that meet most demanding smart card standards.

APPLICATIONS

- Hand-held PINpad smart card readers:
 - Connected through USB, serial or un-connected
 - CCID-compliant
- E-banking (MasterCard CAP, etc)
- Smart card reader modules for PC laptops and desktops: ExpressCard®, USB
- Digital Identification (Secure Login, Gov't ID, ...)
- General purpose smart card readers

ADVANTAGES

- The ideal balance of cost and features for high volume, USB-connected PINpad type of applications:
 - Larger built-in Flash / RAM than its competitors
 - Higher performance CPU core
 - Powerful In-Circuit- Emulation and Programming
 - A complete set of ready-to-use EMV4.1 / USB / CCID libraries

FEATURES

80515 Core:

- 1 clock cycle per instruction (most instructions)
- CPU clocked up to 24MHz
- 64kB Flash memory with security
- 2kB XRAM (User Data Memory)
- 256 byte IRAM
- Hardware watchdog timer

Oscillators:

- Single low-cost 6MHz to 12MHz crystal
- Optional 32768 Hz crystal (with internal RTC)
- An Internal PLL provides all the necessary clocks to each block of the system

Interrupts:

- Standard 80C515 4-priority level structure
- Nine different sources of interrupt to the core

Power Down Modes:

- 2 standard 80C515 Power Down and IDLE modes
- Extensive device power down mode

Timers:

- Two standard 80C52 timers T0 and T1
- One 16-bit timer that can generate RTC interrupts from the 32kHz clock

Built-in ISO-7816 Card Interface:

- LDO regulator produces VCC for the card (1.8V, 3V or 5V)
- Full compliance with EMV 4.1
- Activation/Deactivation sequencers
- Auxiliary I/O lines (C4-C8 signals)
- 6kV ESD protection on all interface pins

Communication with Smart Cards:

- ISO 7816 UART for protocols T=0, T=1
- (2) 2-Byte FIFOs for transmit and receive
- Configured to drive multiple external Teridian 73S8010x interfaces (for multi-SAM architectures)

Communication Interfaces:

- Full-duplex serial interface (1200 to 115kbps UART)
- USB 2.0 Full Speed 12Mbps Interface, PC/SC compliant with 4 Endpoints:
 - Control (16B FIFO)
 - Interrupt IN (32B FIFO)
 - Bulk IN (128B FIFO)
 - Bulk OUT (128B FIFO)
- I²C Master Interface (400kbps)

Man-Machine Interface and I/Os:

- 5x6 Keyboard (hardware scanning, debouncing and scrambling)
- Nine User I/Os
- Up to 4 programmable current outputs (LED)

Voltage Detection:

- Analog Input (detection range: 1.0V to 1.5V)

Operating Voltage:

- 2.7V to 3.6V (3V to 3.6V when USB is in use)
- 4.75 to 5.5V for smart card supply

Operating Temperature:

- -40°C to 85°C

Packages:

- 68-pin QFN
- 44-pin QFN

Software:

- Two-level Application Programming Interface (ANSI C-language libraries)
- USB, T=0/T=1 and EMV-compliant smart card protocol layers
- CCID reference design and Windows® driver

Table of Contents

1	Hardware Description	8
1.1	Pin Description	8
1.2	Hardware Overview	11
1.3	80515 MPU Core	11
1.3.1	80515 Overview	11
1.3.2	Memory Organization	11
1.4	Program Security	16
1.5	Special Function Registers (SFRs)	18
1.5.1	Internal Data Special Function Registers (SFRs)	18
1.5.2	IRAM Special Function Registers (Generic 80515 SFRs)	19
1.5.3	External Data Special Function Registers (SFRs)	20
1.6	Instruction Set	23
1.7	Peripheral Descriptions	23
1.7.1	Oscillator and Clock Generation	23
1.7.2	Power Control Modes	27
1.7.3	Interrupts	33
1.7.4	UART	40
1.7.5	Timers and Counters	45
1.7.6	WD Timer (Software Watchdog Timer)	47
1.7.7	User (USR) Ports	50
1.7.8	Real-Time Clock with Hardware Watchdog (RTC)	52
1.7.9	Analog Voltage Comparator	55
1.7.10	LED Drivers	57
1.7.11	I ² C Master Interface	58
1.7.12	Keypad Interface	65
1.7.13	Emulator Port	72
1.7.14	USB Interface	72
1.7.15	Smart Card Interface Function	76
1.7.16	VDD Fault Detect Function	110
2	Typical Application Schematic	111
3	Electrical Specification	112
3.1	Absolute Maximum Ratings	112
3.2	Recommended Operating Conditions	112
3.3	Digital IO Characteristics	113
3.4	Oscillator Interface Requirements	114
3.5	DC Characteristics: Analog Input	114
3.6	USB Interface Requirements	115
3.7	Smart Card Interface Requirements	117
3.7.1	DC Characteristics	119
3.8	Voltage / Temperature Fault Detection Circuits	119
4	Equivalent Circuits	120
5	Package Pin Designation	129
5.1	68-pin QFN Pinout	129
5.2	44-pin QFN Pinout	130
6	Packaging Information	131
6.1	68-Pin QFN Package Outline	131
6.2	44-Pin QFN Package Outline	132
7	Ordering Information	133
8	Related Documentation	133
9	Contact Information	133
	Revision History	134

Figures

Figure 1: IC Functional Block Diagram	7
Figure 2: Memory Map	15
Figure 3: Clock Generation and Control Circuits	24
Figure 4: Oscillator Circuit	26
Figure 5: Power Down Control	27
Figure 6: Detail of Power Down Interrupt Logic	28
Figure 7: Power Down Sequencing	28
Figure 8: External Interrupt Configuration	33
Figure 9: Real Time Clock Block Diagram	52
Figure 10: I ² C Write Mode Operation	59
Figure 11: I ² C Read Operation	60
Figure 12: Simplified Keypad Block Diagram	65
Figure 13: Keypad Interface Flow Chart	67
Figure 14: USB Block Diagram	72
Figure 15: Smart Card Interface Block Diagram	76
Figure 16: Smart Card Interface Block Diagram	77
Figure 17: Asynchronous Activation Sequence Timing	79
Figure 18: Deactivation Sequence	80
Figure 19: Smart Card CLK and ETU Generation	81
Figure 20: Guard, Block, Wait and ATR Time Definitions	82
Figure 21: Synchronous Activation	84
Figure 22: Example of Sync Mode Operation: Generating/Reading ATR Signals	84
Figure 23: Creation of Synchronous Clock Start/Stop Mode Start Bit in Sync Mode	85
Figure 24: Creation of Synchronous Clock Start/Stop Mode Stop Bit in Sync Mode	85
Figure 25: Operation of 9-bit Mode in Sync Mode	86
Figure 26: 73S1215F Typical Application Schematic	111
Figure 27: 12 MHz Oscillator Circuit	120
Figure 28: 32kHz Oscillator Circuit	120
Figure 29: Digital I/O Circuit	121
Figure 30: Digital Output Circuit	121
Figure 31: Digital I/O with Pull Up Circuit	122
Figure 32: Digital I/O with Pull-Down Circuit	122
Figure 33: Digital Input Circuit	123
Figure 34: Keypad Row Circuit	123
Figure 35: Keypad Column Circuit	124
Figure 36: LED Circuit	125
Figure 37: Test and Security Pin Circuit	125
Figure 38: Analog Input Circuit	126
Figure 39: Smart Card Output Circuit	126
Figure 40: Smart Card I/O Circuit	127
Figure 41: PRES Input Circuit	127
Figure 42: PRES Input Circuit	128
Figure 43: USB Circuit	128
Figure 44: 73S1215F 68 QFN Pinout	129
Figure 45: 73S1215F 44 QFN Pinout	130
Figure 46: 73S1215F 68 QFN Package Drawing	131
Figure 47: 73S1215F 44 QFN Package Drawing	132

Tables

Table 1: 73S1215F Pinout Description	8
Table 2: MPU Data Memory Map.....	11
Table 3: Flash Special Function Registers	13
Table 4: Internal Data Memory Map	14
Table 5: Program Security Registers.....	17
Table 6: IRAM Special Function Registers Locations.....	18
Table 7: IRAM Special Function Registers Reset Values.....	19
Table 8: XRAM Special Function Registers Reset Values	20
Table 9: PSW Register Flags.....	22
Table 10: PSW Bit Functions	22
Table 11: Port Registers	23
Table 12: Frequencies and Mcount Values for MCLK = 96MHz	25
Table 13: The MCLKCtl Register	25
Table 15: The MPUCKCtl Register	26
Table 17: The INT5Ctl Register	29
Table 19: The MISCTl0 Register.....	29
Table 21: The MISCTl1 Register.....	30
Table 23: The MCLKCtl Register	31
Table 25: The PCON Register	32
Table 27: The IEN0 Register.....	34
Table 29: The IEN1 Register.....	35
Table 31: The IEN2 Register.....	35
Table 33: The TCON Register	36
Table 35: The T2CON Register	36
Table 37: The IRCON Register	37
Table 39: External MPU Interrupts.....	37
Table 40: Control Bits for External Interrupts.....	38
Table 41: Priority Level Groups.....	38
Table 42: The IP0 Register	38
Table 43: The IP1 Register	39
Table 44: Priority Levels.....	39
Table 45: Interrupt Polling Sequence.....	39
Table 46: Interrupt Vectors.....	39
Table 47: UART Modes.....	40
Table 48: Baud Rate Generation	40
Table 49: The PCON Register	41
Table 51: The BRCON Register	41
Table 53: The MISCTl0 Register.....	42
Table 55: The S0CON Register	43
Table 57: The S1CON Register	44
Table 59: The TMOD Register.....	45
Table 61: Timers/Counters Mode Description	46
Table 62: The TCON Register	47
Table 64: The IEN0 Register.....	48
Table 66: The IEN1 Register.....	48
Table 68: The IP0 Register	49
Table 70: The WDTREL Register	49
Table 72: Direction Registers and Internal Resources for DIO Pin Groups	50
Table 73: UDIR Control Bit.....	50
Table 74: Selectable Controls Using the UxIS Bits.....	50
Table 75: The USRIntCtl1 Register	51
Table 76: The USRIntCtl2 Register	51
Table 77: The USRIntCtl3 Register	51
Table 78: The USRIntCtl4 Register	51
Table 79: The RTCCtl Register.....	53
Table 81: The 32-bit RTC Counter.....	54
Table 82: The 24-bit RTC Accumulator	54

Table 83: The 24-bit RTC Trim (sign magnitude value).....	54
Table 84: The INT5Ctl Register	54
Table 86: The ACOMP Register	55
Table 88: The INT6Ctl Register	56
Table 90: The LEDCtl Register	57
Table 92: The DAR Register	61
Table 94: The WDR Register	61
Table 96: The SWDR Register.....	62
Table 98: The RDR Register.....	62
Table 100: The SRDR Register	63
Table 102: The CSR Register	63
Table 104: The INT6Ctl Register	64
Table 106: The KCOL Register	68
Table 108: The KROW Register	68
Table 110: The KSCAN Register	69
Table 112: The KSTAT Register	69
Table 114: The KSIZE Register	70
Table 116: The KORDERL Register.....	70
Table 117: The KORDERH Register	71
Table 120: The INT5Ctl Register	71
Table 122: The MISCtl1 Register.....	74
Table 124: The CKCON Register	75
Table 126: The SCSel Register	87
Table 127: The SCSel Bit Functions.....	87
Table 128: The SCInt Register.....	88
Table 130: The SCIE Register	89
Table 132: The VccCtl Register	90
Table 134: The VccTmr Register	91
Table 138: The STXCtl Register	93
Table 140: The STXData Register	94
Table 142: The SRXCtl Register.....	94
Table 144: The SRXData Register	95
Table 146: The SCCtl Register	96
Table 148: The SCECtl Register.....	97
Table 150: The SCDIR Register	98
Table 152: The SPrtcol Register	99
Table 154: The SCCLK Register	100
Table 156: The SCECLK Register	100
Table 158: The SParCtl Register	101
Table 160: The SByteCtl Register.....	102
Table 161: The SByteCtl Bit Functions	102
Table 162: The FDReg Register	103
Table 163: Divider Ratios Provided by the ETU Counter	103
Table 164: Divider Values for the ETU Clock	104
Table 165: The FDReg Bit Functions.....	104
Table 166: The CRCMSB Register	105
Table 167: The CRCLsB Register	105
Table 168: The BGT Register	106
Table 170: The EGT Register	106
Table 172: The BWTB0 Register	107
Table 173: The BWTB1 Register	107
Table 174: The BWTB2 Register	107
Table 175: The BWTB3 Register	107
Table 176: The CWTB0 Register.....	107
Table 177: The CWTB1 Register.....	107
Table 178: The ATRLsB Register	108
Table 179: The ATRMsB Register	108
Table 180: The STSTO Register.....	108

Table 181: The RLength Register 108
 Table 182: Smart Card SFR Table 109
 Table 183: The VDDFctl Register 110
 Table 185: Order Numbers and Packaging Marks 133

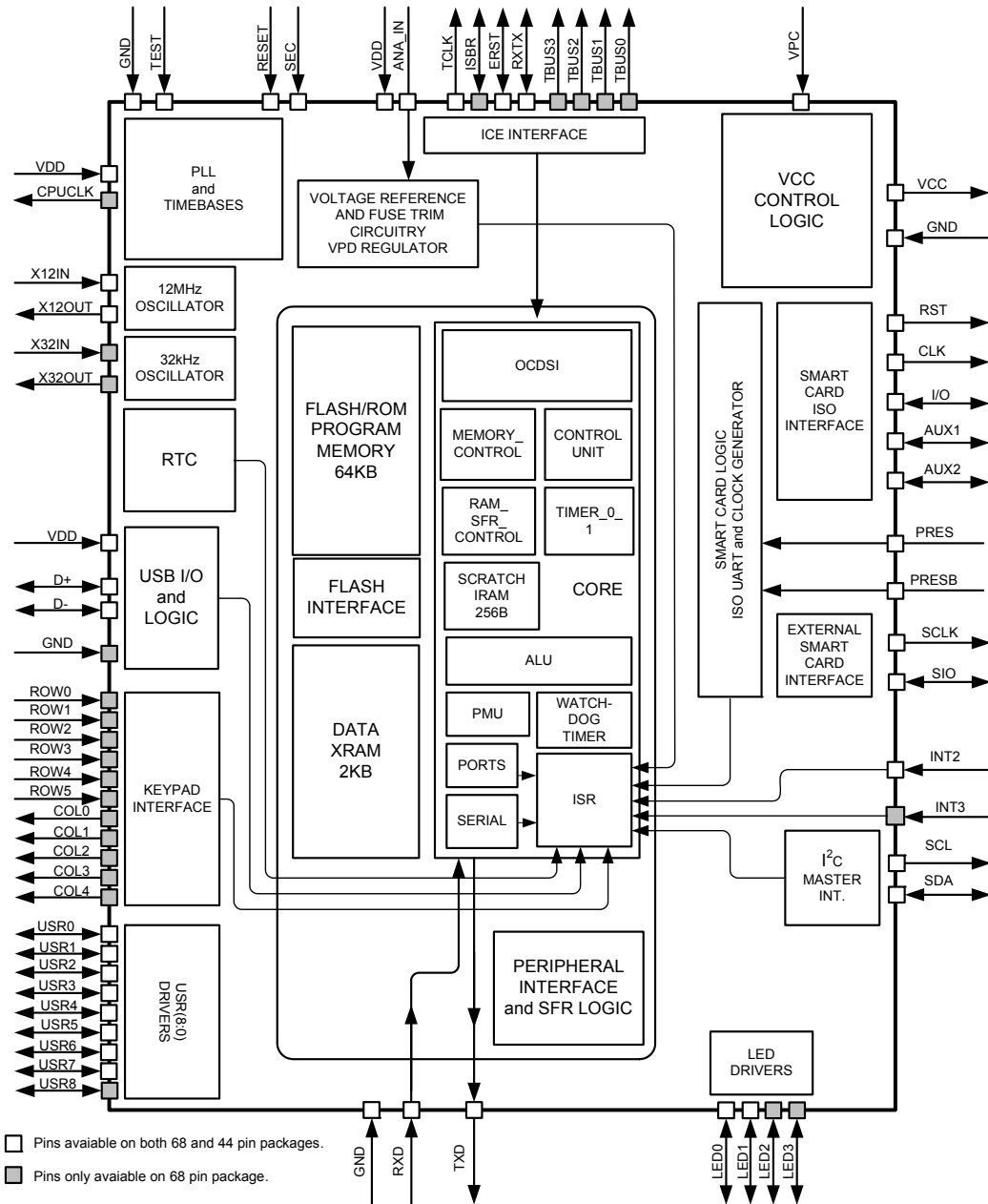


Figure 1: IC Functional Block Diagram

1 Hardware Description

1.1 Pin Description

Table 1: 73S1215F Pinout Description

Pin Name	Pin (68 Qfn)	Pin (44 Qfn)	Type	Equivalent Circuit*	Description
X12IN	10	8	I	Figure 27	MPU/USB clock crystal oscillator input pin. A 12MHz crystal is required for USB operation. A 1M Ω resistor is required between pins X12IN and X12OUT.
X12OUT	11	9	O	Figure 27	MPU/USB clock crystal oscillator output pin.
X32IN	8		I	Figure 28	RTC clock crystal oscillator input pin. A 32768Hz crystal is required for low-power RTC operation.
X32OUT	7		O	Figure 28	RTC clock crystal oscillator output pin.
CPUCLK	39		O	Figure 30	Output signal, square wave at the frequency of the MPU clock.
DP	26	16	IO	Figure 43	USB D+ IO pin, requires series 24 Ω resistor.
DM	27	17	IO	Figure 43	USB D- IO pin, requires series 24 Ω resistor.
ROW(5:0) 0 1 2 3 4 5	21 22 24 34 37 38		I	Figure 34	Keypad row input sense.
COL(4:0) 0 1 2 3 4	12 13 14 16 19		O	Figure 35	Keypad column output scan pins.
USR(8:0) 0 1 2 3 4 5 6 7 8	36 35 33 31 30 29 23 20 32	24 23 22 21 20 19 14 13	IO	Figure 31	General-purpose user pins, individually configurable as inputs or outputs or as external input interrupt ports.
SCL	5	5	O	Figure 30	I ² C (master mode) compatible Clock signal. Note: the pin is configured as an open drain output. When the I ² C interface is being used, an external pull up resistor is required. A value of 3K is recommended.
SDA	6	6	IO	Figure 29	I ² C (master mode) compatible data I/O. Note: this pin is bi-directional. When the pin is configured as output, it is an open drain output. When the I ² C interface is being used, an external pull up resistor is required. A value of 3K is recommended.

Pin Name	Pin (68 Qfn)	Pin (44 Qfn)	Type	Equivalent Circuit*	Description
LED(3:0) 0 1 2 3	1 3 2 4	3 4	IO	Figure 36	Special output drivers, programmable pull-down current to drive LEDs. May also be used as inputs.
RXD	17	11	I	Figure 33	Serial UART Receive data pin.
TXD	18	12	O	Figure 30	Serial UART Transmit data pin.
INT3	51		I	Figure 33	General purpose interrupt input.
INT2	52	32	I	Figure 33	General purpose interrupt input.
SIO	50	31	IO	Figure 29	IO data signal for use with external Smart Card interface circuit such as 73S8024.
SCLK	48	30	O	Figure 30	Clock signal for use with external Smart Card interface circuit.
PRES	64	43	I	Figure 41	Smart Card presence. Active high. Note: the pin has a very weak pull down resistor. In noisy environments, an external pull down may be desired to insure against a false card event.
PRES	56	35	I	Figure 42	Smart Card presence. Active low. Note: the pin has a very weak pull up resistor. In noisy environments, an external pull up may be desired to insure against a false card event.
CLK	57	36	O	Figure 39	Smart card clock signal.
RST	59	38	O	Figure 39	Smart card Reset signal.
IO	63	42	IO	Figure 40	Smart card Data IO signal.
AUX1	62	41	IO	Figure 40	Auxiliary Smart Card IO signal (C4).
AUX2	61	40	IO	Figure 40	Auxiliary Smart Card IO signal (C8).
VCC	60	39	PSO		Smart Card VCC supply voltage output. A 0.47 μ F capacitor is required and should be located at the smart card connector. The capacitor should be a ceramic type with low ESR.
GND	58	37	GND		Smart Card Ground.
VPC	55	34	PSI		Smart Card LDO regulator power supply source. A 10 μ F and a 0.1 μ F capacitor are required at the VPC input. The 10 μ F capacitor should be a ceramic type with low ESR.
TBUS(3:0) 0 1 2 3	53 49 47 43		IO		Trace bus signals for ICE.
RXTX	45	28	IO		ICE control.
ERST	40	25	IO		ICE control.
ISBR	68		IO		ICE control.
TCLK	41	26	I		ICE control.

Pin Name	Pin (68 Qfn)	Pin (44 Qfn)	Type	Equivalent Circuit*	Description
ANA_IN	15	10	AI	Figure 38	Analog input pin. This signal goes to a programmable comparator and is used to sense the value of an external voltage.
SEC	67	2	I	Figure 37	Input pin for use in programming security fuse. It should be connected to ground when not in use.
TEST	54	33	DI	Figure 37	Test pin, should be connected to ground.
VDD	28 42 65	18 27 44	I		General positive power supply pins. All digital IO is referred to this supply voltage. There is an on-chip regulator that uses VDD to provide power for internal circuits (VPD). A 0.1 μ F capacitor is recommended at each VDD pin.
N/C	46	29	0		No connect.
GND	9 25 44	7 15	GND		General ground supply pins for all IO and logic circuits.
RESET	66	1	I	Figure 33	Reset input, positive assertion. Resets logic and registers to default condition.

* See the figures in the [Equivalent Circuits](#) section.

1.2 Hardware Overview

The Teridian 73S1215F single smart card controller integrates all primary functional blocks required to implement a smart card reader. Included on chip are an 8051-compatible microprocessor (MPU) which executes up to one instruction per clock cycle (80515), a fully integrated ISO-7816 compliant smart card interface, expansion smart card interface, full speed USB 2.0 compatible interface, serial interface, I2C interface, 6 x 5 keypad interface, 4 LED drivers, RAM, FLASH memory, a real time clock (RTC), and a variety of I/O pins. [Figure 1](#) shows a functional block diagram of the 73S1215F.

1.3 80515 MPU Core

1.3.1 80515 Overview

The 73S1215F includes an 80515 MPU (8-bit, 8051-compatible) that performs most instructions in one clock cycle. The 80515 architecture eliminates redundant bus states and implements parallel execution of fetch and execution phases. Normally a machine cycle is aligned with a memory fetch, therefore, most of the 1-byte instructions are performed in a single cycle. This leads to an 8x performance (average) improvement (in terms of MIPS) over the Intel 8051 device running at the same clock frequency.

Actual processor clocking speed can be adjusted to the total processing demand of the application (cryptographic calculations, key management, memory management, and I/O management) using the XRAM special function register [MPUCKCtl](#).

Typical smart card, USB, serial, keyboard, I2C, and RTC management functions are available for the MPU as part of the Teridian standard library. A standard ANSI "C" 80515-application programming interface library is available to help reduce design cycle. Refer to the *73S12xxF Software User's Guide*.

1.3.2 Memory Organization

The 80515 MPU core incorporates the Harvard architecture with separate code and data spaces. Memory organization in the 80515 is similar to that of the industry standard 8051. There are three memory areas: Program memory (Flash), external data memory (XRAM), and internal data memory (IRAM). Data bus address space is allocated to on-chip memory as shown [Table 2](#).

Table 2: MPU Data Memory Map

Address (hex)	Memory Technology	Memory Type	Typical Usage	Memory Size (bytes)
0000-FFFF	Flash Memory	Non-volatile	Program and non-volatile data	64KB
0000-07FF	Static RAM	Volatile	MPU data XRAM	2KB
FC00-FFFF	External SFR	Volatile	Peripheral control	1KB

Note: The IRAM is part of the core and is addressed differently.

Program Memory: The 80515 can address up to 64KB of program memory space from 0x0000 to 0xFFFF. Program memory is read when the MPU fetches instructions or performs a MOVC operation. After reset, the MPU starts program execution from location 0x0000. The lower part of the program memory includes reset and interrupt vectors. The interrupt vectors are spaced at 8-byte intervals, starting from 0x0003 (Reset is located at 0x0000).

Flash Memory: The program memory consists of flash memory. The flash memory is intended to primarily contain MPU program code. Flash erasure is initiated by writing a specific data pattern to specific SFR registers in the proper sequence. These special pattern/sequence requirements prevent inadvertent erasure of the flash memory.

The mass erase sequence is:

1. Write 1 to the FLSH_MEEN bit in the **FLSHCTL** register (SFR address 0xB2[1]).
2. Write pattern 0xAA to **ERASE** (SFR address 0x94).

Note: The mass erase cycle can only be initiated when the ICE port is enabled.

The page erase sequence is:

1. Write the page address to **PGADDR** (SFR address 0xB7[7:1]).
2. Write pattern 0x55 to **ERASE** (SFR address 0x94).

The **PGADDR** register denotes the page address for page erase. The page size is 512 (200h) bytes and there are 128 pages within the flash memory. The **PGADDR** denotes the upper seven bits of the flash memory address such that bit 7:1 of the **PGADDR** corresponds to bit 15:9 of the flash memory address. Bit 0 of the **PGADDR** is not used and is ignored. The MPU may write to the flash memory. This is one of the non-volatile storage options available to the user. The **FLSHCTL** SFR bit **FLSH_PWE** (flash program write enable) differentiates 80515 data store instructions (**MOVX@DPTR,A**) between Flash and XRAM writes. Before setting **FLSH_PWE**, all interrupts need to be disabled by setting **EAL = 1**. Table 3 shows the location and description of the 73S1215F flash-specific SFRs.

- ✓ Any flash modifications must set the **CPUCLK** to operate at 3.6923 MHz (**MPUCLKCti = 0x0C**) before any flash memory operations are executed to insure the proper timing when modifying the flash memory.

Table 3: Flash Special Function Registers

Register	SFR Address	R/W	Description
ERASE	0x94	W	<p>This register is used to initiate either the Flash Mass Erase cycle or the Flash Page Erase cycle. Specific patterns are expected for ERASE in order to initiate the appropriate Erase cycle (default = 0x00).</p> <p>0x55 – Initiate Flash Page Erase cycle. Must be preceded by a write to PGADDR @ SFR 0xB7.</p> <p>0xAA – Initiate Flash Mass Erase cycle. Must be preceded by a write to FLSH_MEEN @ SFR 0xB2 and the debug port must be enabled.</p> <p>Any other pattern written to ERASE will have no effect.</p>
PGADDR	0xB7	R/W	<p>Flash Page Erase Address register containing the flash memory page address (page 0 through 127) that will be erased during the Page Erase cycle (default = 0x00). Note: the page address is shifted left by one bit (see detailed description above).</p> <p>Must be re-written for each new Page Erase cycle.</p>
FLSHCTL	0xB2	R/W	<p>Bit 0 (FLSH_PWE): Program Write Enable:</p> <p>0 – MOVX commands refer to XRAM Space, normal operation (default).</p> <p>1 – MOVX @DPTR,A moves A to Program Space (Flash) @ DPTR.</p> <p>This bit is automatically reset after each byte written to flash. Writes to this bit are inhibited when interrupts are enabled.</p>
		W	<p>Bit 1 (FLSH_MEEN): Mass Erase Enable:</p> <p>0 – Mass Erase disabled (default).</p> <p>1 – Mass Erase enabled.</p> <p>Must be re-written for each new Mass Erase cycle.</p>
		R/W	<p>Bit 6 (SECURE):</p> <p>Enables security provisions that prevent external reading of flash memory and CE program RAM. This bit is reset on chip reset and may only be set. Attempts to write zero are ignored.</p>

Internal Data Memory: The Internal data memory provides 256 bytes (0x00 to 0xFF) of data memory. The internal data memory address is always one byte wide and can be accessed by either direct or indirect addressing. The Special Function Registers occupy the upper 128 bytes. **This SFR area is available only by direct addressing. Indirect addressing accesses the upper 128 bytes of Internal RAM.**

The lower 128 bytes contain working registers and bit-addressable memory. The lower 32 bytes form four banks of eight registers (R0-R7). Two bits on the program memory status word (PSW) select which bank is in use. The next 16 bytes form a block of bit-addressable memory space at bit addresses 0x00-0x7F. All of the bytes in the lower 128 bytes are accessible through direct or indirect addressing. Table 4 shows the internal data memory map.

Table 4: Internal Data Memory Map

Address	Direct Addressing	Indirect Addressing
0xFF	Special Function Registers (SFRs)	RAM
0x80		
0x7F	Byte-addressable area	
0x30		
0x2F	Byte or bit-addressable area	
0x20		
0x1F	Register banks R0...R7 (x4)	
0x00		

External Data Memory: While the 80515 can address up to 64KB of external data memory in the space from 0x0000 to 0xFFFF, only the memory ranges shown in Figure 2 contain physical memory. The 80515 writes into external data memory when the MPU executes a MOVX @Ri,A or MOVX @DPTR,A instruction. The MPU reads external data memory by executing a MOVX A,@Ri or MOVX A,@DPTR instruction.

There are two types of instructions, differing in whether they provide an eight-bit or sixteen-bit indirect address to the external data RAM.

In the first type (MOVX A,@Ri), the contents of R0 or R1, in the current register bank, provide the eight lower-ordered bits of address. This method allows the user access to the first 256 bytes of the 2KB of external data RAM. In the second type of MOVX instruction (MOVX A,@DPTR), the data pointer generates a sixteen-bit address.

Address	Use	Address	Use
0xFFFF	Flash Program Memory 64K Bytes	0xFFFF	Peripheral Control Registers (128b)
		0xFF80	
		0xFF7F	Smart Card Control (384b)
		0xFE00	
		0xFDFF	USB Registers (512b)
		0xFC00	
		0xFBFF	-
		0x0800	
		0x07FF	XRAM
0x0000		0x0000	
Program Memory		External Data Memory	

Address	Use	
	Indirect Access	Direct Access
0xFF	Byte RAM	SFRs
0x80		
0x7F	Byte RAM	
0x48		
0x47	Bit/Byte RAM	
0x20		
0x1F	Register bank 3	
0x18		
0x17	Register bank 2	
0x10		
0x0F	Register bank 1	
0x08		
0x07	Register bank 0	
0x00		
Internal Data Memory		

Figure 2: Memory Map

Dual Data Pointer: The Dual Data Pointer accelerates the block moves of data. The standard DPTR is a 16-bit register that is used to address external memory. In the 80515 core, the standard data pointer is called DPTR, the second data pointer is called DPTR1. The data pointer select bit chooses the active pointer. The data pointer select bit is located at the LSB of the DPS IRAM special function register (DPS.0). DPTR is selected when DPS.0 = 0 and DPTR1 is selected when DPS.0 = 1.

The user switches between pointers by toggling the LSB of the DPS register. All DPTR-related instructions use the currently selected DPTR for any activity.

Note: The second data pointer may not be supported by certain compilers.

1.4 Program Security

Two levels of program and data security are available. Each level requires a specific fuse to be blown in order to enable or set the specific security mode. Mode 0 security is enabled by setting the SECURE bit (bit 6 of SFR register [FLSHCTL 0xB2](#)). Mode 0 limits the ICE interface to only allow bulk erase of the flash program memory. All other ICE operations are blocked. This guarantees the security of the user's MPU program code. Security (Mode 0) is enabled by MPU code that sets the SECURE bit. The MPU code must execute the setting of the SECURE bit immediately after a reset to properly enable Mode 0. This should be the first instruction after the reset vector jump has been executed. If the "startup.a51" assembly file is used in an application, then it must be modified to set the SECURE bit after the reset vector jump. If not using "startup.a51", then this should be the first instruction in main(). Once security Mode 0 is enabled, the only way to disable it is to perform a global erase of the flash followed by a full circuit reset. Once the flash has been erased and the reset has been executed, security Mode 0 is disabled and the ICE has full control of the core. The flash can be reprogrammed after the bulk erase operation is completed. Global erase of the flash will also clear the data XRAM memory.

The security enable bit (SECURE) is reset whenever the MPU is reset. Hardware associated with the bit only allows it to be set. As a result, the code may set the SECURE bit to enable the security Mode 0 feature but may not reset it. Once the SECURE bit is set, the code is protected and no external read of program code in flash or data (in XRAM) is possible. In order to invoke the security Mode 0, the SECSET0 (bit 1 of the XRAM SFR register [SECReg 0xFFD7](#)) fuse must be blown beforehand or the security mode 0 will not be enabled. The SECSET0 and SECSET1 fuses once blown, cannot be overridden.

Specifically, when SECURE is set:

- The ICE is limited to bulk flash erase only.
- Page zero of flash memory may not be page-erased by either MPU or ICE. Page zero may only be erased with global flash erase. Note that global flash erase erases XRAM whether the SECURE bit is set or not.
- Writes to page zero, whether by MPU or ICE, are inhibited.

Security mode 1 is in effect when the SECSET1 fuse has been programmed (blown open). In security mode 1, the ICE is completely and permanently disabled. The Flash program memory and the MPU are not available for alteration, observation, nor control. As soon as the fuse has been blown, the ICE is disabled. The testing of the SECSET1 fuse will occur during the reset and before the start of pre-boot and boot cycles. This mode is not reversible, nor recoverable. In order to blow the SECSET1 fuse, the SEC pin must be held high for the fuse burning sequence to be executed properly. The firmware can check to see if this pin is held high by reading the SECPIN bit (bit 5 of XRAM SFR register [SECReg 0xFFD7](#)). If this bit is set and the firmware desires, it can blow the SECSET1 fuse. The burning of the SECSET0 does not require the SEC pin to be held high.

In order to blow the fuse for SECSET1 and SECSET0, a particular set of register writes in a specific order need to be followed. There are two additional registers that need to have a specific value written to them in order for the desired fuse to be blown. These registers are [FUSECtl](#) (0xFFD2) and [TRIMPctl](#) (0xFFD1). The sequence for blowing the fuse is as follows:

1. Write 0x54H to [FUSECtl](#).
2. Write 0x81H for security mode 0. Note: only program one security mode at a time.
3. Write 0x82H for security mode 1. Note: SEC pin must be high for security mode 1.
4. Write 0xA6 to [TRIMPctl](#).
5. Delay about 500 us.
6. Write 0x00 to [TRIMPctl](#).

Table 5: Program Security Registers

Register	SFR Address	R/W	Description
FLSHCTL	0xB2	R/W	Bit 0 (FLSH_PWE): Program Write Enable: 0 – MOVX commands refer to XRAM Space, normal operation (default). 1 – MOVX @DPTR,A moves A to Program Space (Flash) @ DPTR. This bit is automatically reset after each byte written to flash. Writes to this bit are inhibited when interrupts are enabled.
		W	Bit 1 (FLSH_MEEN): Mass Erase Enable: 0 – Mass Erase disabled (default). 1 – Mass Erase enabled. Must be re-written for each new Mass Erase cycle.
		R/W	Bit 6 (SECURE): Enables security provisions that prevent external reading of flash memory and CE program RAM. This bit is reset on chip reset and may only be set. Attempts to write zero are ignored.
TRIMPCTl	0xFFD1	W	0xA6 value will cause the selected fuse to be blown. All other values will stop the burning process.
FUSECtl	0xFFD2	W	0x54 value will set up for security fuse control. All other values are reserved and should not be used.
SECReg	0xFFD7	W	Bit 7 (PARAMSEC): 0 – Normal operation. 1 – Enable permanent programming of the security fuses.
		R	Bit 5 (SECPIN): Indicates the state of the SEC pin. The SEC pin is held low by a pull-down resistor. The user can force this pin high during boot sequence time to indicate to firmware that sec mode 1 is desired.
		R/W	Bit 1 (SECSET1): See the Program Security section.
		R/W	Bit 0 (SECSET0): See the Program Security section.

1.5 Special Function Registers (SFRs)

The 73S1215F utilizes numerous SFRs to communicate with the 73S1215F's many peripherals. This results in the need for more SFR locations outside the direct address IRAM space (0x80 to 0xFF). While some peripherals are mapped to unused IRAM SFR locations, additional SFRs for the USB, smart card and other peripheral functions are mapped to the top of the XRAM data space (0xFC00 to 0xFFFF).

1.5.1 Internal Data Special Function Registers (SFRs)

A map of the Special Function Registers is shown in Table 6.

Table 6: IRAM Special Function Registers Locations

Hex/ Bin	X000	X001	X010	X011	X100	X101	X110	X111	Bin/ Hex
F8									FF
F0	B								F7
E8									EF
E0	A								E7
D8	BRCON								DF
D0	PSW	KCOL	KROW	KSCAN	KSTAT	KSIZE	KORDERL	KORDERH	D7
C8	T2CON								CF
C0	IRCON								C7
B8	IEN1	IP1	S0RELH	S1RELH					BF
B0			FLSHCTL					PGADDR	B7
A8	IEN0	IP0	S0RELL						AF
A0	USR8	UDIR8							A7
98	S0CON	S0BUF	IEN2	S1CON	S1BUF	S1RELL			9F
90	USR70	UDIR70	DPS		ERASE				97
88	TCON	TMOD	TL0	TL1	TH0	TH1	CKCON	MCLKCTL	8F
80		SP	DPL	DPH	DPL1	DPH1	WDTREL	PCON	87

Only a few addresses are used, the others are not implemented. SFRs specific to the 73S1215F are shown in **bold** print (gray background). Any read access to unimplemented addresses will return undefined data, while most write access will have no effect. However, a few locations are reserved and not user configurable in the 73S1215F. **Writes to the unused SFR locations can affect the operation of the core and therefore must not be written to. This applies to all the SFR areas in both the IRAM and XRAM spaces. In addition, all unused bit locations within valid SFR registers must be left in their default (power on default) states.**

1.5.2 IRAM Special Function Registers (Generic 80515 SFRs)

Table 7 shows the location of the SFRs and the value they assume at reset or power-up.

Table 7: IRAM Special Function Registers Reset Values

Name	Location	Reset Value	Description
SP	0x81	0x07	Stack Pointer
DPL	0x82	0x00	Data Pointer Low 0
DPH	0x83	0x00	Data Pointer High 0
DPL1	0x84	0x00	Data Pointer Low 1
DPH1	0x85	0x00	Data Pointer High 1
WDTREL	0x86	0x00	Watchdog Timer Reload register
PCON	0x87	0x00	Power Control
TCON	0x88	0x00	Timer/Counter Control
TMOD	0x89	0x00	Timer Mode Control
TL0	0x8A	0x00	Timer 0, low byte
TL1	0x8B	0x00	Timer 1, high byte
TH0	0x8C	0x00	Timer 0, low byte
TH1	0x8D	0x00	Timer 1, high byte
CKCON	0x8E	0x01	Clock Control (wait state control)
MCLKCTL	0x8F	0x0A	Master Clock Control
USR70	0x90	0xFF	User Port Data (7:0)
UDIR70	0x91	0xFF	User Port Direction (7:0)
DPS	0x92	0x00	Data Pointer select Register
ERASE	0x94	0x00	Flash Erase
S0CON	0x98	0x00	Serial Port 0, Control Register
S0BUF	0x99	0x00	Serial Port 0, Data Buffer
IEN2	0x9A	0x00	Interrupt Enable Register 2
S1CON	0x9B	0x00	Serial Port 1, Control Register
S1BUF	0x9C	0x00	Serial Port 1, Data Buffer
S1RELL	0x9D	0x00	Serial Port 1, Reload Register, low byte
USR8	0xA0	0x00	User Port Data (8)
UDIR8	0xA1	0x01	User Port Direction (8)
IEN0	0xA8	0x00	Interrupt Enable Register 0
IP0	0xA9	0x00	Interrupt Priority Register 0
S0RELL	0xAA	0xD9	Serial Port 0, Reload Register, low byte
FLSHCTL	0xB2	0x00	Flash Control
PGADDR	0xB7	0x00	Flash Page Address
IEN1	0xB8	0x00	Interrupt Enable Register 1
IP1	0xB9	0x00	Interrupt Priority Register 1
S0RELH	0xBA	0x03	Serial Port 0, Reload Register, high byte
S1RELH	0xBB	0x03	Serial Port 1, Reload Register, high byte
IRCON	0xC0	0x00	Interrupt Request Control Register
T2CON	0xC8	0x00	Timer 2 Control

PSW	0xD0	0x00	Program Status Word
KCOL	0xD1	0x1F	Keypad Column
KROW	0xD2	0x3F	Keypad Row
KSCAN	0xD3	0x00	Keypad Scan Time
KSTAT	0xD4	0x00	Keypad Control/Status
KSIZE	0xD5	0x00	Keypad Size
KORDERL	0xD6	0x00	Keypad Column LS Scan Order
KORDERH	0xD7	0x00	Keypad Column MS Scan Order
BRCON	0xD8	0x00	Baud Rate Control Register (only BRCON.7 bit used)
A	0xE0	0x00	Accumulator
B	0xF0	0x00	B Register

1.5.3 External Data Special Function Registers (SFRs)

A map of the XRAM Special Function Registers is shown in [Table 8](#). The smart card registers are listed separately in [Table 117](#).

Table 8: XRAM Special Function Registers Reset Values

Name	Location	Reset Value	Description
DAR	0x FF80	0x00	Device Address Register (I ² C)
WDR	0x FF81	0x00	Write Data Register (I ² C)
SWDR	0x FF82	0x00	Secondary Write Data Register (I ² C)
RDR	0x FF83	0x00	Read Data Register (I ² C)
SRDR	0x FF84	0x00	Secondary Read Data Register (I ² C)
CSR	0x FF85	0x00	Control and Status Register (I ² C)
USRIntCtl1	0x FF90	0x00	External Interrupt Control 1
USRIntCtl2	0x FF91	0x00	External Interrupt Control 2
USRIntCtl3	0x FF92	0x00	External Interrupt Control 3
USRIntCtl4	0x FF93	0x00	External Interrupt Control 4
INT5Ctl	0x FF94	0x00	External Interrupt Control 5
INT6Ctl	0x FF95	0x00	External Interrupt Control 6
MPUCKCtl	0x FFA1	0x0C	MPU Clock Control
RTCCtl	0x FFB0	0x00	Real Time Clock Control
RTCCnt3	0x FFB1	0x00	RTC Count 3
RTCCnt2	0x FFB2	0x00	RTC Count 2
RTCCnt1	0x FFB3	0x00	RTC Count 1
RTCCnt0	0x FFB4	0x00	RTC Count 0
RTCACC2	0x FFB5	0x00	RTC Accumulator 2
RTCACC1	0x FFB6	0x00	RTC Accumulator 1
RTCACC0	0x FFB7	0x00	RTC Accumulator 0
RTCTrim2	0x FFB8	0x00	RTC TRIM 2
RTCTrim1	0x FFB9	0x00	RTC TRIM 1
RTCTrim0	0x FFBA	0x00	RTC TRIM 0
ACOMP	0x FFD0	0x00	Analog Compare Register

Name	Location	Reset Value	Description
TRIMPctI	0x FFD1	0x00	TRIM Pulse Control
FUSEctI	0x FFD2	0x00	FUSE Control
VDDFctI	0x FFD4	0x00	VDDFault Control
SECReg	0x FFD7	0x00	Security Register
MISctI0	0x FFF1	0x00	Miscellaneous Control Register 0
MISctI1	0x FFF2	0x10	Miscellaneous Control Register 1
LEDctI	0x FFF3	0xFF	LED Control Register

Accumulator (ACC, A): ACC is the accumulator register. Most instructions use the accumulator to hold the operand. The mnemonics for accumulator-specific instructions refer to accumulator as “A”, not ACC.

B Register: The B register is used during multiply and divide instructions. It can also be used as a scratch-pad register to hold temporary data.

Program Status Word (PSW):**Table 9: PSW Register Flags**

MSB				LSB			
CV	AC	F0	RS1	RS	OV	–	P

Table 10: PSW Bit Functions

Bit	Symbol	Function			
PSW.7	CV	Carry flag.			
PSW.6	AC	Auxiliary Carry flag for BCD operations.			
PSW.5	F0	General purpose Flag 0 available for user.			
PSW.4	RS1	Register bank select control bits. The contents of RS1 and RS0 select the working register bank:			
PSW.3	RS0		RS1/RS0	Bank Selected	Location
			00	Bank 0	(0x00 – 0x07)
			01	Bank 1	(0x08 – 0x0F)
			10	Bank 2	(0x10 – 0x17)
		11	Bank 3	(0x18 – 0x1F)	
PSW.2	OV	Overflow flag.			
PSW.1	F1	General purpose Flag 1 available for user.			
PSW.0	P	Parity flag, affected by hardware to indicate odd / even number of “one” bits in the Accumulator, i.e. even parity.			

Stack Pointer (SP): The stack pointer is a 1-byte register initialized to 0x07 after reset. This register is incremented before PUSH and CALL instructions, causing the stack to begin at location 0x08.

Data Pointer: The data pointer (DPTR) is 2 bytes wide. The lower part is DPL, and the highest is DPH. It can be loaded as a 2-byte register (MOV DPTR,#data16) or as two registers (e.g. MOV DPL,#data8). It is generally used to access external code or data space (e.g. MOVC A,@A+DPTR or MOVX A,@DPTR respectively).

Program Counter: The program counter (PC) is 2 bytes wide initialized to 0x0000 after reset. This register is incremented during the fetching operation code or when operating on data from program memory. Note: The program counter is not mapped to the SFR area.

Port Registers: The I/O ports are controlled by Special Function Registers [USR70](#), and [USR8](#). The contents of the SFR can be observed on corresponding pins on the chip. Writing a 1 to any of the ports (see [Table 11](#)) causes the corresponding pin to be at high level (3.3V), and writing a 0 causes the corresponding pin to be held at low level (GND). The data direction registers [UDIR70](#), and [UDIR8](#) define individual pins as input or output pins (see the [User \(USR\) Ports](#) section for details).

Table 11: Port Registers

Register	SFR Address	R/W	Description
USR70	0x90	R/W	Register for User port bit 7:0 read and write operations (pins USR0... USR7).
UDIR70	0x91	R/W	Data direction register for User port bits 0:7. Setting a bit to 0 means that the corresponding pin is an output.
USR8	0xA0	R/W	Register for User port bit 8 read and write operations (pin *USR8).
UDIR8	0xA1	R/W	Data direction register for port 1.

All ports on the chip are bi-directional. Each consists of a Latch (SFR [USR70](#) to [USR8](#)), an output driver, and an input buffer, therefore the MPU can output or read data through any of these ports if they are not used for alternate purposes.

1.6 Instruction Set

All instructions of the generic 8051 microcontroller are supported. A complete list of the instruction set and of the associated op-codes is contained in the *73S12xxF Software User's Guide*.

1.7 Peripheral Descriptions

1.7.1 Oscillator and Clock Generation

The 73S1215F has two oscillator circuits; one for the main CPU clock and another for the RTC. The main oscillator circuit is designed to operate with various crystals or external clock frequencies. An internal divider working in conjunction with a PLL and VCO needs to provide a 96MHz internal clock within the 73S1215F. 96 MHz is the required frequency for proper operation of specific peripheral blocks such as the USB, specific timers, ISO 7816 UART and interfaces and keypad. The clock generation and control circuits are shown in [Figure 3](#).

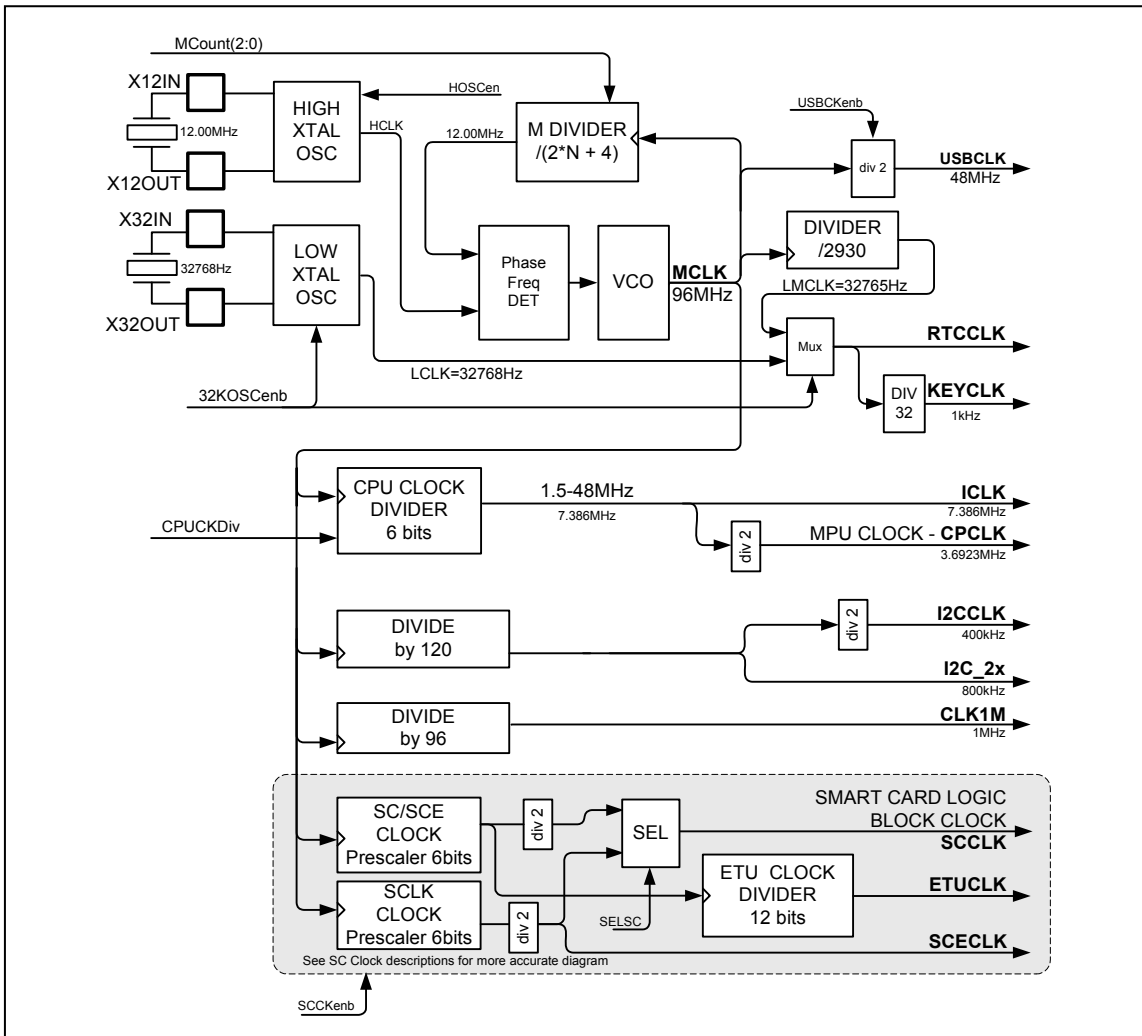


Figure 3: Clock Generation and Control Circuits

The master clock control register enables different sections of the clock circuitry and specifies the value of the VCO Mcount divider. The MCLK must be configured to operate at 96MHz to ensure proper operation of some of the peripheral blocks according to the following formula:

$$\text{MCLK} = (\text{Mcount} * 2 + 4) * F_{\text{XTAL}} = 96\text{MHz}$$

Mcount is configured in the [MCLKCtl](#) register must be bound between a value of 1 to 7. The possible crystal or external clock frequencies for getting MCLK = 96MHz are shown in Table 12.

Table 12: Frequencies and Mcount Values for MCLK = 96MHz

F_{XTAL} (MHz)	Mcount (N)
12.00	2
9.60	3
8.00	4
6.86	5
6.00	6

Master Clock Control Register (MCLKCtl): 0x8F ← 0x0A

Table 13: The MCLKCtl Register

Bit	Symbol	Function
MCLKCtl.7	HSOEN	High-speed oscillator disable. When set = 1, disables the high-speed crystal oscillator and VCO/PLL system. Do not set this bit = 1.
MCLKCtl.6	KBEN	1 = Disable the keypad logic clock.
MCLKCtl.5	SCEN	1 = Disable the smart card logic clock.
MCLKCtl.4	USBEN	1 = Disable the USB logic clock.
MCLKCtl.3	32KEN	1 = Disable the 32Khz oscillator. When the 32kHz oscillator is enabled, the RTC and other circuits such as debounce clocks are clocked using the 32kHz oscillator output. When disabled, the main oscillator provides the 32kHz clock for the RTC and other circuits. Note: This bit must be set if there is no 32KHz crystal or the 44 pin package is used. Some internal clocks and circuits will not run if the oscillator is enabled and no crystal is connected.
MCLKCtl.2	MCT.2	This value determines the ratio of the VCO frequency (MCLK) to the high-speed crystal oscillator frequency such that: MCLK = (MCount*2 + 4)* F_{XTAL} . The default value is MCount = 2h such that MCLK = (2*2 + 4)*12.00MHz = 96MHz.
MCLKCtl.1	MCT.1	
MCLKCtl.0	MCT.0	

The MPU clock that drives the CPU core defaults to 3.6923MHz after reset. The MPU clock is scalable by configuring the MPU Clock Control register ([MPUCKCtl](#)).