



STLS2F01

Loongson 2F: High performance 64-bit superscalar MIPS® microprocessor

Preliminary Data

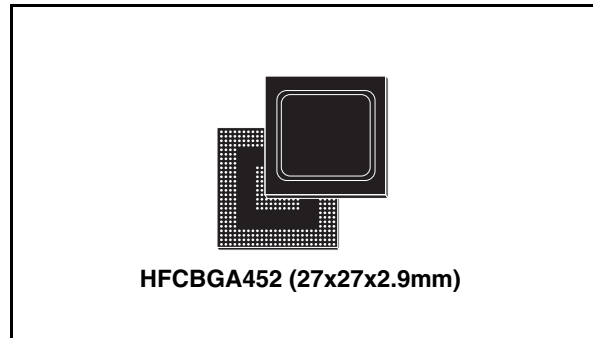
Features

- 64-bit superscalar architecture
- 900 MHz clock frequency
- Single/double precision floating-point units
- New streaming multimedia instruction set support (SIMD)
- 64 Kbyte instruction cache, 64 Kbyte data cache, on-chip 512 Kbyte unified L2 cache
- On chip DDR2-667 and PCI-X controller
- 4 W @ 900 MHz power consumption:
 - Best in class for power management
 - Voltage/frequency scaling
 - Stand-by mode support
 - L2 cache disable/enable option
- Leading edge 90 nm process technology
- 27x27 heat spreader flip-chip BGA package
- MIPS based instruction set (MIPS III compatible)

Description

The STLS2F01 is a MIPS based 64-bit superscalar microprocessor, able to issue four instructions per clock cycle among six functional units: two integer, two single/double-precision floating-point, one 64bit SIMD and one load/store unit.

The micro architecture is organized with nine-stage of pipeline and support of dynamic branch prediction.



The memory hierarchy is composed by the first level of 64 Kbyte 4-way set associative caches for instructions and data, the second level of 512 Kbyte unified 4-way set associative cache and the memory management unit (MMU) with translation lookaside buffer (TLB).

The Loongson microprocessor family is the outcome of a successful collaboration started in 2004 between STMicroelectronics and the Institute of Computing Technology, part of the Chinese Academy of Science. Loongson microprocessors were co-developed by STMicroelectronics and the Institute of Computing Technology to address all the applications requiring high level of performance and low power dissipation.

Compared to the STLS2E02 processor, the STLS2F01 has an enhanced architecture providing higher performance, reduced power consumption, integrated DDR2 memory controller and PCI-X bus interface.

Table 1. Device summary

Part numbers	Package	Packing
STLS2F01	HFCBGA452 (27x27x2.9mm)	Tray

Contents

1	Introduction	6
2	Interface description	8
2.1	Interface signal block diagram	8
2.2	PCI bus interface signal components	9
2.3	DDR2 SDRAM interface signal components	10
2.4	Local bus signals	11
2.5	Initialization signals	12
2.6	Interrupt signals	13
2.7	JTAG signals	13
2.8	Test and control signals	13
2.9	Clock signals	14
2.10	Supply and ground	16
3	I/O bus interface description	17
3.1	PCI interface characteristic	17
3.2	Host and agent mode	17
3.3	PCI bus arbitrator	17
3.4	System interface connection	17
3.5	Local bus description	18
3.6	Interrupt handling	20
4	DDR2 SDRAM controller interface description	21
4.1	DDR2 SDRAM controller features	21
4.2	DDR2 SDRAM read protocol	21
4.3	DDR2 SDRAM write protocol	22
4.4	DDR2 SDRAM parameter format	23
4.5	DDR2 SDRAM sample mode configuration	34
5	Initialization process	35
6	Electrical characteristics	37

6.1	Absolute maximum rating	37
6.2	Recommended operation environment	37
6.3	DC parameters	38
6.4	AC parameters	39
7	Thermal characteristics	41
7.1	Thermal resistivity	41
7.2	Reflow temperature to time curve	41
8	Pin arrangement and package information	43
8.1	Pin arrangement	43
9	Package information	46
10	Revision history	47

List of tables

Table 1.	Device summary	1
Table 2.	PCI bus signals	9
Table 3.	DDR2 SDRAM controller interface signals	10
Table 4.	Local bus signals	11
Table 5.	Initialization interface signals	12
Table 6.	Interrupt interface signals	13
Table 7.	JTAG interface signals	13
Table 8.	Clock signals	14
Table 9.	Processor internal/external frequency configuration	14
Table 10.	DDR internal/external frequency division factor	15
Table 11.	Supply and GND signals	16
Table 12.	DDR SDRAM configuration parameter register format	23
Table 13.	Absolute maximum rating	37
Table 14.	Recommended operating temperature, voltage supply and frequency	37
Table 15.	DC parameters	38
Table 16.	DC parameters (JTAG)	38
Table 17.	Clock parameters	39
Table 18.	Input setup and hold time	39
Table 19.	Input setup and hold time	40
Table 20.	Output delay time	40
Table 21.	JTAG parameters	40
Table 22.	Reflow temperature parameters	42
Table 23.	Document revision history	47

List of figures

Figure 1.	Block diagram	6
Figure 2.	Interface signal block diagram	8
Figure 3.	STLS2F01 uniprocessor system connection	18
Figure 4.	STLS2F01 multiprocessor system connections	18
Figure 5.	Local bus read timing	19
Figure 6.	Local bus write timing	20
Figure 7.	DDR2 SDRAM read protocol	22
Figure 8.	DDR2 SDRAM write protocol	22
Figure 9.	Initialization process when in main bridge mode	36
Figure 10.	Reflow temperature to time curve	41
Figure 11.	Pin arrangement (left-hand side)	43
Figure 12.	Pin arrangement (middle)	44
Figure 13.	Pin arrangement (right-hand side)	45
Figure 14.	HFCBGA452 mechanical data & package dimensions	46

1 Introduction

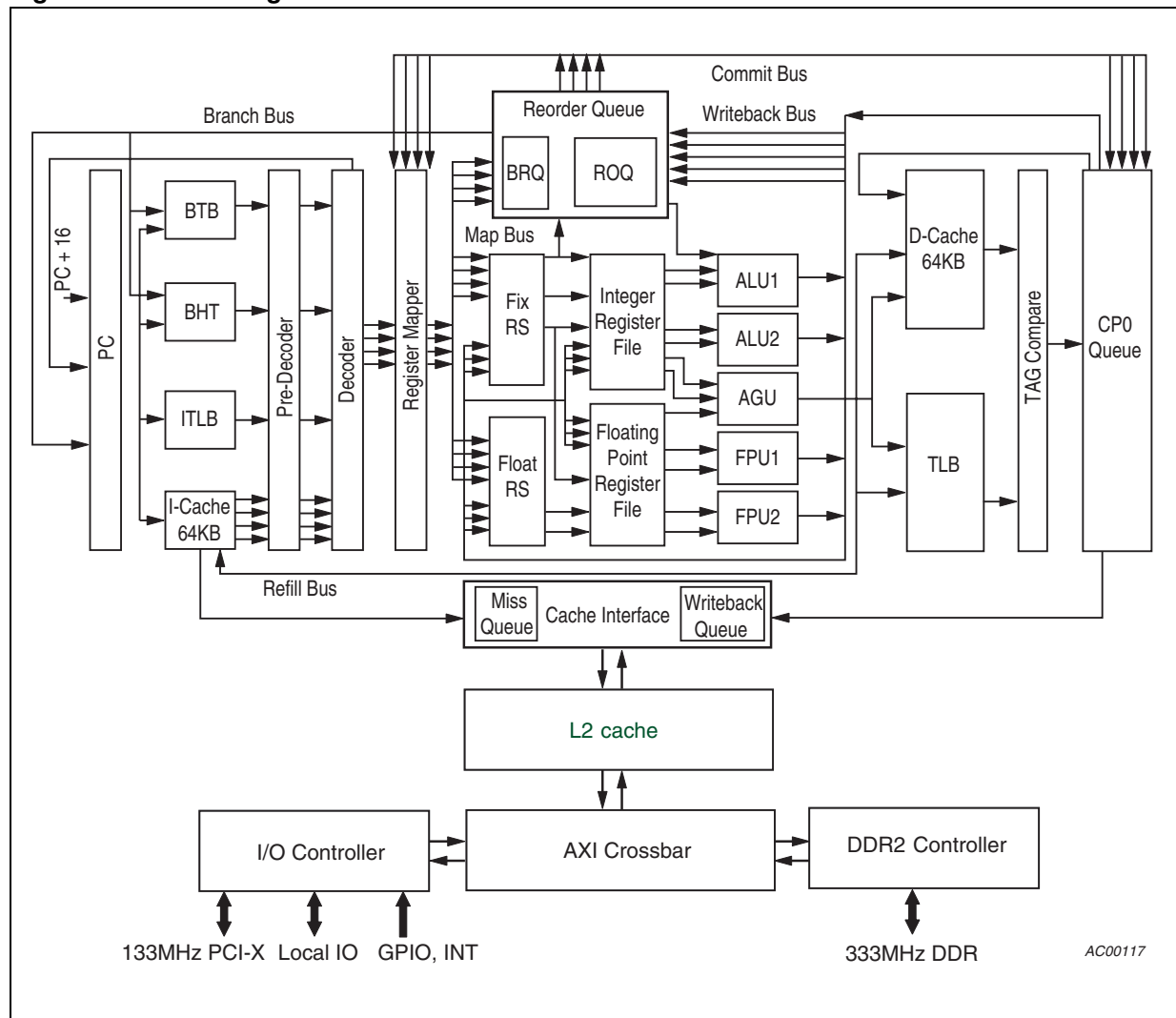
STLS processors are based on the Loongson CPU architecture licensed by STMicroelectronics from the Institute of Computing Technology (ICT), which is part of the Chinese Academy of Science. The STLS family belongs to the 64-bit high-end processors for applications requiring high level of performance and efficiency in terms of cost, power consumption and area.

Loongson CPU architecture is compatible in user mode at the MIPS III level of the MIPS 64-bit architecture.

This microprocessor achieves one of the top positions in the MIPS family for the combination of multiple features: high clock frequency, out-of-order superscalar execution and ability to run single-instruction-multiple data (SIMD).

STLS processors implement a superscalar, out-of-order execution pipeline with dynamic branch prediction and non-blocking cache.

Figure 1. Block diagram



The instruction pipeline allows to fetch and code four instructions per cycle and dynamically issue the decoded instructions to five fully pipe lined function components.

The STLS2F01 uses out-of-order execution and aggressive memory hierarchy design to maximize pipeline efficiency.

Out-of-order execution is accomplished with a combination of register renaming, dynamic scheduling, and branch prediction techniques. The result is fewer pipeline stalls caused by WAR (write after read) and WAW (write after write) hazards, RAW (read after write) hazards, and control hazards. The STLS2F01 has a 64-entry physical register file for fixed- and floating-point register renaming, a 16-entry fixed-point reservation station, and a 16-entry floating-point reservation station that is responsible for out-of-order instruction issuing. A 64-entry ROQ (reorder queue) ensures that out-of-order executed instructions are committed in the program order. For precise branch prediction, a 16-entry branch target buffer (BTB), a 4K-entry branch history table (BHT), a 9-bit global history register (GHR), and a 4-entry return address stack (RAS) are used to record branch history information.

The STLS2F01 memory hierarchy is also engineered for high performance. There is a 64 Kbyte instruction cache, a 64 Kbyte data cache, and a 512 Kbyte level-two cache. All four-way set associative. The on-chip DDR memory allows the STLS2F01 to achieve high memory bandwidth with low latency. The fully associative translation lookaside buffer (TLB) has 64 entries, each mapping an odd and even page. A 24-entry memory access queue contains a content-addressable memory for dynamic memory disambiguation and allows the STLS2F01 to implement out-of-order memory access, non-blocking cache, load speculation, and store forwarding.

The STLS2F01 has two fixed-point functional units, two floating-point functional units, and one memory access unit. The floating-point units can also execute 32- or 64-bit fixed-point instructions and 8- or 16-bit SIMD fixed-point instructions through extension of the `fmt` field of the floating-point instructions. The SIMD unit extends the STLS2E02 with new XX SSE2 type instructions.

The basic pipeline stages of the STLS2F01 include instruction fetch, pre-decode, decode, register rename, dispatch, issue, register read, execution, and commit.

The STLS2F01 device is manufactured in ST 90 nm CMOS technology.

The STLS2F01 is an evolution of the STLS2E02 with enhanced I/O and memory accessing bandwidth and a software working frequency changing scheme.

The STLS2F01 has a standard 32-bit PCI/PCI-X interface, a standard 64-bit DDR2 interface, an 8/16-bit local I/O interface, a 4-bit GPIO interface.

The STLS2F01 achieves a higher memory access bandwidth by utilizing a 64-bit DDR2 memory controller.

Compared to its predecessor, the STLS2F01 provides better power management ability by using a software manageable working frequency changing scheme. The operating system can utilize this feature to change the processor frequency according to the workload.

The STLS2F01 integrates a video accelerate module in its write data path to the PCI/PCI-X controller. Coupled with software drivers, the video accelerate module can transfer YUV format video data to RGB format and zoom automatically. This greatly reduces the processor's workload when the system utilizes a simple VGA controller.

The cores are centered on 2x2 AXI cross bar with 128-bit width data bus. The CPU core and PCI/PCI-X slave takes up two master ports, DDR2 controller one slave port, and all other modules including the PCI/PCI-X master share one slave port.

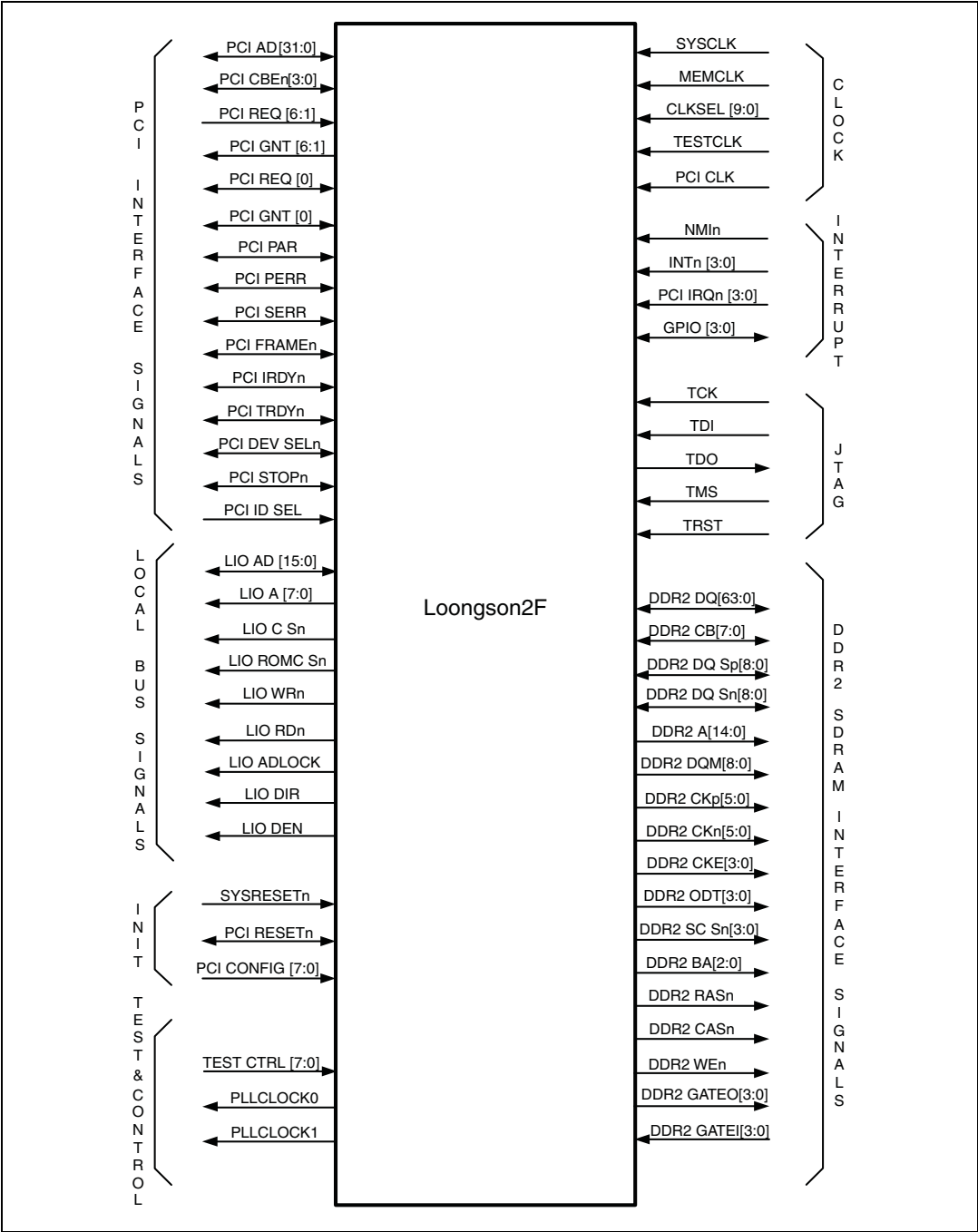
2 Interface description

2.1 Interface signal block diagram

The STLS2F01's interface signals are showed in [Figure 2](#).

Note: The arrow indicates signal directions, e.g. input, output or bidirectional.

Figure 2. Interface signal block diagram



2.2 PCI bus interface signal components

The STLS2F01's PCI bus signal includes:

- 32-bit address data bus
- 4-bit command data ID bus
- 14-bit bus arbitrator
- 7-bit interface control
- 2-bit error report signals

The STLS2F01's PCI bus signals are listed in [Table 2](#).

Table 2. PCI bus signals

Name	Input/output	Description
PCI_AD[63:0]	I/O	PCI address/data bus
PCI_CBE _n [7:0]	I/O	PCI command/byte
PCI_PAR	I/O	Address/data parity check signal
PCI_REQ _n [6:1]	I	External Request
PCI_REQ _n [0]	I/O	External request input/request output to external arbiter
PCI_GNT[6:1]	O	PCI bus grant to external device
PCI_GNT[0]	I/O	PCI bus grant to external device / grant input from external arbiter
PCI_FRAME _n	I/O	PCI bus cycle frame
PCI_IRDY _n	I/O	PCI initiator ready
PCI_TRDY _n	I/O	PCI target ready
PCI_STOP _n	I/O	PCI stop
PCI_DEVSEL _n	I/O	PCI device select

2.3 DDR2 SDRAM interface signal components

The STLS2F01 includes a built-in memory controller fully compatible with DDR2 SDRAM industry standard (JESD79-2B). These signals include:

- 72-bit bidirectional data bus (ECC included)
- 9-bit bidirectional data strobe differential signal (ECC included)
- 9-bit data mask signal (ECC included)
- 15-bit address bus
- 7-bit bank and chip select signal
- 6-bit differential clock
- 4-bit clock enable
- 3-bit command bus
- 4-bit delay sample input/output signal
- 4-bit ODT (on die termination) signal

The STLS2F01 DDR2 SDRAM controller signals are listed in [Table 3](#).

Table 3. DDR2 SDRAM controller interface signals

Name	Input/output	Description
DDR2_DQ[63:0]	IO	DDR2 SDRAM data bus
DDR2_CB[7:0]	IO	DDR2 SDRAM data ECC data bus
DDR2_DQSp[8:0]	IO	DDR2 SDRAM data strobe (ECC included)
DDR2_DQSn[8:0]	IO	DDR2 SDRAM data strobe (ECC included)
DDR2_DQM[8:0]	O	DDR2 SDRAM data mask (ECC included)
DDR2_A[14:0]	O	DDR2 SDRAM address bus
DDR2_BA[2:0]	O	DDR2 SDRAM bank address signal
DDR2_WEn	O	DDR2 SDRAM write enable
DDR2_CASn	O	DDR2 SDRAM column select enable
DDR2_RASn	O	DDR2 SDRAM row select enable
DDR2_SCSn[3:0]	O	DDR2 SDRAM chip select
DDR2_CKE[3:0]	O	DDR2 SDRAM clock enable
DDR2_CKp[5:0]	O	DDR2 SDRAM phase clock output
DDR2_CKn[5:0]	O	DDR2 SDRAM phase inversion clock output
DDR2_GATEI[3:0]	I	DDR2 SDRAM delay sample input signal
DDR2_GATEO[3:0]	O	DDR2 SDRAM delay sample output signal
DDR2_ODT[3:0]	O	DDR2 SDRAM on-die termination signal

2.4 Local bus signals

The local bus provides a simple bus interface for system boot ROM and I/O device. The interface is designed for chip-connect simplicity.

The local bus signals are listed in [Table 4](#).

Table 4. Local bus signals

Name	Input/output	Description
LIO_AD[15:0]	I/O	Local I/O address and data bus When ADLOCK valid output the most significant 16 bits
LIO_A[7:0]	O	Lowest significant 8-bit address bus
LIO_CS _n	O	Local I/O chip select
LIO_ROMCS _n	O	Local I/O ROM chip select
LIO_WR _n	O	Local I/O write enable
LIO_RD _n	O	Local I/O read enable
LIO_ADLOCK	O	Local I/O address lock
LIO_DIR	O	Local I/O direction
LIO_DEN	O	Local I/O device enable

2.5 Initialization signals

[Table 5](#) provides the names, definitions, and directions and descriptions of the initialization signals.

Table 5. Initialization interface signals

Name	Input/output	Description			
SYSRESETn	I	System reset. Low state of the signal must be maintained more than one SYSCLK period. It can be asynchronous to SYSCLK.			
PCI_RESETn	I/O	PCI interface reset.			
PCI_CONFIG	I	PCI Configuration 7 undefined 6:5 PCI-X bus speed selection 4 PCI-X bus mode 3 Master mode 2 Start from PCI 1 External PCI arbitration 0 16-bit starting ROM Note:			
		6	5	4	PCI-X BUS mode
		0	0	0	PCI 33/66
		0	1	1	PCI-X 66
		1	0	1	PCI-X 100
		1	1	1	PCI-X 133

The STLS2F01 processor includes two reset signals: SYSRESETn and PCI_RESETn.

- **SYSRESETn:** This reset signal is the only way to reset whole STLS2F01 processor. SYSCLK and MEMCLK must provide stable clock when SYSRESETn is valid. The width of SYSRESETn should be more than one clock period. Internal reset-control begins to reset internal logic when reset signal is invalid. The internal reset will be finished after 64K SYSCLK cycle. Then reset exception vector could be executed
- **PCI_RESETn:** This signal works as output when the processor works as a system main bridge. And the reset of PCI-X devices in the system must be controlled by the signal. When the processor works as PCI/PCI-X devices used in other system, the signal works as input to reset the PCI interface of processor. (Note: Resetting PCI interface when process is running may cause the processor stop working)

PCI_CONFIG: defines the mode of working of the processor interface. It must keep stable during system reset, so that software could read this value from internal register after system started. The PCI address of the first instruction is 0x1fc00000 when system starting from PCI is configured. Otherwise the first instruction will be fetched from address 0 of Local Bus ROM.

2.6 Interrupt signals

The STLS2F01 processor supports up to 12 external interrupts and one non-maskable interrupt (NMI). There are 4 PCI interrupt signals, 4 special interrupt signals and 4 configurable GPIO interrupt. In addition, there are 3 internal interrupts, two PCI bus error report signals and one DDR2 control interrupt. When an interrupt takes place, the processor handles the exception. [Table 6](#) shows the names, definitions, directions and descriptions of the interrupt signals.

Table 6. Interrupt interface signals

Name	Input/output	Description
INTn[3:0]	I	4 external interrupt signals. OR operations are performed on these signals with interrupt register from bit 5 to bit 2 separately.
NMIIn	I	NMI. An OR operation is performed on the NOT-value of this signal and the interrupt register's 6th bit.
GPIO[3:0]	I/O	These interrupts should be enabled in the interrupt controller and can be configured as different active power level and different trigger mode. These interrupts could be routed to interrupt register bit 0/1.
PCI_IRQ[3:0]	I	These interrupts should be enabled in the interrupt controller and low active. These interrupts could be routed to interrupt register bit 0/1.
PCI_PERR	I/O	PCI bus parity error, high pulse active. These interrupts could be routed to interrupt register bit 0/1.
PCI_SERR	I/O	PCI bus error, high pulse active. These interrupts could be routed to interrupt register bit 0/1.

2.7 JTAG signals

The STLS2F01 provides a JTAG-compliant boundary scan interface. The JTAG interface is particularly suitable for testing the processor pins for connectivity. The [Table 7](#) provides the names, definitions, directions and descriptions of the JTAG signals.

Table 7. JTAG interface signals

Name	Input/output	Description
TDI	I	JTAG serial scan data input
TDO	O	JTAG serial scan data input
TMS	I	JTAG Command, indicating that the input serial data is a command.
TCK	I	TAG serial scan clock

2.8 Test and control signals

On the STLS2F01 chip, the test signals are only used for chip physical test, e.g. scan chain test. When the chip works normally, these signals are set invalid 1.

2.9 Clock signals

For information about clock on the STLS2F01 chip, see [Table 8](#). The processor has three system input clock signals. (SYSCLK, MEMCLK and PCI_CLK) The TESTCLK is only used for chip test. The CPU core clock and DDR2 control clock are generated separately by PLL using SYSCLK and MEMCLK. The frequency division is controlled by CLKSEL. For more about the division factor, see [Table 9](#) and [Table 10](#).

Table 8. Clock signals

Name	Input/output	Description
SYSCLK	I	System input clock, which drives the built-in PLL to generate core clock. It also used as clock of system reset circuit.
MEMCLK	I	DDR2 controller input clock, which is used by the built-in PLL to generate DDR2 control clock.
CLKSEL[4:0]	I	PLL frequency division control signal of core clock, see Table 9 .
CLKSEL[9:5]	I	PLL frequency division control signal of DDR2 controller clock, see Table 10 .
PCI_CLK	I	Clock for PCI and Local bus interface.

Table 9. Processor internal/external frequency configuration

CLKSEL[4:0]	Multi. factor	Input frequency range (MHz)	CLKSEL[4:0]	Multi. factor	Input frequency range (MHz)
11xxx	1	-			
10000	2.25	88.9~177.8	01100	6.5	61.5~123.1
10001	2.5	80.0~160.0	01101	7	57.1~114.3
10010	2.75	72.7~145.5	01110	7.5	53.3~106.7
10011	3	66.7~133.3	01111	8	50.0~100.0
10100	3.25	61.5~123.1	00000	9	88.9~177.8
10101	3.5	57.1~114.3	00001	10	80.0~160.0
10110	3.75	53.3~106.7	00010	11	72.7~145.5
10111	4	50.0~100.0	00011	12	66.7~133.3
01000	4.5	88.9~177.8	00100	13	61.5~123.1
01001	5	80.0~160.0	00101	14	57.1~114.3
01010	5.5	72.7~145.5	00110	15	53.3~106.7
01011	6	66.7~133.3	00111	16	50.0~100.0

Table 10. DDR internal/external frequency division factor

CLKSEL[9:5]	Multi. factor	Input frequency range (MHz)	CLKSEL[9:5]	Multi. factor	Input frequency range (MHz)
11000	1.125	88.9~177.8	10100	3.25	61.5~123.1
11001	1.25	80.0~160.0	10101	3.5	57.1~114.3
11010	1.375	72.7~145.5	10110	3.75	53.3~106.7
11011	1.5	66.7~133.3	10111	4	50.0~100.0
11100	1.625	61.5~123.1	01000	4.5	88.9~177.8
11101	1.75	57.1~114.3	01001	5	80.0~160.0
11110	1.875	53.3~106.7	01010	5.5	72.7~145.5
11111	2	50.0~100.0	01011	6	66.7~133.3
10000	2.25	88.9~177.8	01100	6.5	61.5~123.1
10001	2.5	80.0~160.0	01101	7	57.1~114.3
10010	2.75	72.7~145.5	01110	7.5	53.3~106.7
10011	3	66.7~133.3	01111	8	50.0~100.0
			00xxx	1	-

2.10 Supply and ground

See [Table 11](#) for supply and GND signals at the STLS2F01.

Table 11. Supply and GND signals

Name	Input/output	Description
vdd	PWR	1.2 V CPU core voltage
gnd	GND	1.2 V CPU core ground
Vdde1v8	PWR	1.8 V DDR2 power supply
gnde	GND	1.8 V DDR2 and 3.3V I/O ground
Vdde3v3	PWR	3.3 V IO power supply
DDR2_VREF	I	0.9 V DDR reference voltage input
pll_vdd_1	PWR	1.0 V PLL 1 digital power supply
pll_gnd_1	GND	1.0V PLL 1 digital ground
pll_vdd_0	PWR	1.0V PLL 0 digital power supply
pll_gnd_0	GND	1.0V PLL 0 digital ground
Pllio_vdde1v8	PWR	1.8V PLL I/O power supply
pllio_gnde	GND	1.8V PLL I/O ground
pllio_vdd	PWR	1.2V PLL I/O power Supply
pllio_gnd	GND	1.2V PLL I/O ground
Pll_vdde1v8_1	PWR	1.8V PLL 1 analog power supply
Pll_gnde_1	GND	1.8V PLL 1 analog ground
Pll_vdde1v8_0	PWR	1.8V PLL 0 analog power supply
Pll_gnde_0	GND	1.8V PLL 0 analog ground
comp1v8_gnd	GND	Compensation reference current ground
comp1v8_resistor	I	Compensation external resistor input

3 I/O bus interface description

The STLS2F01 processor I/O interface consists of PCI bus and Local bus. PCI bus is used to for generic peripheral devices interface, while Local bus is the simple interface to boot or debug the processor.

3.1 PCI interface characteristic

The PCI interface features:

- PCI 2.3 and PCI-X 1.0 compatible
- Support PCI 66 MHz and PCI-X133 MHz
- Support dual address cycle for 64-bit addressing
- Support 8 outstanding master request in PCI-X mode
- Support 4 delay-split read request in PCI-X mode

3.2 Host and agent mode

The STLS2F01's PCI interface could be worked in Host mode or Agent mode. It depends on initial signal PCI_CONFIG. When the processor works in Host mode, the interface initializes the bus device according to the value of PCI_CONFIG[6:4]. In this case, PCI_IDSEL could connect to GND directly. When the processor works in Agent mode, the initial value of PCI bus defines the work-mode of the interface. In Host mode, on the system main board, the value of PCI_CONFIG[6:4] should be set according to the ability of bus device. (Please refer to PCI-X 1.0 standard)

3.3 PCI bus arbitrator

PCI/PCI-X bus arbitrator built in STLS2F01 supports 7 external masters at most. The arbitration rules are two levels Round Robin scheduling. The level of each request is determined by software configuration. The bus is granted to insert a dummy cycle during switching. Bus parking can be configured as the last master or any specified master.

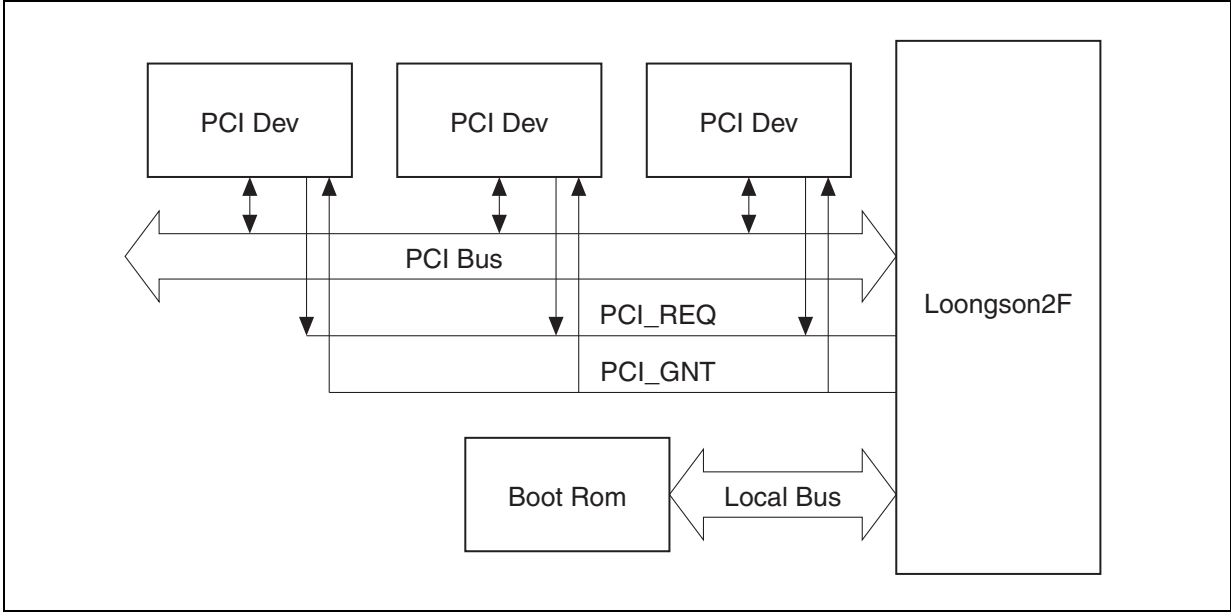
The internal request/grant wire of interface could be set to connect to the number 0 request/grant wire by PCI_CONFIG [1], so that the external bus arbitrator can be used.

3.4 System interface connection

The STLS2F01 processor can be easily implemented in uniprocessor system. Since no multi-processor cache coherence protocol is supported in PCI interface, the cache coherence should be managed by software in multiprocessor system.

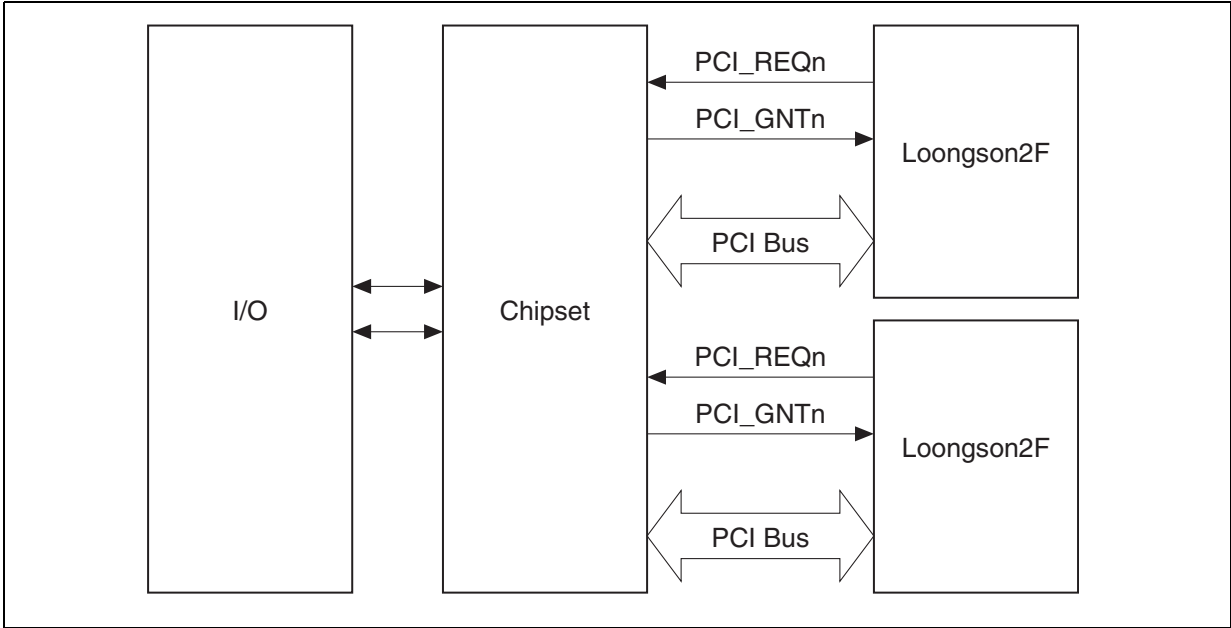
- Single processor system connection

Figure 3. STLS2F01 uniprocessor system connection



- Multiprocessor system connections

Figure 4. STLS2F01 multiprocessor system connections



3.5 Local bus description

Local bus is a simple peripheral interface. It's mainly used to connect to boot ROM. There are two chip select signals, and corresponding configurable data width and access delay.

The read and write timing are shown in the [Figure 5](#) and [Figure 6](#). When the data width is 16-bit, the output address can be generated by shifting the physical address right one bit.

Figure 5. Local bus read timing

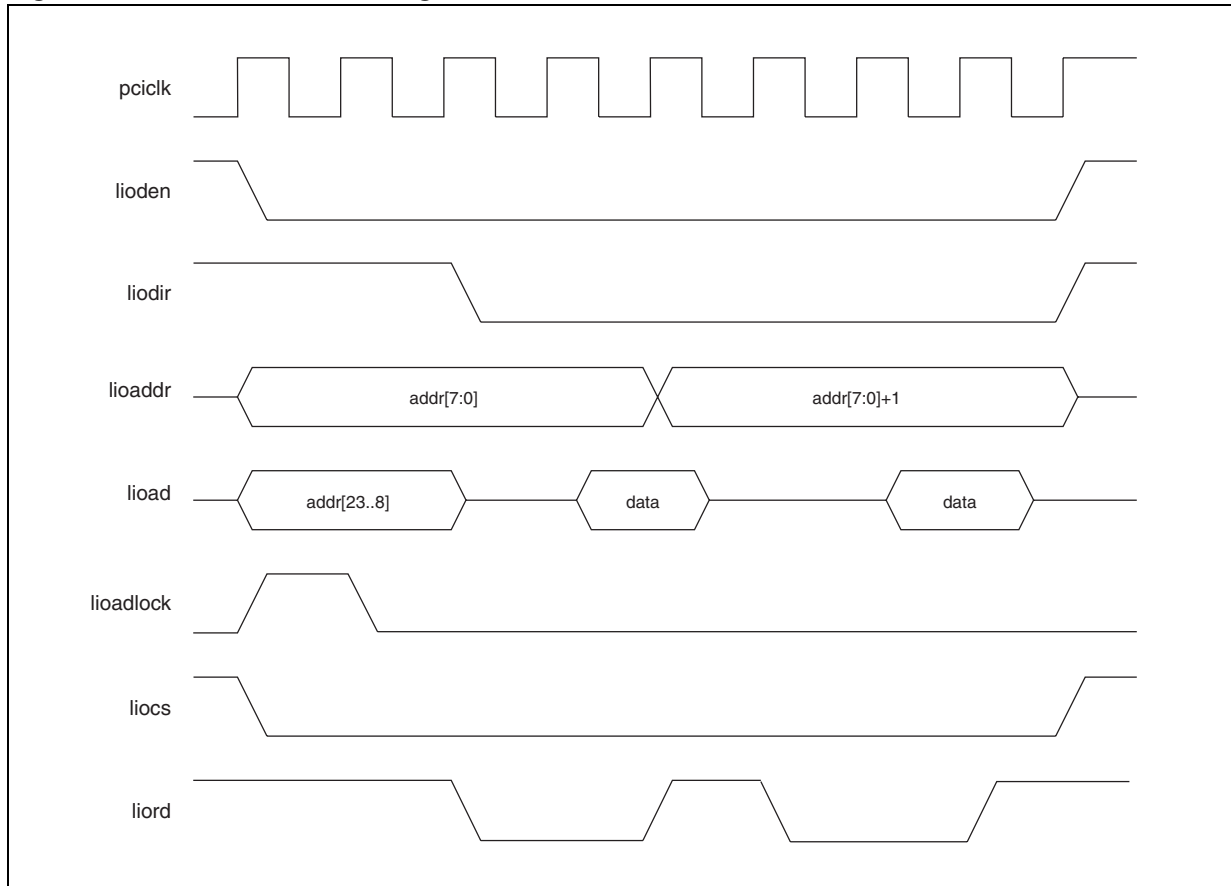
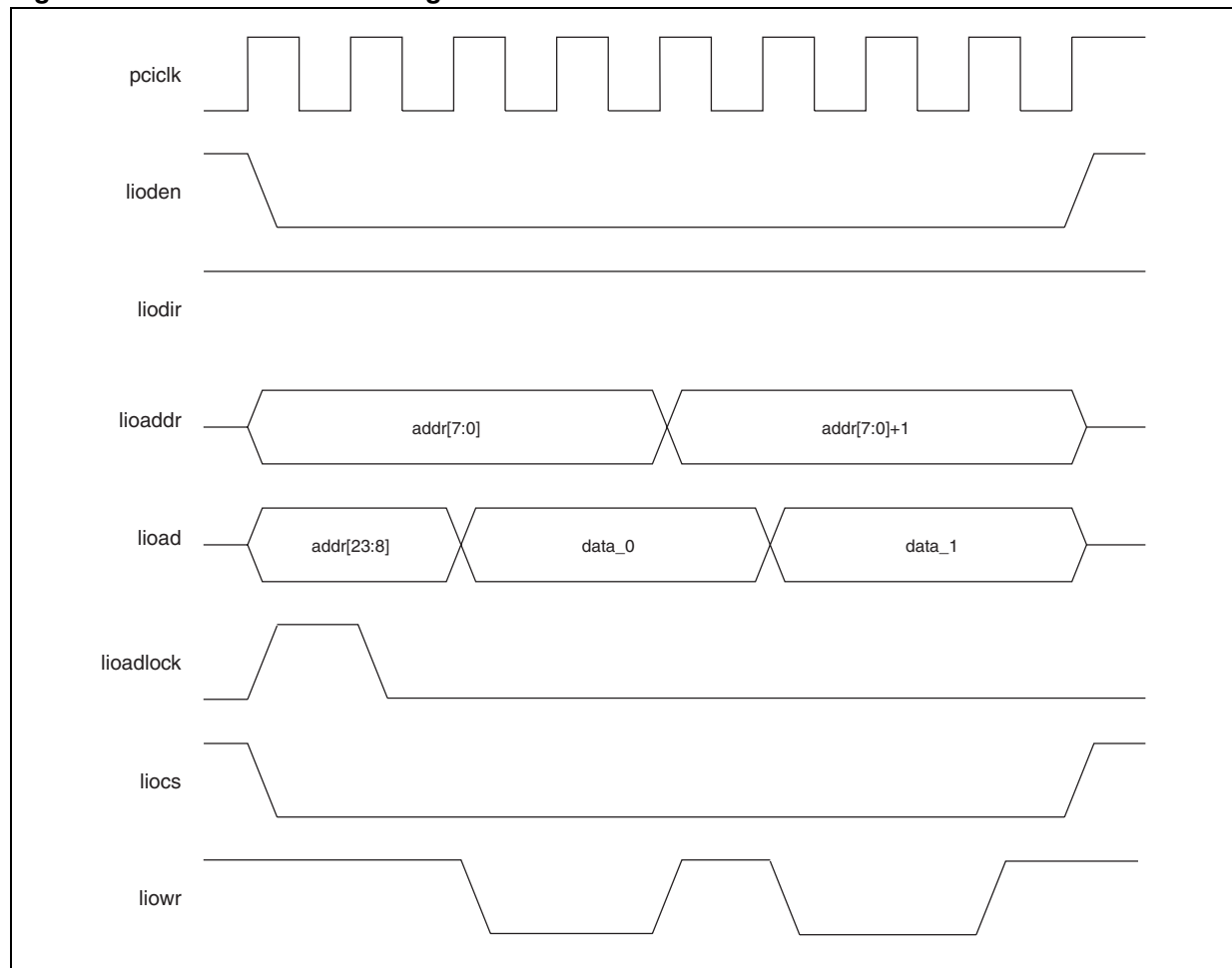


Figure 6. Local bus write timing

3.6 Interrupt handling

An interrupt controller is built in STLS2F01 processor to handle internal and external interrupt. The most significant 4 bits of the interrupt `INTn[5:0]` in STLS2E01 are still being used as interrupt in STLS2F01, while the other two bits are used for new interrupt in STLS2F01, such as `PCI_IRQ` and `GPIO`, etc.

How to handle the interrupt between processors: the interrupt initiator writes the dedicated interrupt register in the chipset. Upon receiving the request for interrupt transmission, the chipset will request the target processor for interrupt. The processor handles the request in the same way as the previous STLS2E01 and beyond.

4 DDR2 SDRAM controller interface description

The STLS2F01 integrates a built-in memory controller compliant with DDR2 SDRAM standard (JESD79-2B). The STLS2F01 provide JESD79-2B-compliant read/write operations onto memory.

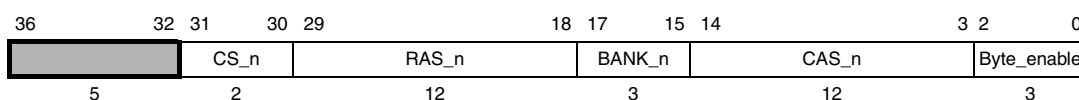
4.1 DDR2 SDRAM controller features

The STLS2F01 CPU supports up to 4 physical memory by using two DDR SDRAM chip select signals, with a 18-bit address bus (15-bit row/column address and 3-bit logic bank bus). The maximum address space is 128GB (2^{37} bytes).

This device supports all the JESD79-2B-compatible memory chips. The DDR2 controller parameters can be set to support specific memory chip type. The maximum number of chip selection (CS_n) is 2-bit. The maximum width of row address (RAS_n) is 15-bit, and the maximum width of column address (CAS_n) is 14-bit. And there is 3-bit logic bank bus (BANK_n).

For example, in the 4GB address space configuration of 2-bit CS_n, 3-bit BANK_n, 12-bit RAS_n and 12-bit CAS_n, the physical memory address CPU required can be translated into row/column address as shown in the [DDR2 SDRAM row/column address translation](#) paragraph.

DDR2 SDRAM row/column address translation



The built-in memory controller IC receives only memory read/write requests from a processor or external device. The controller IC is in Slave state whenever memory are read or written.

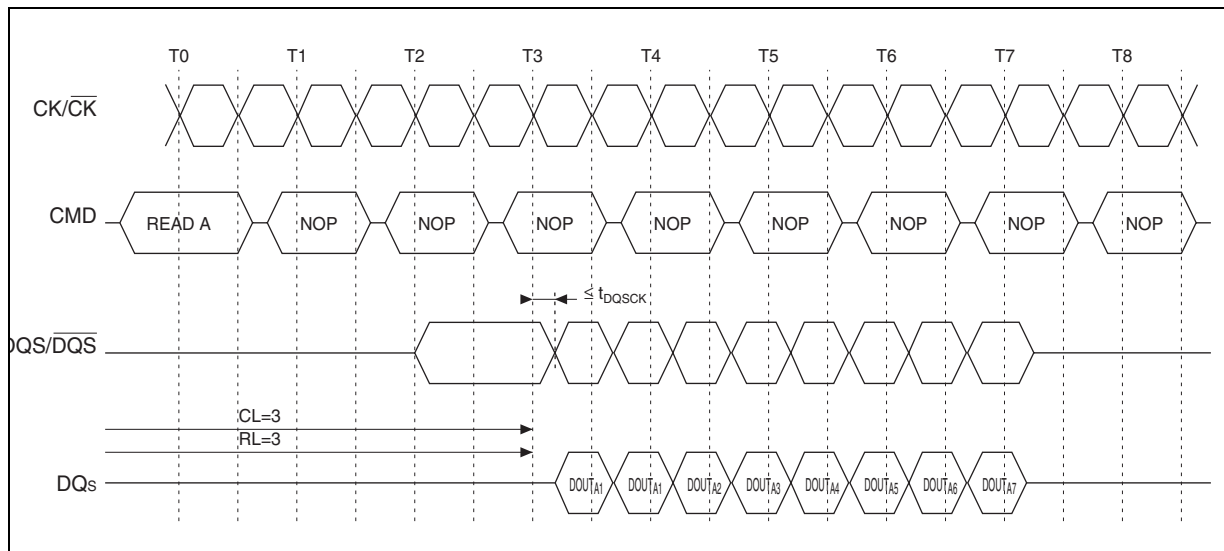
A dynamic page management policy is implemented on the integrated memory controller. For one access to memory, the controller selects Open Page/Close Page strategies on a hardware circuit, without software designers' intervention. The memory controller features:

- Full pipeline support to command and read/write data of interface
- Increasing bandwidth by merging and sorting memory command
- Modify fundamental parameters through the configuration of register read/write ports
- Built-in delay compensation circuit (DCC), it is used to send/receive data reliably
- 1-bit and 2-bit error detection, 1-bit error correction by error correcting-code (ECC)
- Frequency: 133 MHz - 333 MHz

4.2 DDR2 SDRAM read protocol

As showed in [Figure 7](#) DDR2 SDRAM read protocol, the command (CMD) includes RAS_n, CAS_n and WE_n. When a read request happens, RAS_n=1, CAS_n=0, and WE_n=1.

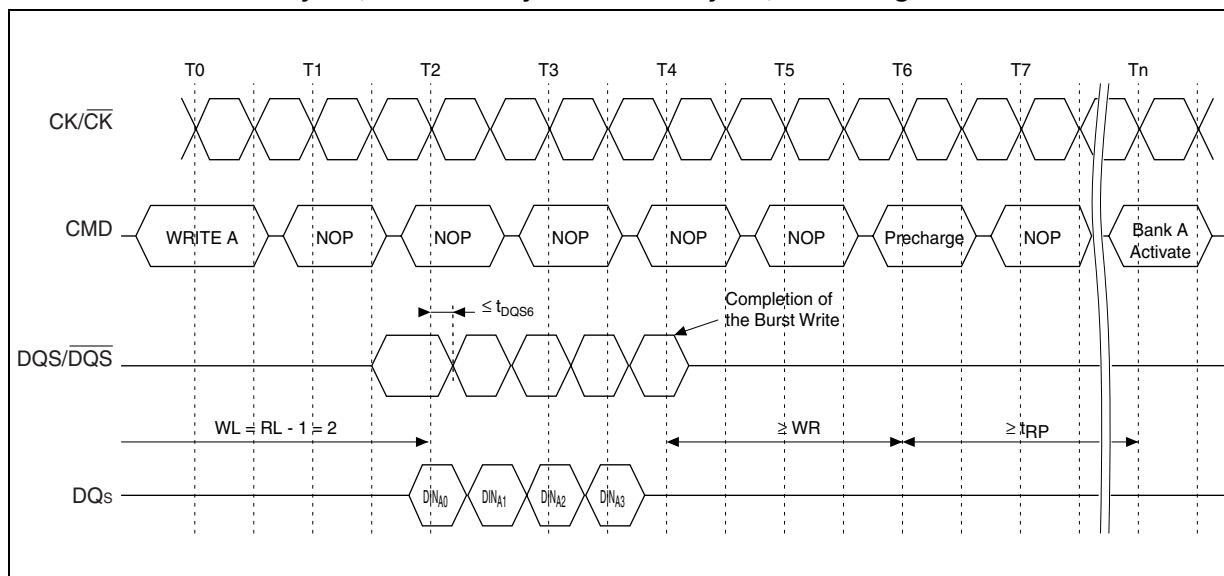
Figure 7. DDR2 SDRAM read protocol
CAS latency = 3, read latency = 3, burst length = 8



4.3 DDR2 SDRAM write protocol

As shown in [Figure 8](#) DDR2 SDRAM write protocol, the command (CMD) includes RAS_n, CAS_n and WE_n. When a write request happens, RAS_n=1, CAS_n=0, and WE_n=0. Unlike a read transaction, DQM is used to identify the write mask. In other words, the number of written bytes is needed. DQM is synchronous with DQS.

Figure 8. DDR2 SDRAM write protocol
CAS latency = 3, write latency = read latency = 2, burst length = 4



4.4 DDR2 SDRAM parameter format

Since different DDR2 SDRAMs may be used in the system, DDR2 SDRAM needs configuration after power-on reset. The JESD79-2B standard defines detailed configuration operation and process. DDR2 is not available before the memory is initialized. Memory initialization sequence:

1. System reset, aresetn signal is set 0, all registers content will be initial value.
2. System reset release, aresetn signal is set 1.
3. Issue 64-bit write command to configuration register, all 29 registers are configured. If register CTRL_03 is written in this step, the parameter of start should be set 0.
4. Issue 64-bit write command to register CTRL_03. Set the parameter of start to 1. Then, memory controller will send initial instruction to memory automatically.

In the STLS2F01 processor design, after the system motherboard is initialized, the DDR2 SDRAM controller needs configure memory type before the memory is used. Specifically, corresponding configuration parameters are written into the 29 64-bit registers corresponding to the physical address 0x0000 0000 0FFF FE00. In one register, one, multiple or partial parameter data can be included. The configuration register and its parameters are shown in [Table 12](#) Note: the bits not used are all reserved bits.

Table 12. DDR SDRAM configuration parameter register format

Parameters	Bits	Default value	Range	Description
CONF_CTL_00[31:0] Offset: 0x00 DDR2 667:0x00000101				
AREFRESH	24:24	0x0	0x0-0x1	Initiate auto-refresh when specified by AUTO_REFRESH_MODE. Write-only
AP	16:16	0x0	0x0-0x1	Enable auto pre-charge mode of controller.
ADDR_CMP_EN	8:8	0x0	0x0-0x1	Enable address collision detection for command queue placement logic.
ACTIVE_AGING	0:0	0x0	0x0-0x1	Enable command aging in the command queue, avoiding low priority command hungry.
CONF_CTL_00[63:32] Offset: 0x00 DDR2 667:0x01000100				
DDR2_SDRAM_MODE	56:56	0x0	0x0-0x1	DDR1 or DDR11 mode.
CONCURRENTAP	48:48	0x0	0x0-0x1	Allow controller to issue command to other banks while a bank is in auto pre-charge. Note: most DDR2 DIMM vendor do not support this feature.
BANK_SPLIT_EN	40:40	0x0	0x0-0x1	Enable bank splitting for command queue placement logic.
AUTO_REFRESH_MODE	32:32	0x0	0x0-0x1	Sets if auto-refresh will be at next burst or next command boundary.
CONF_CTL_01[31:0] Offset: 0x10 DDR2 667:0x00010000				

Table 12. DDR SDRAM configuration parameter register format (continued)

Parameters	Bits	Default value	Range	Description
ECC_DISABLE_W_UC_ERR	24:24	0x0	0x0-0x1	Disable auto-corruption of ECC when un-correctable errors occur in R/M/W operations.
DQS_N_EN	16:16	0x0	0x0-0x1	Single-ended or differential DQS pins.
DLL_BYPASS_MODE	8:8	0x0	0x0-0x1	Enable the DLL bypass feature of the controller.
DLLLOCKREG	0:0	0x0	0x0-0x1	Status of DLL lock coming out of master delay. Read-only.
CONF_CTL_01[63:32] Offset: 0x10 DDR2 667:0x00100000				
FWC	56:56	0x0	0x0-0x1	Force a write checks. Xor XOR_CHECK_BITS with ECC code and write to memory. Write-only
FAST_WRITE	48:48	0x0	0x0-0x1	Sets when write command are issued to DRAM device.
ENABLE_QUICK_SREFRESH	40:40	0x0	0x0-0x1	Allows user to interrupt memory initialization to enter self-refresh mode.
EIGHT_BANK_MODE	32:32	0x0	0x0-0x1	Number of banks on the DRAM(s).
CONF_CTL_02[31:0] Offset: 0x20 DDR2 667:0x00000000				
NO_CMD_INIT	24:24	0x0	0x0-0x1	Disable DRAM command until TDLL has expired during initialization.
INTRPTWRITENA	16:16	0x0	0x0-0x1	Allow the controller to interrupt a combined write command with auto pre-charge with another write command.
INTRPTREADA	8:8	0x0	0x0-0x1	Allow the controller to interrupt a combined read with auto pre-charge command with another read command.
INTRPTAPBURST	0:0	0x0	0x0-0x1	Allow the controller to interrupt an auto pre-charge command with another command.
CONF_CTL_02[63:32] Offset: 0x20 DDR2 667:0x01000101				
PRIORITY_EN	56:56	0x0	0x0-0x1	Enable priority for command queue placement logic.
POWER_DOWN	48:48	0x0	0x0-0x1	Disable clock enable and set DRAMs in power-down state.
PLACEMENT_EN	40:40	0x0	0x0-0x1	Enable placement logic for command queue.
ODT_ADD_TURN_CLK_EN	32:32	0x0	0x0-0x1	Enable extra turn-around clock between back-to-back reads/writes to different chip selects.

Table 12. DDR SDRAM configuration parameter register format (continued)

Parameters	Bits	Default value	Range	Description
CONF_CTL_03[31:0] Offset: 0x30 DDR2 667:0x01000000				
RW_SAME_EN	24:24	0x0	0x0-0x1	Enable read/write grouping for command queue placement logic.
REG_DIMM_EN	16:16	0x0	0x0-0x1	Enable registered DIMM operation of the controller.
REDUC	8:8	0x0	0x0-0x1	Enable the half data path (32-bit) feature of the controller.
PWRUP_SREFRESH_EXIT	0:0	0x0	0x0-0x1	Power-up via self-refresh instead of full memory initialization.
CONF_CTL_03[63:32] Offset: 0x30 DDR2 667:0x01010000				
SWAP_PORT_RW_SAME_EN	56:56	0x0	0x0-0x1	Enable command swapping logic between commands of the same type from the same port in execution unit.
SWAP_EN	48:48	0x0	0x0-0x1	Enable command swapping logic in execution unit.
START	40:40	0x0	0x0-0x1	Initiate command processing in the controller.
SREFRESH	32:32	0x0	0x0-0x1	Place DRAMs in self-refresh mode.
CONF_CTL_04[31:0] Offset: 0x40 DDR2 667:0x00010101				
WRITE_MODEREG	24:24	0x0	0x0-0x1	Write EMRS data to the DRAMs. Write-only.
WRITEINTERP	16:16	0x0	0x0-0x1	Allow controller to interrupt write bursts to the DRAMs with a read command.
TREF_ENABLE	8:8	0x0	0x0-0x1	Issue self-refresh commands to the DRAMs every TREF cycle.
TRAS_LOCKOUT	0:0	0x0	0x0-0x1	Allow the controller to execute auto pre-charge commands before TRAS_MIN expires.
CONF_CTL_04[63:32] Offset: 0x40 DDR2 667:0x01000202				
RTT_0	57:56	0x0	0x0-0x3	On-Die termination resistance setting for all DRAM devices.
CTRL_RAW	49:48	0x0	0x0-0x3	ECC error checking and correcting control. 2'b00 – no ECC 2'b01 – report error only, not corrected 2'b10 – no ECC device used 2'b11 – report and correct ECC error
AXI0_W_PRIORITY	41:40	0x0	0x0-0x3	Priority of write command from port 0.

Table 12. DDR SDRAM configuration parameter register format (continued)

Parameters	Bits	Default value	Range	Description
AXI0_R_PRIORITY	33:32	0x0	0x0-0x3	Priority of read command from port 0.
CONF_CTL_05[31:0] Offset: 0x50 DDR2 667:0x04050202				
COLUMN_SIZE	26:24	0x0	0x0-0x7	Difference between number of column pins available and number being used.
CASLAT	18:16	0x0	0x0-0x7	Encoded CAS latency sent to DRAMs during initialization.
ADDR_PINS	10:8	0x0	0x0-0x7	Difference between number of address pins available and number being used.
RTT_PAD_TERMINATION	1:0	0x0	0x0-0x3	Set termination resistance in controller pads.
CONF_CTL_05[63:32] Offset: 0x50 DDR2 667:0x00000000				
Q_FULLNESS	58:56	0x0	0x0-0x7	Quantity that determines command queue full.
PORT_DATA				
_ERROR_TYPE	50:48	0x0	0x0-0x7	Type of error and access type that caused the PORT data error. Read-only. bit 0 – data overflow. The write data quantity exceeded the Maximum_Byte_Request configured option. bit 1 – write data interleaved beyond supported interleaving depth. bit 2 – ECC 2-bit error.
OUT_OF_RANGE_TYPE	42:40	0x0	0x0-0x7	Type of command that caused and Out-of-Range interrupt. Read-only.
MAX_CS_REG	34:32	0x4	0x0-0x4	Maximum number of chip selects available. Read-only
CONF_CTL_06[31:0] Offset: 0x60 DDR2 667:0x03040203				
TRTP	26:24	0x0	0x0-0x7	DRAM TRTP parameter in cycles.
TRRD	18:16	0x0	0x0-0x7	DRAM TRRD parameter in cycles.
TEMRS	10:8	0x0	0x0-0x7	DRAM TEMRS parameter in cycles.
TCKE	2:0	0x0	0x0-0x7	Minimum CKE pulse width.
CONF_CTL_06[63:32] Offset: 0x60 DDR2 667:0x0a040305				
APREBIT	59:56	0x0	0x0-0xf	Location of the auto pre-charge bit in the DRAM address.
WRLAT	50:48	0x0	0x0-0x7	DRAM WRLAT parameter in cycles.
TWTR	42:40	0x0	0x0-0x7	DRAM TWTR parameter in cycles.
TWR_INT	34:32	0x0	0x0-0x7	DRAM TWR parameter in cycles.

Table 12. DDR SDRAM configuration parameter register format (continued)

Parameters	Bits	Default value	Range	Description
CONF_CTL_07[31:0] Offset: 0x70 DDR2 667:0x000f090a				
ECC_C_ID	27:24	0x0	0x0-0xf	Source ID associated with correctable ECC event. Read-only
CS_MAP	19:16	0x0	0x0-0xf	Number of active chip selects used in address decoding.
CASLAT_LIN_GATE	11:8	0x0	0x0-0xf	Adjusts data capture gate open by half cycles.
CASLAT_LIN	3:0	0x0	0x0-0xf	Sets latency from read command send to data receive from/to controller.
CONF_CTL_07[63:32] Offset: 0x70 DDR2 667:0x00000400				
MAX_ROW_REG	59:56	0xf	0x0-0xf	Maximum width of memory address bus. Read-only
MAX_COL_REG	51:48	0xe	0x0-0xe	Maximum width of column address in DRAMs. Read-only
INITAREF	43:40	0x0	0x0-0xf	Number of auto-refresh command to execute during DRAM initialization.
ECC_U_ID	35:32	0x0	0x0-0xf	Source ID associated with the uncorrectable ECC even. Read-only.
CONF_CTL_08[31:0] Offset: 0x80 DDR2 667:0x01020408				
ODT_RD_MAP_CS3	27:24	0x0	0x0-0xf	ODT chip select 3 map for reads. Determines which chip(s) will have termination when a read occurs on chip 3.
ODT_RD_MAP_CS2	19:16	0x0	0x0-0xf	ODT chip select 2 map for reads. Determines which chip(s) will have termination when a read occurs on chip 2.
ODT_RD_MAP_CS1	11:8	0x0	0x0-0xf	ODT chip select 1 map for reads. Determines which chip(s) will have termination when a read occurs on chip 1.
ODT_RD_MAP_CS0	3:0	0x0	0x0-0xf	ODT chip select 0 map for reads. Determines which chip(s) will have termination when a read occurs on chip 0.
CONF_CTL_08[63:32] Offset: 0x80 DDR2 667:0x01020408				
ODT_WR_MAP_CS3	59:56	0x0	0x0-0xf	ODT chip select 3 map for writes. Determines which chip(s) will have termination when a write occurs on chip 3.

Table 12. DDR SDRAM configuration parameter register format (continued)

Parameters	Bits	Default value	Range	Description
ODT_WR_MAP_CS2	51:48	0x0	0x0-0xf	ODT chip select 2 map for writes. Determines which chip(s) will have termination when a write occurs on chip 2.
ODT_WR_MAP_CS1	43:40	0x0	0x0-0xf	ODT chip select 1 map for writes. Determines which chip(s) will have termination when a write occurs on chip 1.
ODT_WR_MAP_CS0	35:32	0x0	0x0-0xf	ODT chip select 0 map for writes. Determines which chip(s) will have termination when a write occurs on chip 0.
CONF_CTL_09[31:0] Offset: 0x90 DDR2 667:0x00000000				
PORT_DATA_ERROR_ID	27:24	0x0	0x0-0xf	Port number of command that caused the PORT data error. Read-only
PORT_CMD_ERROR_TYPE	19:16	0x0	0x0-0xf	Type of error and access type that caused the PORT command error. Read-only)
PORT_CMD_ERROR_ID	11:8	0x0	0x0-0xf	Port number of command that caused the PORT command error. Read-only
OUT_OF_RANGE_SOURCE_ID	3:0	0x0	0x0-0xf	Source ID of command that caused an Out-of-Range interrupt. Read-only
CONF_CTL_09[63:32] Offset: 0x90 DDR2 667:0x0000050b				
OCD_ADJUST_PUP_CS0	60:56	0x0	0x0-0x1f	OCD pull-up adjust setting for DRAMs for chip select 0.
OCD_ADJUST_PDN_CS0	52:48	0x0	0x0-0x1f	OCD pull-down adjust setting for DRAMs for chip select 0.
TRP	43:40	0x0	0x0-0xf	DRAM TRP parameter in cycles.
TDAL	35:32	0x0	0x0-0xf	DRAM TDAL parameter in cycles.
CONF_CTL_10[31:0] Offset: 0xa0 DDR2 667:0x3f130200				
AGE_COUNT	29:24	0x0	0x0-0x3f	Initial value of master aging-rate counter for command aging.
TRC	20:16	0x0	0x0-0x1f	DRAM TRC parameter in cycles.
TMRD	12:8	0x0	0x0-0x1f	DRAM TMRD parameter in cycles.
TFAW	4:0	0x0	0x0-0x1f	DRAM TFAW parameter in cycles.
CONF_CTL_10[63:32] Offset: 0xa0 DDR2 667:0x1d1d1d3f				
DLL_DQS_DELAY_2	62:56	0x0	0x0-0x7f	Fraction of a cycle to delay the DQS signal from the DRAMs for dll_rd_dqs_slice 2 during reads.

Table 12. DDR SDRAM configuration parameter register format (continued)

Parameters	Bits	Default value	Range	Description
DLL_DQS_DELAY_1	54:48	0x0	0x0-0x7f	Fraction of a cycle to delay the DQS signal from the DRAMs for dll_rd_dqs_slice 1 during reads.
DLL_DQS_DELAY_0	46:40	0x0	0x0-0x7f	Fraction of a cycle to delay the DQS signal from the DRAMs for dll_rd_dqs_slice 0 during reads.
COMMAND_AGE_COUNT	37:32	0x0	0x0-0x3f	Initial value of individual command aging counters for command aging.
CONF_CTL_11[31:0] Offset: 0xb0 DDR2 667:0x1d1d1d1d				
DLL_DQS_DELAY_6	30:24	0x0	0x0-0x7f	Fraction of a cycle to delay the DQS signal from the DRAMs for dll_rd_dqs_slice 6 during reads.
DLL_DQS_DELAY_5	22:16	0x0	0x0-0x7f	Fraction of a cycle to delay the DQS signal from the DRAMs for dll_rd_dqs_slice 5 during reads.
DLL_DQS_DELAY_4	14:8	0x0	0x0-0x7f	Fraction of a cycle to delay the DQS signal from the DRAMs for dll_rd_dqs_slice 4 during reads.
DLL_DQS_DELAY_3	6:0	0x0	0x0-0x7f	Fraction of a cycle to delay the DQS signal from the DRAMs for dll_rd_dqs_slice 3 during reads.
CONF_CTL_11[63:32] Offset: 0xb0 DDR2 667:0x507f1d1d				
WR_DQS_SHIFT	62:56	0x0	0x0-0x7f	Fraction of a cycle to delay the clk_wr signal in the controller.
DQS_OUT_SHIFT	54:48	0x0	0x0-0x7f	Fraction of a cycle to delay the write DQS signal to the DRAMs during writes.
DLL_DQS_DELAY_8	46:40	0x0	0x0-0x7f	Fraction of a cycle to delay the DQS signal from the DRAMs for dll_rd_dqs_slice 8 during reads.
DLL_DQS_DELAY_7	38:32	0x0	0x0-0x7f	Fraction of a cycle to delay the DQS signal from the DRAMs for dll_rd_dqs_slice 7 during reads.
CONF_CTL_12[31:0] Offset: 0xc0 DDR2 667:0x0e000000				
TRAS_MIN	31:24	0x0	0x0-0xff	DRAM TRAS_MIN parameter in cycles.
OUT_OF_RANGE_LENGTH	23:16	0x0	0x0-0xff	Length of command that caused an Out-of-Range interrupt. Read-only.
ECC_U_SYND	15:8	0x0	0x0-0xff	Syndrom for uncorrectable ECC event. Read-only.
ECC_C_SYND	7:0	0x0	0x0-0xff	Syndrom for correctable ECC event. Read-only.
CONF_CTL_12[63:32] Offset: 0xc0 DDR2 667:0x002a3305				

Table 12. DDR SDRAM configuration parameter register format (continued)

Parameters	Bits	Default value	Range	Description
DLL_DQS_DELAY_BYPASS_0	56:48	0x0	0x0-0x1ff	Number of delay elements to include in the DQS signal from the DRAMs for dll_rd_dqs_slice 0 during reads when DLL is being bypassed.
TRFC	47:40	0x0	0x0-0xff	DRAM TRFC parameter in cycles.
TRCD_INT	39:32	0x0	0x0-0xff	DRAM TRCD parameter in cycles.
CONF_CTL_13[31:0] Offset: 0xd0 DDR2 667:0x002a002a				
DLL_DQS_DELAY_BYPASS_2	24:16	0x0	0x0-0x1	Number of delay elements to include in the DQS signal from the DRAMs for dll_rd_dqs_slice 2 during reads when DLL is being bypassed.
DLL_DQS_DELAY_BYPASS_1	8:0	0x0	0x0-0x1	Number of delay elements to include in the DQS signal from the DRAMs for dll_rd_dqs_slice 1 during reads when DLL is being bypassed.
CONF_CTL_13[63:32] Offset: 0xd0 DDR2 667:0x002a002a				
DLL_DQS_DELAY_BYPASS_4	56:48	0x0	0x0-0x1ff	Number of delay elements to include in the DQS signal from the DRAMs for dll_rd_dqs_slice 4 during reads when DLL is being bypassed.
DLL_DQS_DELAY_BYPASS_3	40:32	0x0	0x0-0x1ff	Number of delay elements to include in the DQS signal from the DRAMs for dll_rd_dqs_slice 3 during reads when DLL is being bypassed.
CONF_CTL_14[31:0] Offset: 0xe0 DDR2 667:0x002a002a				
DLL_DQS_DELAY_BYPASS_6	24:16	0x0	0x0-0x1ff	Number of delay elements to include in the DQS signal from the DRAMs for dll_rd_dqs_slice 6 during reads when DLL is being bypassed.
DLL_DQS_DELAY_BYPASS_5	8:0	0x0	0x0-0x1ff	Number of delay elements to include in the DQS signal from the DRAMs for dll_rd_dqs_slice 7 during reads when DLL is being bypassed.
CONF_CTL_14[63:32] Offset: 0xe0 DDR2 667:0x002a002a				
DLL_DQS_DELAY_BYPASS_8	56:48	0x0	0x0-0x1ff	Number of delay elements to include in the DQS signal from the DRAMs for dll_rd_dqs_slice 8 during reads when DLL is being bypassed.
DLL_DQS_DELAY_BYPASS_7	40:32	0x0	0x0-0x1ff	Number of delay elements to include in the DQS signal from the DRAMs for dll_rd_dqs_slice 7 during reads when DLL is being bypassed.
CONF_CTL_15[31:0] Offset: 0xf0 DDR2 667:0x00000004				

Table 12. DDR SDRAM configuration parameter register format (continued)

Parameters	Bits	Default value	Range	Description
DLL_LOCK	24:16	0x0	0x0-0x1ff	Number of delay elements in master DLL lock. Read-only.
DLL_INCREMENT	8:0	0x0	0x0-0x1ff	Number of elements to add to DLL_START_POINT when searching for lock.
CONF_CTL_15[63:32] Offset: 0xf0 DDR2 667:0x00b4000a				
DQS_OUT_SHIFT_BYPASS	56:48	0x0	0x0-0x1ff	Number of delay elements to include in the write DQS signal to the DRAMs during writes when DLL is being bypassed.
DLL_START_POINT	40:32	0x0	0x0-0x1ff	Initial delay count when searching for lock in master DLL.
CONF_CTL_16[31:0] Offset: 0x100 DDR2 667:0x00000087				
INT_ACK	25:16	0x0	0x0-0x3ff	Clear mask of the INT_STATUS parameter. Write-only.
WR_DQS_SHIFT_BYPASS	8:0	0x0	0x0-0x1ff	Number of delay elements to include in the clk_wr signal in the controller when DLL is being bypassed.
CONF_CTL_16[63:32] Offset: 0x100 DDR2 667:0x00000000				
INT_STATUS	58:48	0x0	0x0-0x7ff	Status of interrupt features in the controller. Read-only.
INT_MASK	42:32	0x0	0x0-0x7ff	Mask for controller_int signals from the INT_STATUS parameter.
CONF_CTL_17[31:0] Offset: 0x110 DDR2 667:0x0000181b				
EMRS1_DATA	30:16	0x0	0x0-0x7ff	EMRS1 data.
TREF	13:0	0x0	0x0-0x3ff	DRAM TREF parameter in cycles.
CONF_CTL_17[63:32] Offset: 0x110 DDR2 667:0x00000000				
EMRS2_DATA_1	62:48	0x0000	0x0-0x7fff	EMRS2 data for chip select 1.
EMRS2_DATA_0	46:32	0x0000	0x0-0x7fff	EMRS2 data for chip select 0.
CONF_CTL_18[31:0] Offset: 0x120 DDR2 667:0x00000000				
EMRS2_DATA_3	30:16	0x0000	0x0-0x7fff	EMRS2 data for chip select 3.
EMRS2_DATA_2	14:0	0x0000	0x0-0x7fff	EMRS2 data for chip select 2.
CONF_CTL_18[63:32] Offset: 0x120 DDR2 667:0x001c0000				
AXI0_EN_SIZE_LT_WIDTH_IN STR	63:48	0x0000	0x0-0xffff	Allow narrow instructions from port 0 requestors with bit enabled.

Table 12. DDR SDRAM configuration parameter register format (continued)

Parameters	Bits	Default value	Range	Description
EMRS3_DATA	46:32	0x0000	0x0-0x7fff	EMRS3 data.
CONF_CTL_19[31:0] Offset: 0x130 DDR2 667:0x00c8006b				
TDLL	31:16	0x0000	0x0-0xffff	DRAM TDLL parameter in cycles.
TCPD	15:0	0x0000	0x0-0xffff	DRAM TCPD parameter in cycles.
CONF_CTL_19[63:32] Offset: 0x130 DDR2 667:0x48e10002				
TRAS_MAX	63:48	0x0000	0x0-0xffff	DRAM TRAS_MAX parameter in cycles.
TPDEX	47:32	0x0000	0x0-0xffff	DRAM TPDEX parameter in cycles.
CONF_CTL_20[31:0] Offset: 0x140 DDR2 667:0x00c8002f				
TXSR	31:16	0x0000	0x0-0xffff	DRAM TXSR parameter in cycles.
TXSNR	15:0	0x0000	0x0-0xffff	DRAM TXSNR parameter in cycles.
CONF_CTL_20[63:32] Offset: 0x140 DDR2 667:0x00000000				
XOR_CHECK_BITS	63:48	0x0000	0x0-0xffff	Value to XOR with generated ECC codes for forced write check.
VERSION	47:32	0x2041	0x2041	Controller version number. Read-only.
CONF_CTL_21[31:0] Offset: 0x150 DDR2 667:0x00000036				
ECC_C_ADDR[7:0]	31:24	0x0000	0x0-0xffffffff	Address of correctable ECC event. Read-only.
TINIT	23:0	0x0000	0x0-0xffff	DRAM TINIT parameter in cycles.
CONF_CTL_21[63:32] Offset: 0x150 DDR2 667:0x00000000				
ECC_C_ADDR[36:8]	60:32	0x0	0x0-0xffffffff	Address of correctable ECC event. Read-only.
CONF_CTL_22[31:0] Offset: 0x160 DDR2 667:0x00000000				
ECC_U_ADDR[31:0]	31:0	0x0	0x0-0xffffffff	Address of uncorrectable ECC event. Read-only.
CONF_CTL_22[63:32] Offset: 0x160 DDR2 667:0x00000000				
ECC_U_ADDR[36:32]	36:32	0x0	0x0-0xffffffff	Address of uncorrectable ECC event. Read-only.
CONF_CTL_23[31:0] Offset: 0x170 DDR2 667:0x00000000				
OUT_OF_RANGE_ADDR[31:0]	31:0	0x0	0x0-0xffffffff	Address of command that caused an Out-of-Range interrupt. Read-only
CONF_CTL_23[63:32] Offset: 0x170 DDR2 667:0x00000000				
OUT_OF_RANGE_ADDR[36:32]	36:32	0x0	0x0-0xffffffff	Address of command that caused an Out-of-Range interrupt. Read-only.
CONF_CTL_24[31:0] Offset: 0x180 DDR2 667:0x00000000				

Table 12. DDR SDRAM configuration parameter register format (continued)

Parameters	Bits	Default value	Range	Description
PORT_CMD_ERROR_ADDR[31:0]	31:0	0x0	0x0-0x1fffffff	Address of port that caused the PORT command error. Read-only.
CONF_CTL_24[63:32] Offset: 0x180 DDR2 667:0x00000000				
PORT_CMD_ERROR_ADDR[36:32]	36:32	0x0	0x0-0x1fffffff	Address of port that caused the PORT command error. Read-only
CONF_CTL_25[31:0] Offset: 0x190 DDR2 667:0x00000000				
ECC_C_DATA[31:0]	31:0	0x0	0x0-0x1fffffff	Data associated with correctable ECC event. Read-only.
CONF_CTL_25[63:32] Offset: 0x190 DDR2 667:0x00000000				
ECC_C_DATA[63:32]	63:32	0x0	0x0-0x1fffffff	Data associated with correctable ECC event. Read-only.
CONF_CTL_26[31:0] Offset: 0x1a0 DDR2 667:0x00000000				
ECC_U_DATA[31:0]	31:0	0x0	0x0-0x1fffffff	Data associated with uncorrectable ECC event. Read-only.
CONF_CTL_26[63:32] Offset: 0x1a0 DDR2 667:0x00000000				
ECC_U_DATA[63:32]	63:32	0x0	0x0-0x1fffffff	Data associated with uncorrectable ECC event. Read-only.
CONF_CTL_27[63:32] Offset: 0x1b0 DDR2 667:0x00000000				
CKE_DELAY	2:0	0x0	0x0-0x7	Additional cycles to delay CKE for status reporting.
CONF_CTL_28[63:32] Offset: 0x1c0 DDR2 667:0x00000001				
UB_DIMM	0:0	0x0	0x0-0x1	Enable unbuffered DIMM.

Note:

1. CONF_CTL_00 AP
The parameter determines whether the auto pre-charge function is enabled. Once the function is enabled, memory will close the page, after each write/read instruction. If mass continuous address operation happens, the parameter will caused the performance degradation.
2. CONF_CTL_00 CONCURRENTAP
The parameter determines whether the concurrent auto pre-charge function is enabled. Most of SDRAM vendors do not support this feature.
3. CONF_CTL_03 SREFRESH
The parameter is used set the self-refresh style. It must be set 0, when returning from self-refresh.
4. CONF_CTL_07 CASLAT_LIN_GATE
The parameter is used to control the data sample of memory controller when read

operation returns. In general, It is equal to or less than half period of ACALAT_LIN. The Value of CASLAT_LIN is twice of the one of CAS.

5. CONF_CTL_15 DLL_INCREMENT
The parameter should not be set 0.
6. CONF_CTL_15 DLL_START_POINT
The parameter should not be set 0/1 and should be less than the 1.5 times of DLL_LOCK_VALUE.
7. CONF_CTL_28 UB_DIMM
The parameter should be set 1, when unbuffered DIMM(s) are used. It should be set 0, when the SDRAM(s) are used.

4.5 DDR2 SDRAM sample mode configuration

DDR2 SDRAM controller is integrated in the STLS2F01. And the delay compensation circuit (using DLL) is used to sample return data of DQS. Since there is the delay of data return path between the memory controller and SDRAM module, it is necessary to introduce a set of control signals used to measure the delay.

The control signals of DDR2_GATE_I[3:0] and DDR2_GATE_O[3:0] are used to the delay measurement. On the PCB, DDR2_GATE_I and DDR2_GATE_O are connected together to imitate the wiring delay on the PCB. Thus, the accuracy of sampling can be guaranteed.

5 Initialization process

The initialization of STLS2F01 is divided into core part and interface part.

When STLS2F01 PCI interface is configured as main bridge, interface initialization is finished internally. And PCI_RESETn is output signal. When the processor works as PCI/PCI-X devices used in other system, PCI_RESETn acts as input to reset the PCI interface of STLS2F01.

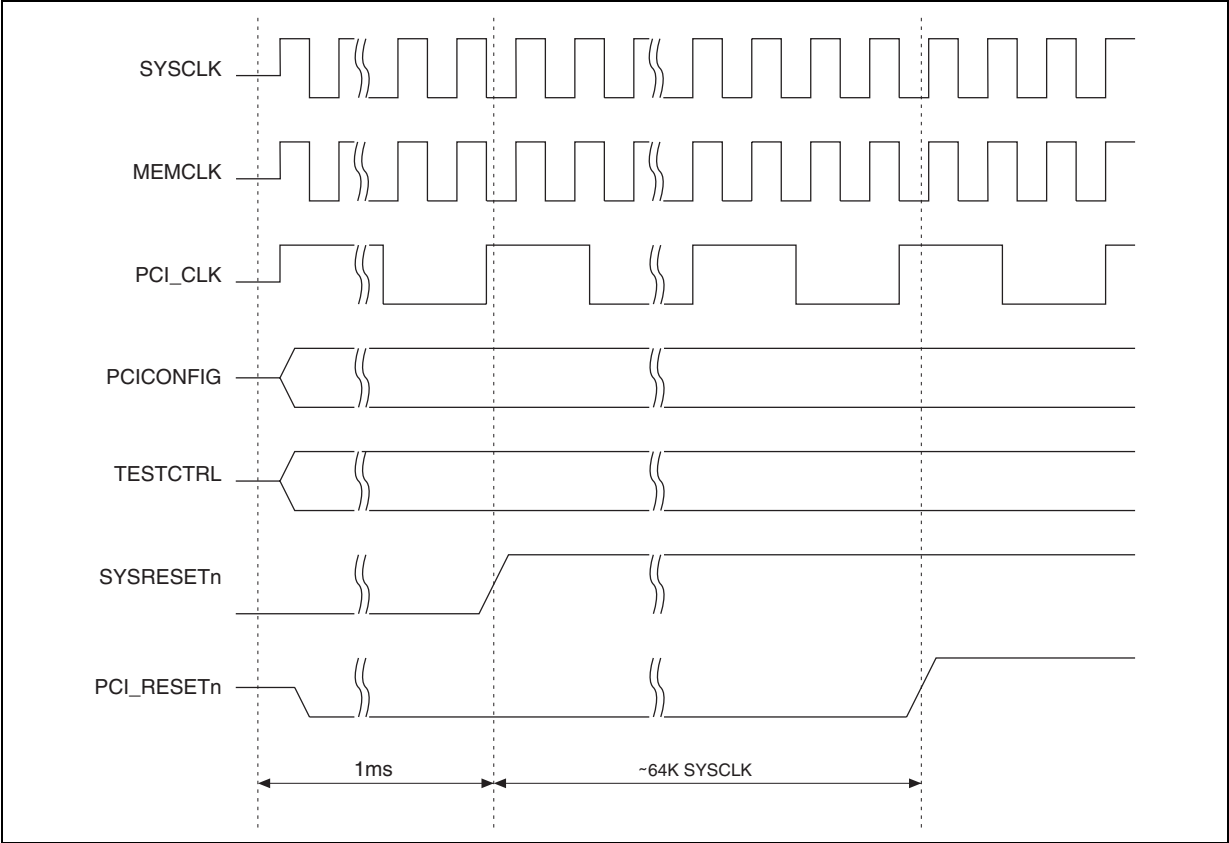
When processor reset signal SYSRESETn is low, related clock, test signals and initial signals must be valid.

- SYSCLK, MEMCLK, CLKSEL and PCI_CLK must be stable
- Initial signal PCI_CONFIG should set to appropriate value
- TEST_CTRL[7:0] are all high

When SYSRESETn is invalid, the processor internal reset logic begins to work to initialize the chip. The SYSRESETn should be valid at least one clock cycle to ensure it can be sampled by reset logic.

The work-mode of PCI bus is decided by main bridge during reset period. As such, PCI_RESETn output generated by processor when it works as main bridge will be used to ensure all devices working at the same mode. When not in main bridge mode, PCI_RESETn input will be used to receive bus configuration.

Figure 9. Initialization process when in main bridge mode



6 Electrical characteristics

6.1 Absolute maximum rating

Stresses above the absolute maximum ratings listed in [Table 13](#) may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions is not implied. Exposure to maximum rating conditions for extended period may affect device reliability.

Table 13. Absolute maximum rating.

Parameter	Description	Min	Max	Unit
vdd	CPU core voltage	1.2	1.3	V
vdde1v8	DDR2 voltage	1.7	1.9	V
vdde3v3	IO voltage	3.0	3.6	V
DDR2_VREF	DDR2 voltage reference	0.83	0.97	V
pll_vdd_1	1.0V PLL1 digital voltage	0.9	1.3	V
pll_vdd_0	1.0V PLL0 digital voltage	0.9	1.3	V
pllio_vdde1v8	1.8V PLL IO voltage	1.7	1.9	V
pll_vdde1v8_1	1.8V PLL1 analog voltage	1.7	1.9	V
Pll_vdde1v8_0	1.8V PLL0 analog voltage	1.7	1.9	V
pllio_vdd	1.2V PLL IO voltage	0.9	1.3	V
TS	Storage Temperature			°C

6.2 Recommended operation environment

Table 14. Recommended operating temperature, voltage supply and frequency

Parameter	Description	Min	Typ	Max	Unit
TA	Operating Temperature	0		85	°C
vdd	CPU core voltage		1.25		V
Vdde1v8	DDR2 voltage		1.8		V
vdde3v3	I/O voltage		3.3		V
DDR2_VREF	DDR2 voltage reference		0.9		V
pll_vdd_1	1.0V PLL1 digital voltage		1.2		V
pll_vdd_0	1.0V PLL0 digital voltage		1.2		V
pllio_vdde1v8	1.8V PLL I/O voltage		1.8		V
pll_vdde1v8_1	1.8V PLL1 analog voltage		1.8		V
Pll_vdde1v8_0	1.8V PLL0 analog voltage		1.8		V
pllio_vdd	1.2V PLL I/O voltage		1.2		V

6.3 DC parameters

Table 15. DC parameters

Parameter	Description	Min	Typ	Max	Unit	Note
V_{IH}	Input high level voltage			2	V	(1)
V_{IL}	input low level voltage	0.8			V	(1)
V_{OH}	output high level voltage	vdde3v3-0.3			V	(2)
V_{OL}	output low level voltage			0.3	V	(2)
I_{IH}	input high level leakage current	0.002		0.4	μ A	(3)
I_{IL}	input low level leakage current	-67.3		-65	μ A	(3)
I_{OL}	output low level current		8		mA	(4)
I_{OH}	output high level current		8		mA	(4)
C_{IN}	Input pin capacitor	4.4	7	7.5	pF	
C_{OUT}	Output pin capacitor	23	25	27	pF	
R_{PH}	Pull-up resistance	32	50	81	$K\Omega$	(5)

1. Input pin level (including tri-state pin).
2. Individual output pin (including output state tri-state pin) level.
3. For tri-state input pin (excluding input).
4. Individual output pin (including output state tri-state pin) driving capability.
5. For input pin (excluding tri-state pin).

Table 16. DC parameters (JTAG)

Parameter	Description	Min	Typ	Max	Unit	Note
C_{TIN}	Test input capacitance	4.4	7	7.5	pF	(1)
C_{TOUT}	Test output capacitance	23	25	27	pF	(2)
C_{TCK}	TCK capacitance	4.4	7	7.5	pF	

1. For TDI, TMS and TRST in JTAG.
2. For TDO in JTAG.

6.4 AC parameters

Table 17. Clock parameters

(Test Conditions: SYSCLK=100 MHz, PCICLK=133 MHz, MEMCLK=333 MHz, CoreClk=1000 MHz)

Parameter	Min	Typ	Max	Unit
SYSCLK High Level Time	2	5	8	ns
SYSCLK Low Level Time	2		8	ns
SYSCLK Rising Time	1		1	ns
SYSCLK Falling Time	1		1	ns
SYSCLK Cycle Variation			±300	ps
PCI_CLK High Level Time	3			ns
PCI_CLK Low Level Time	3			ns
PCI_CLK Rising Slew	1.5			V/ns
PCI_CLK Falling Slew	1.5			V/ns
PCI_CLK Cycle Variation			±500	ps
MEMCLK High Level Time	1.41		1.59	ns
MEMCLK Low Level Time	1.41		1.59	ns
MEMCLK Rising Slew	1			V/ns
MEMCLK Falling Slew	1			V/ns
MEMCLK Cycle Variation			±225	ps
DQS High Level Time	1.35		1.65	ns
DQS Low Level Time	1.35		1.65	ns
DQS Rising Slew	1			V/ns
DQS Falling Slew	1			V/ns
DQS Cycle Variation			±225	ps

Table 18. Input setup and hold time

(Test Conditions: SYSCLK=100 MHz, PCICLK=133 MHz, MEMCLK=333 MHz, CoreClk=1000 MHz)

Parameter	Min	Tpy	Max	Unit
PCI_* Signals Setup Time	1.2			ns
PCI_* Signals Hold Time	0.5			ns
LIO_* Signals Setup Time	1.2			ns
LIO_* Signals Hold Time	0.5			ns
DDR2_DQ*/CB* Signals Setup Time	0.1			ns
DDR2_DQ*/CB* Signals Hold Time	0.175			ns

Table 19. Input setup and hold time

(Test Conditions: SYSCLK=100 MHz, PCICLK=66 MHz, CoreClk=1000 MHz)

Parameter	Min	Typ	Max	Unit
PCI_* Signals Setup Time	3.0			ns
PCI_* Signals Hold Time	0.0			ns
LIO_* Signals Setup Time	3.0			ns
LIO_* Signals Hold Time	0.0			ns

Table 20. Output delay time

(Test Conditions: SYSCLK=100 MHz, PCICLK=133 MHz, CoreClk=1000 MHz)

Parameter	Min	Typ	Max	Unit
PCI_* Signals Effective Delay	0.7		3.8	ns
LIO_* Signals Effective Delay	1.5		6.0	ns
DDDR2_A*/RAS*/CAS*/WE*/CS*/CKE*/ODT* Signals Effective Delay		1.5		ns
DDR2_DQ*/DQM* Effective Delay		0.75		ns

Table 21. JTAG parameters

(Test Condition: TCK = 100 MHz)

Parameter	Min	Typ	Max	Unit
TCK high level time	2	5	8	ns
TCK low level time	2		8	ns
TCK rising time	1		1	ns
TCK falling time	1		1	ns
TRST pulse width	10			ns
TDI,TMS setup time	3.5		4.4	ns
TDI,TMS hold time	2.5		5.5	ns
TDO output effective delay			1.28	ns
TDO output disable delay			1.28	ns

7 Thermal characteristics

7.1 Thermal resistivity

Heat spreader optimized with the following assumptions

- Ambient temperature 40 °C
- Package assembled on PCB as per JEDEC EIA/JESD51-9
- Max power 7.45 W

Customer should implement power extraction from the top of the package so that package case to ambient R_{th} is below 16 °C/W.

Without air flow, this can be achieved with a 40x40x15 heat spreader or 27x27x25 HS or 35x35x18 HS. This should guarantee 120 °C max junction temperature (low margin).

The preferred configuration is to use a 27x27x10 HS with 0.5m/s air flow. A single fan in PC case should be enough. In such case, max Junction temp should be around 112 °C.

7.2 Reflow temperature to time curve

The STLS2F01 processor uses a flip-chip eutectic packaging technology. It can endure maximum reflow temperature ranging from 235 °C to 245 °C. The reflow temperature curve and parameters are showed in [Figure 10](#) and [Table 22](#).

Figure 10. Reflow temperature to time curve

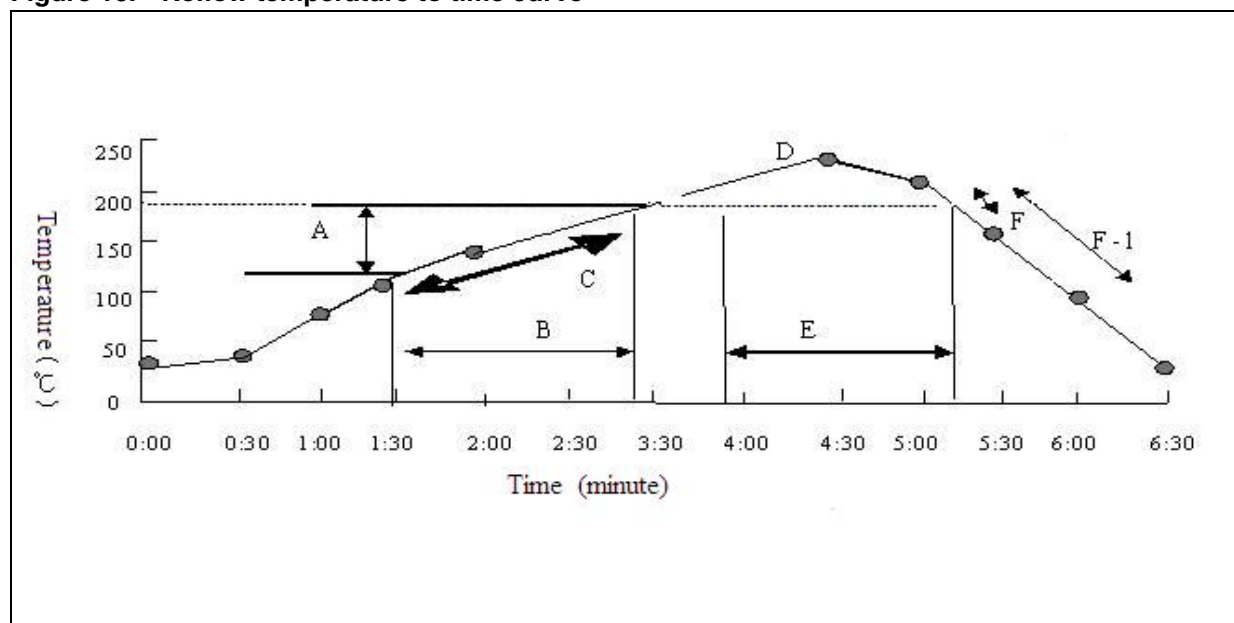


Table 22. Reflow temperature parameters

Parameter	Value	Unit
A	120 ~ 180	°C
B	90 ~ 120	sec
C	0.3 ~ 2.0	°C/sec
D	235 ~ 245	°C
E	85 ~ 105	sec
F	< 1.2	°C/sec
F-1	< 1.0	°C/sec

8 Pin arrangement and package information

8.1 Pin arrangement

The STLS2F01 processor is packaged in HFCBGA452. The pin arrangement is showed in [Figure 11](#), and [Figure 13](#),

Figure 11. Pin arrangement (left-hand side)

	1	2	3	4	5	6	7	8	9
A	gnde	vdd	TEST_CTRL7	LIO_AD01	LIO_AD04	LIO_AD12	LIO_A3	LIO_A5	LIO_A7
B	vdd	gnde	TEST_CTRL5	TEST_CTRL6	LIO_AD05	LIO_AD08	LIO_A1	LIO_A4	sysclk
C	vdd	TEST_CTRL3	gnde	memclk	SYSRESETN	LIO_AD06	LIO_AD14	LIO_A0	testclk
D	TEST_CTRL0	TEST_CTRL1	TEST_CTRL2	gnde	pllclk0	LIO_AD02	LIO_AD10	LIO_AD09	pllclk0
E	pll_vdd_1	gpio0	gpio2	gpio3					
F	pllio_vdde1v8	pll_gnd_1	pll_vdde1v8_1	pll_gnde_1					
G	gpio1	pllio_gnd	pllio_vdd	pllio_gnde					
H	vdd	pll_gnde_0	gnde	gnde					9
J	vdd	gnde	pll_gnd_0	pll_vdde1v8_0				J	gnde
K	CLKSEL7	pll_vdd_0	gnde	gnde				K	gnde
L	CLKSEL6	CLKSEL5	CLKSEL8	CLKSEL9				L	vdd
M	CLKSEL3	CLKSEL4	CLKSEL0	CLKSEL2				M	vdd
N	vdd	CLKSEL1	PCI_CONFIG7	PCI_CONFIG6				N	vdd
P	vdd	PCI_CONFIG5	PCI_CONFIG4	vdde3v3				P	vdd
R	PCI_CONFIG3	PCI_CONFIG0	PCI_CONFIG1	vdde3v3				R	vdd
T	PCI_CONFIG2	PCI_IDSEL	PCI_AD00	PCI_AD02				T	vdd
U	PCI_AD01	PCI_AD03	PCI_AD05	PCI_AD04				U	gnde
V	PCI_CBE0	PCI_AD06	PCI_AD07	PCI_AD08				V	gnde
W	PCI_AD10	PCI_AD09	PCI_AD12	PCI_AD14					9
Y	GND	PCI_AD11	PCI_AD13	PCI_CBE1					
AA	PCI_AD15	PCI_PAR	PCI_SERR	PCI_FRAME0					
AB	PCI_PERR	PCI_STOP0	PCI_IRDY0	VDD					
AC	PCI_TRDY0	PCI_DEVSEL0	vdd	gnde	PCI_AD19	PCI_AD22	PCI_AD28	PCI_AD30	PCI_GNT05
AD	vdd	PCI_CBE2	gnde	PCI_AD17	PCI_AD23	PCI_AD24	PCI_AD27	PCI_GNT06	PCI_REQ05
AE	vdd	gnde	PCI_AD16	PCI_AD18	PCI_AD21	PCI_AD26	PCI_AD31	PCI_REQ06	PCI_GNT03
AF	gnde	vdd	vdd	PCI_AD20	PCI_CBE3	PCI_AD25	PCI_AD29	PCI_REQ04	PCI_GNT04
	1	2	3	4	5	6	7	8	9

Figure 12. Pin arrangement (middle)

10	11	12	13	14	15	16	17	18	
TEST_CTRL4	LIO_AD07	LIO_A2	LIO_ADLOCK	DDR2_VREF	DDR2_DQSn0	DDR2_DQ03	DDR2_DQ12	DDR2_DQM1	A
LIO_AD00	LIO_AD15	LIO_A6	LIO_DIR	DDR2_DQ00	DDR2_DQSp0	DDR2_DQ02	DDR2_DQ09	DDR2_DQSp1	B
LIO_AD03	LIO_AD13	LIO_RDn	LIO_DEN	DDR2_DQ04	DDR2_DQ05	DDR2_DQ06	DDR2_DQ08	DDR2_DQSn1	C
LIO_AD11	LIO_CSn	LIO_WRn	LIO_ROMCSn	DDR2_DQ01	DDR2_DQM0	DDR2_DQ07	DDR2_DQ13	DDR2_GATEI0	D
									E
									F
									G
10	11	12	13	14	15	16	17	18	H
vdd	vdd	vdd	gnde	gnde	gnde	vdde1v8	vdde1v8	gnde	J
gnde	vdde3v3	vdde3v3	vdde3v3	vdde1v8	vdde1v8	vdde1v8	vdde1v8	gnde	K
vdde3v3	vdde3v3	vdde3v3	gnd	gnd	vdde1v8	vdde1v8	vdde1v8	vdde1v8	L
vdde3v3	gnd	gnd	gnd	gnd	gnd	gnd	vdde1v8	gnde	M
vdde3v3	gnd	gnd	gnd	gnd	gnd	gnd	vdde1v8	gnde	N
vdde3v3	gnd	gnd	gnd	gnd	gnd	gnd	vdde1v8	gnde	P
vdde3v3	gnd	gnd	gnd	gnd	gnd	gnd	vdde1v8	gnde	R
vdde3v3	vdde3v3	vdde3v3	gnd	gnd	vdde1v8	vdde1v8	vdde1v8	vdde1v8	T
vdde3v3	vdde3v3	vdde3v3	vdde3v3	vdde1v8	vdde1v8	vdde1v8	vdde1v8	gnde	U
gnde	vdd	vdd	vdde3v3	gnde	gnde	vdde1v8	vdde1v8	gnde	V
10	11	12	13	14	15	16	17	18	W
									Y
									AA
									AB
PCI_REQn3	PCI_GNTn1	PCI_IRQnA	INTN1	tck	comp1v8_resistor	DDR2_SCSn1	DDR2_A00	DDR2_ODT0	AC
PCI_REQn2	PCI_REQn0	PCI_IRQnC	INTN2	tdo	PCI_CLK	DDR2_ODT3	DDR2_SCSn3	DDR2_ODT2	AD
PCI_GNTn2	PCI_GNTn0	PCI_IRQnB	INTN3	trst	tms	DDR2_ODT1	DDR2_A01	DDR2_CASn	AE
PCI_REQn1	PCI_RESETn	PCI_IRQnD	NMIN	INTN0	tdi	comp1v8_gnd	DDR2_A02	DDR2_A13	AF
10	11	12	13	14	15	16	17	18	

Figure 13. Pin arrangement (right-hand side)

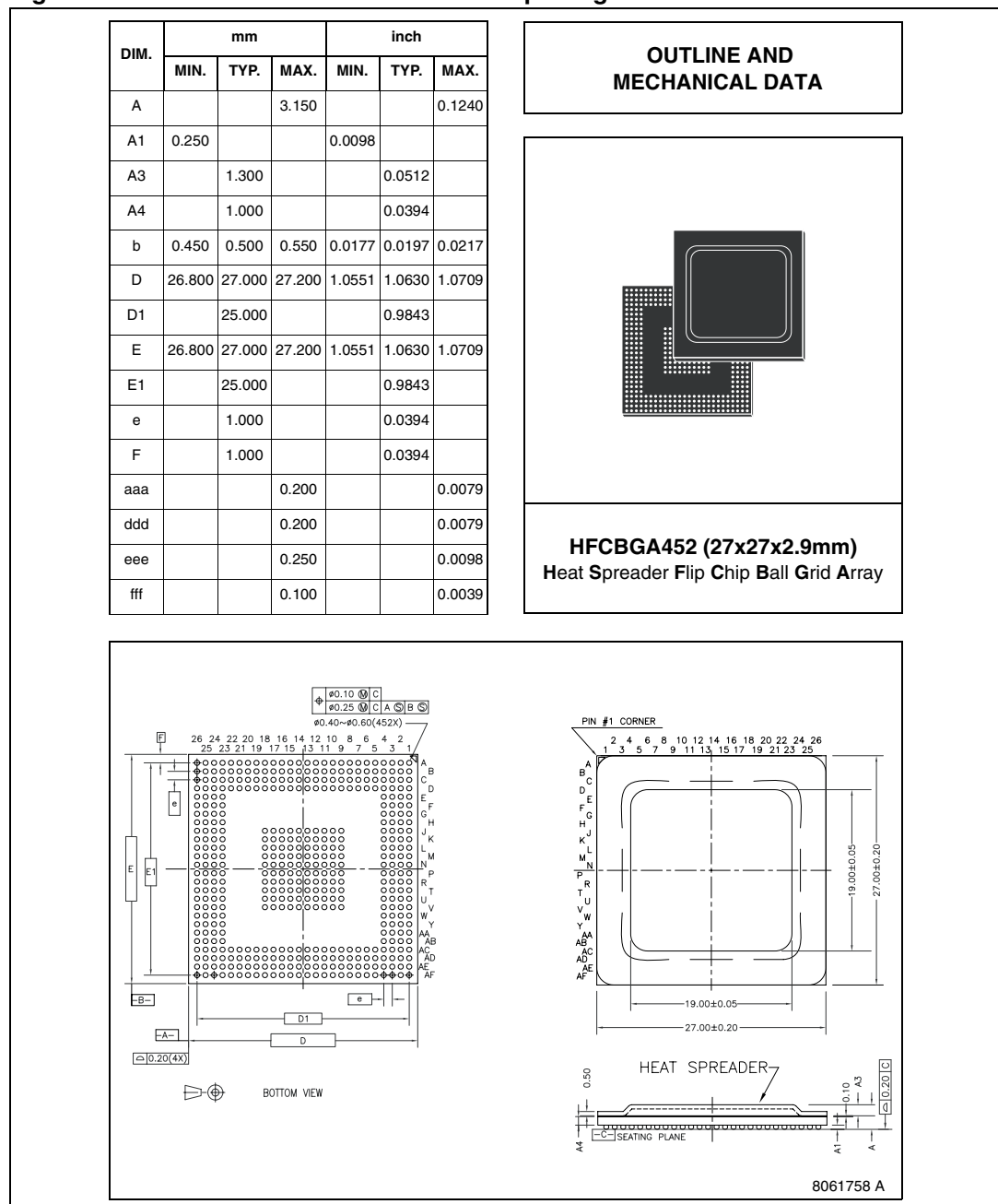
19	20	21	22	23	24	25	26	
DDR2_GATE00	DDR2_DQM2	DDR2_DQ20	DDR2_DQ22	DDR2_CKE3	vdde1v8	vdde1v8	gnde	A
DDR2_DQ14	DDR2_DQ16	DDR2_DQ17	DDR2_DQ23	DDR2_CK4	DDR2_CKE1	gnde	vdde1v8	B
DDR2_DQ15	DDR2_DQ10	DDR2_DQSp2	DDR2_DQ18	DDR2_CKp4	gnde	DDR2_CKE2	DDR2_A12	C
DDR2_DQ11	DDR2_DQ21	DDR2_DQSn2	DDR2_DQ19	gnde	DDR2_CK1	DDR2_CKp1	DDR2_BA2	D
				DDR2_A14	DDR2_A07	DDR2_A11	DDR2_A06	E
				DDR2_A08	DDR2_CKE0	DDR2_A05	DDR2_A04	F
				DDR2_A09	DDR2_A03	DDR2_DQ29	DDR2_DQ28	G
				DDR2_DQM3	DDR2_DQ25	DDR2_DQ24	DDR2_DQ31	H
J				DDR2_DQ30	DDR2_DQ36	DDR2_DQSn3	DDR2_DQSp3	J
K				DDR2_DQ27	DDR2_DQ26	DDR2_GATE01	DDR2_GATE11	K
L				DDR2_DQ37	DDR2_DQ33	DDR2_DQ32	DDR2_DQM4	L
M				DDR2_DQ39	DDR2_DQ38	DDR2_DQSn4	DDR2_DQSp4	M
N				DDR2_DQ34	DDR2_DQ35	DDR2_CKp3	DDR2_CK3	N
P				DDR2_BA1	DDR2_A10	DDR2_CK0	DDR2_CKp0	P
R				DDR2_SCSn2	DDR2_SCS0	DDR2_BA0	DDR2_RASn	R
T				DDR2_DQ44	DDR2_DQ40	DDR2_DQ45	DDR2_DQ41	T
U				DDR2_DQ43	DDR2_DQSn5	DDR2_DQSp5	DDR2_DQM5	U
V				DDR2_DQ48	DDR2_DQ47	DDR2_DQ42	DDR2_DQ46	V
				DDR2_DQ52	DDR2_DQ49	DDR2_GATE12	DDR2_GATE02	W
				DDR2_DQ55	DDR2_DQ51	DDR2_DQSp6	DDR2_DQSn6	Y
				DDR2_DQM6	DDR2_DQ53	DDR2_DQ54	DDR2_DQ50	AA
				DDR2_DQ61	DDR2_DQ60	DDR2_DQM7	DDR2_DQ56	AB
DDR2_WEn	DDR2_CB2	DDR2_DQM8	DDR2_GATE13	gnde	DDR2_DQSp7	DDR2_DQSn7	DDR2_DQ57	AC
DDR2_CKp2	DDR2_CB3	DDR2_CB6	DDR2_GATE03	DDR2_DQ59	gnde	DDR2_DQ62	DDR2_DQ58	AD
DDR2_CK2	DDR2_CB7	DDR2_DQSp8	DDR2_CB5	DDR2_CB4	DDR2_DQ63	gnde	vdde1v8	AE
DDR2_CK5	DDR2_CKp5	DDR2_DQSn8	DDR2_CB1	DDR2_CB0	vdde1v8	vdde1v8	gnde	AF
19	20	21	22	23	24	25	26	

9 Package information

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect. The category of second Level Interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label.

ECOPACK is an ST trademark. ECOPACK specifications are available at: www.st.com.

Figure 14. HFCBGA452 mechanical data & package dimensions



10 Revision history

Table 23. Document revision history

Date	Revision	Changes
30-May-2008	1	Initial release.

Please Read Carefully:

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST's terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

UNLESS OTHERWISE SET FORTH IN ST'S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

UNLESS EXPRESSLY APPROVED IN WRITING BY AN AUTHORIZED ST REPRESENTATIVE, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCTS OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS "AUTOMOTIVE GRADE" MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER'S OWN RISK.

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

© 2008 STMicroelectronics - All rights reserved

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

www.st.com