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IS42/45S16100F, IS42VS16100F

512K Words x 16 Bits x 2 Banks 16Mb SDRAM

JUNE 2012

FEATURES

- Clock frequency:
  IS42/45S16100F: 200, 166, 143 MHz
  IS42VS16100F: 133, 100 MHz
- Fully synchronous; all signals referenced to a positive clock edge
- Two banks can be operated simultaneously and independently
- Dual internal bank controlled by A11 (bank select)
- Single power supply:
  IS42/45S16100F: V_{DD}/V_{DDQ} = 3.3V
  IS42VS16100F: V_{DD}/V_{DDQ} = 1.8V
- LVTTL interface
- Programmable burst length
  – (1, 2, 4, 8, full page)
- Programmable burst sequence: Sequential/Interleave
- 2048 refresh cycles every 32 ms
- Random column address every clock cycle
- Programmable $\overline{CAS}$ latency (2, 3 clocks)
- Burst read/write and burst read/single write operations capability
- Burst termination by burst stop and precharge command
- Byte controlled by LDQM and UDQM
- Packages 400-mil 50-pin TSOP-II and 60-ball BGA
- Lead-free package option
- Available in Industrial Temperature

DESCRIPTION

ISSI's 16Mb Synchronous DRAM IS42S16100F, IS45S16100F and IS42VS16100F are each organized as a 524,288-word x 16-bit x 2-bank for improved performance. The synchronous DRAMs achieve high-speed data transfer using pipeline architecture. All inputs and outputs signals refer to the rising edge of the clock input.

ADDRESS TABLE

Parameter	IS42/45S16100F	IS42VS16100F
Power Supply V_{DD}/V_{DDQ}	3.3V	1.8V
Refresh Count	2K/32ms	2K/32ms
Row Addressing	A0-A10	
Column Addressing	A0-A7	
Bank Addressing	A11	
Precharge Addressing	A10	

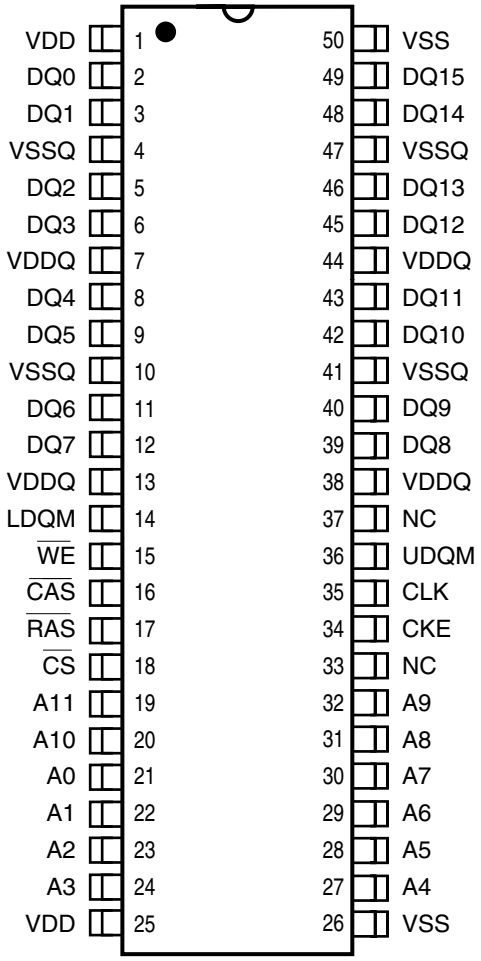
KEY TIMING PARAMETERS

Parameter	-5(1)	-6(2)	-7 (2)	-75 (3)	-10 (3)	Unit
CLK Cycle Time						
$\overline{CAS}$ Latency = 3	5	6	7	7.5	10	ns
$\overline{CAS}$ Latency = 2	10	10	10	10	12	ns
CLK Frequency						
$\overline{CAS}$ Latency = 3	200	166	143	133	100	Mhz
$\overline{CAS}$ Latency = 2	100	100	100	100	83	Mhz
Access Time from Clock						
$\overline{CAS}$ Latency = 3	5	5.5	5.5	6	7	ns
$\overline{CAS}$ Latency = 2	6	6	6	8	8	ns

Notes:
1. Available for IS42S16100F only
2. Available for IS42S16100F and IS45S16100F only
3. Available for IS42VS16100F only

PIN CONFIGURATIONS

50-Pin TSOP (Type II)

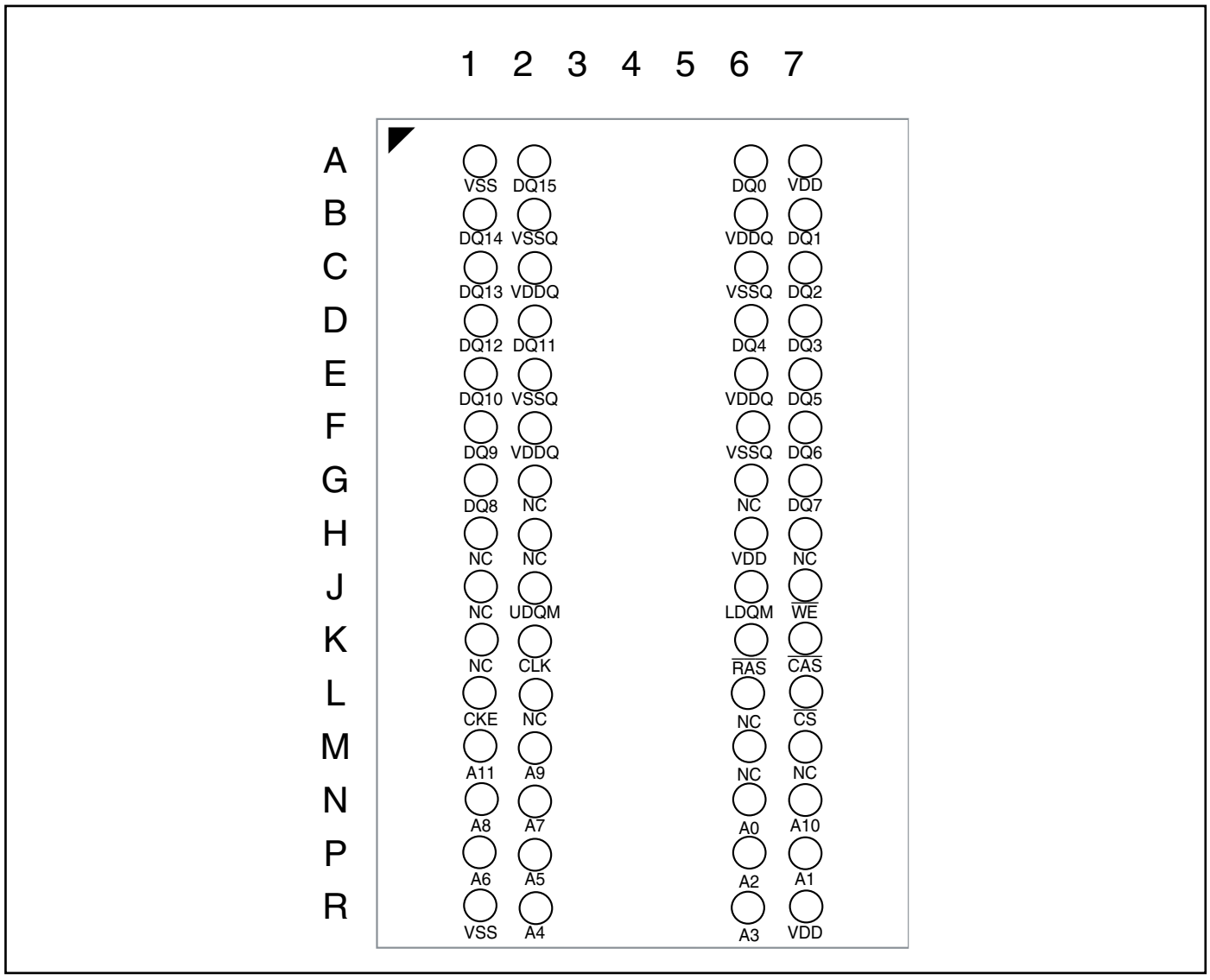


PIN DESCRIPTIONS

A0-A11	Address Input
A0-A10	Row Address Input
A11	Bank Select Address
A0-A7	Column Address Input
DQ0 to DQ15	Data DQ
CLK	System Clock Input
CKE	Clock Enable
$\overline{CS}$	Chip Select
$\overline{RAS}$	Row Address Strobe Command
$\overline{CAS}$	Column Address Strobe Command
$\overline{WE}$	Write Enable
LDQM	Lower Bye, Input/Output Mask
UDQM	Upper Bye, Input/Output Mask
VDD	Power
VSS	Ground
VDDQ	Power Supply for DQ Pin
VSSQ	Ground for DQ Pin
NC	No Connection

PIN CONFIGURATION

PACKAGE CODE: B 60 BALL TF-BGA (Top View) (10.1 mm x 6.4 mm Body, 0.65 mm Ball Pitch)



PIN DESCRIPTIONS

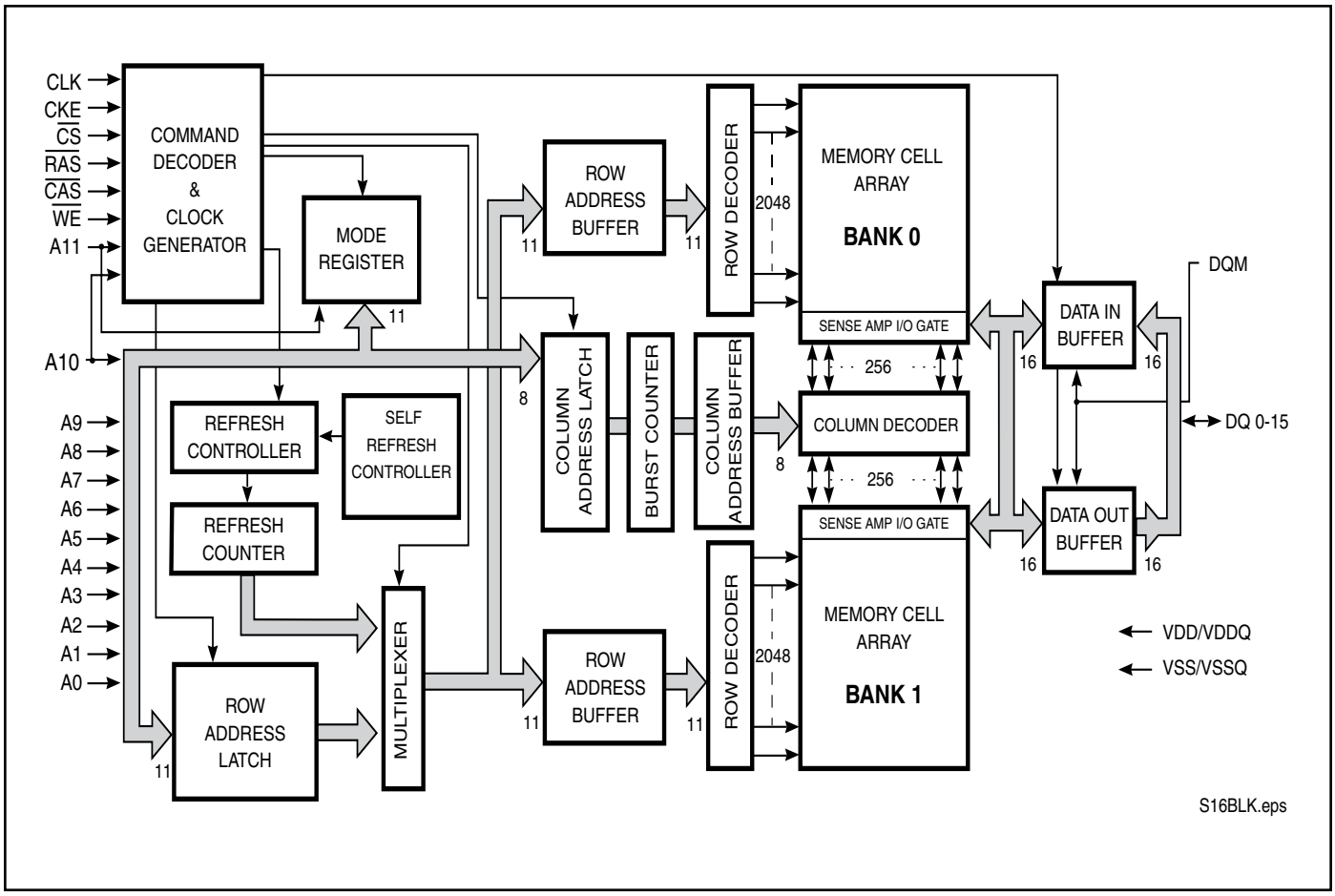
A0-A10	Row Address Input
A0-A7	Column Address Input
A11	Bank Select Address
DQ0 to DQ15	Data I/O
CLK	System Clock Input
CKE	Clock Enable
$\overline{CS}$	Chip Select
$\overline{RAS}$	Row Address Strobe Command
$\overline{CAS}$	Column Address Strobe Command

$\overline{WE}$	Write Enable
LDQM, UDQM	x16 Input/Output Mask
V_{DD}	Power
Vss	Ground
V_{DDQ}	Power Supply for I/O Pin
V_{SSQ}	Ground for I/O Pin
NC	No Connection

PIN FUNCTIONS

Pin No.	Symbol	Type	Function (In Detail)
20 to 24 27 to 32	A0-A10	Input Pin	A0 to A10 are address inputs. A0-A10 are used as row address inputs during active command input and A0-A7 as column address inputs during read or write command input. A10 is also used to determine the precharge mode during other commands. If A10 is LOW during precharge command, the bank selected by A11 is precharged, but if A10 is HIGH, both banks will be precharged. When A10 is HIGH in read or write command cycle, the precharge starts automatically after the burst access. These signals become part of the OP CODE during mode register set command input.
19	A11	Input Pin	A11 is the bank selection signal. When A11 is LOW, bank 0 is selected and when high, bank 1 is selected. This signal becomes part of the OP CODE during mode register set command input.
16	$\overline{CAS}$	Input Pin	$\overline{CAS}$, in conjunction with the $\overline{RAS}$ and $\overline{WE}$, forms the device command. See the "Command Truth Table" item for details on device commands.
34	CKE	Input Pin	The CKE input determines whether the CLK input is enabled within the device. When is CKE HIGH, the next rising edge of the CLK signal will be valid, and when LOW, invalid. When CKE is LOW, the device will be in either the power-down mode, the clock suspend mode, or the self refresh mode. The CKE is an asynchronous input.
35	CLK	Input Pin	CLK is the master clock input for this device. Except for CKE, all inputs to this device are acquired in synchronization with the rising edge of this pin.
18	$\overline{CS}$	Input Pin	The $\overline{CS}$ input determines whether command input is enabled within the device. Command input is enabled when $\overline{CS}$ is LOW, and disabled with $\overline{CS}$ is HIGH. The device remains in the previous state when $\overline{CS}$ is HIGH.
2, 3, 5, 6, 8, 9, 11 12, 39, 40, 42, 43, 45, 46, 48, 49	DQ0 to DQ15	DQ Pin	DQ0 to DQ15 are DQ pins. DQ through these pins can be controlled in byte units using the LDQM and UDQM pins.
14, 36	LDQM, UDQM	Input Pin	LDQM and UDQM control the lower and upper bytes of the DQ buffers. In read mode, LDQM and UDQM control the output buffer. When LDQM or UDQM is LOW, the corresponding buffer byte is enabled, and when HIGH, disabled. The outputs go to the HIGH impedance state when LDQM/UDQM is HIGH. This function corresponds to $\overline{OE}$ in conventional DRAMs. In write mode, LDQM and UDQM control the input buffer. When LDQM or UDQM is LOW, the corresponding buffer byte is enabled, and data can be written to the device. When LDQM or UDQM is HIGH, input data is masked and cannot be written to the device.
17	$\overline{RAS}$	Input Pin	$\overline{RAS}$, in conjunction with $\overline{CAS}$ and $\overline{WE}$, forms the device command. See the "Command Truth Table" item for details on device commands.
15	$\overline{WE}$	Input Pin	$\overline{WE}$, in conjunction with $\overline{RAS}$ and $\overline{CAS}$, forms the device command. See the "Command Truth Table" item for details on device commands.
7, 13, 38, 44	VDDQ	Power Supply Pin	VDDQ is the output buffer power supply.
1, 25	VDD	Power Supply Pin	VDD is the device internal power supply.
4, 10, 41, 47	VSSQ	Power Supply Pin	VSSQ is the output buffer ground.
26, 50	VSS	Power Supply Pin	VSS is the device internal ground.

FUNCTIONAL BLOCK DIAGRAM



IS42S16100F ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS(1)

Symbol	Parameters		Rating	Unit
$V_{DD\ MAX}$	Maximum Supply Voltage		–1.0 to +4.6	V
$V_{DDQ\ MAX}$	Maximum Supply Voltage for Output Buffer		–1.0 to +4.6	V
V_{IN}	Input Voltage		–1.0 to +4.6	V
V_{OUT}	Output Voltage		–1.0 to +4.6	V
$P_{D\ MAX}$	Allowable Power Dissipation		1	W
I_{CS}	Output Shorted Current		50	mA
T_{OPR}	Operating Temperature	Com.	0 to +70	°C
		Ind.	-40 to +85	°C
		Automotive, A1	-40 to +85	°C
T_{STG}	Storage Temperature		–55 to +150	°C

DC RECOMMENDED OPERATING CONDITIONS(2)

Commercial (T_A = 0°C to +70°C), Industrial (T_A = -40°C to +85°C), Automotive, A1 (T_A = -40°C to +85°C)

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V_{DD}, V_{DDQ}	Supply Voltage		3.0	3.3	3.6	V
V_{IH}	Input High Voltage(3)		2.0	—	V_{DDQ} + 0.3	V
V_{IL}	Input Low Voltage(4)		-0.3	—	+0.8	V
I_{IL}	Input Leakage Current	0V ≤ V_{IN} ≤ VDD, with pins other than the tested pin at 0V	-5		5	µA
I_{OL}	Output Leakage Current	Output is disabled, 0V ≤ V_{OUT} ≤ VDD	-5		5	µA
V_{OH}	Output High Voltage Level	I_{OUT} = –2 mA	2.4		—	V
V_{OL}	Output Low Voltage Level	I_{OUT} = +2 mA	—		0.4	V

CAPACITANCE CHARACTERISTICS(1,2) (At T_A = 0 to +25°C, VDD = VDDQ = 3.3 ± 0.3V, f = 1 MHz)

Symbol	Parameter	Min.	Max.	Unit
$C_{IN}1$	Input Capacitance: CLK	2.5	4.0	pF
$C_{IN}2$	Input Capacitance: (A0-A11, CKE, $\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$, LDQM, UDQM)	2.5	4.0	pF
CI/O	Data Input/Output Capacitance: DQ0-DQ15	4.0	5.0	pF

Notes:

1. Stress greater than those listed under ABSOLUTE MAXIMUM RATINGS may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.
2. All voltages are referenced to VSS.
3. V_{IH} (max) = V_{DDQ} + 1.2V with a pulse width ≤ 3 ns.
4. V_{IL} (min) = -1.2V with a pulse width ≤ 3 ns.

IS42S16100F and IS45S16100F DC ELECTRICAL CHARACTERISTICS

(Recommended Operation Conditions unless otherwise noted.)

Symbol	Parameter	Test Condition		-5	-6	-7	Unit
I_{CC1}	Operating Current(1,2)	One Bank Operation, $\overline{CAS}$ Latency = 3 Burst Length=1 $t_{RC} \geq t_{RC}$ (min) I_{OUT} = 0mA	Com. Ind., A1	120 —	110 120	100 110	mA mA
I_{CC2P}	Precharge Standby Current (In Power-Down Mode)	CKE ≤ V_{IL} (MAX) $t_{CK} = t_{CK}$ (min)		2	2	2	mA
I_{CC2PS}	Precharge Standby Current (In Power-Down and Clock Suspend Mode)	CKE ≤ V_{IL} (MAX) $t_{CK} = \infty$ CLK ≤ V_{IL} (MAX)		2	2	2	mA
I_{CC2N}	Precharge Standby Current(3) (In Non Power-Down Mode)	CKE ≥ V_{IH} (MIN) $t_{CK} = t_{CK}$ (min) $\overline{CS}$ ≥ V_{IH} (MIN)		35	35	35	mA
I_{CC2NS}	Precharge Standby Current (In Non Power-Down and Clock Suspend Mode)	CKE ≥ V_{IH} (MIN) $t_{CK} = \infty$ CLK ≤ V_{IL} (MAX) Inputs are stable		20	20	20	mA
I_{CC3P}	Active Standby Current (In Power-Down Mode)	CKE ≤ V_{IL} (MAX) $t_{CK} = t_{CK}$ (min)		3	3	3	mA
I_{CC3PS}	Active Standby Current (In Power-Down and Clock Suspend Mode)	CKE ≤ V_{IL} (MAX) $t_{CK} = \infty$ CLK ≤ V_{IL} (MAX) Inputs are stable		3	3	3	mA
I_{CC3N}	Active Standby Current(3) (In Non Power-Down Mode)	CKE ≥ V_{IH} (MIN) $t_{CK} = t_{CK}$ (min) $\overline{CS}$ ≥ V_{IH} (MIN)		55	55	55	mA
I_{CC3NS}	Active Standby Current (In Non Power-Down and Clock Suspend Mode)	CKE ≥ V_{IH} (MIN) $t_{CK} = \infty$ CLK ≤ V_{IL} (MAX) Inputs are stable		30	30	30	mA
I_{CC4}	Operating Current (In Burst Mode)(1,3)	Both Banks activated $t_{CK} = t_{CK}$ (MIN) Page Burst I_{OUT} = 0mA		120	110	100	mA
I_{CC5}	Auto-Refresh Current	$t_{RC} = t_{RC}$ (MIN)	Com. Ind., A1	120 —	100 110	80 90	mA mA
I_{CC6}	Self-Refresh Current	CKE ≤ 0.2V		2	2	2	mA

Notes:

1. These are the values at the minimum cycle time. Since the currents are transient, these values decrease as the cycle time increases. Also note that a bypass capacitor of at least 0.01 µF should be inserted between V_{DD} and Vss for each memory chip to suppress power supply voltage noise (voltage drops) due to these transient currents.
2. I_{CC1} and I_{CC4} depend on the output load. The maximum values for I_{CC1} and I_{CC4} are obtained with the output open state.
3. Inputs changed once every two clocks.

IS42S16100F and IS45S16100F AC CHARACTERISTICS[1,2,3]

Symbol	Parameter		-5 Min.	-5 Max.	-6 Min.	-6 Max.	-7 Min.	-7 Max.	Units
$t_{CK}3$	Clock Cycle Time	$\overline{CAS}$ Latency = 3	5	—	6	—	7	—	ns
$t_{CK}2$		$\overline{CAS}$ Latency = 2	10	—	10	—	10	—	ns
$t_{AC}3$	Access Time From CLK[4]	$\overline{CAS}$ Latency = 3	—	5	—	5.5	—	5.5	ns
$t_{AC}2$		$\overline{CAS}$ Latency = 2	—	6	—	6	—	6	ns
t_{CHI}	CLK HIGH Level Width		2	—	2.5	—	2.5	—	ns
t_{CL}	CLK LOW Level Width		2	—	2.5	—	2.5	—	ns
$t_{OH}3$	Output Data Hold Time	$\overline{CAS}$ Latency = 3	2	—	2.0	—	2.0	—	ns
$t_{OH}2$		$\overline{CAS}$ Latency = 2	2.5	—	2.5	—	2.5	—	ns
t_{LZ}	Output LOW Impedance Time		0	—	0	—	0	—	ns
$t_{HZ}3$	Output HIGH Impedance Time[5]	$\overline{CAS}$ Latency = 3	—	5	—	5.5	—	5.5	ns
$t_{HZ}2$		$\overline{CAS}$ Latency = 2	—	6	—	6	—	6	ns
t_{DS}	Input Data Setup Time		2	—	2	—	2	—	ns
t_{DH}	Input Data Hold Time		1	—	1	—	1	—	ns
t_{AS}	Address Setup Time		2	—	2	—	2	—	ns
t_{AH}	Address Hold Time		1	—	1	—	1	—	ns
t_{CKS}	CKE Setup Time		2	—	2	—	2	—	ns
t_{CKH}	CKE Hold Time		1	—	1	—	1	—	ns
t_{CKA}	CKE to CLK Recovery Delay Time		1CLK+3	—	1CLK+3	—	1CLK+3	—	ns
t_{CS}	Command Setup Time ($\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$, DQM)		2	—	2	—	2	—	ns
t_{CH}	Command Hold Time ($\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$, DQM)		1	—	1	—	1	—	ns
t_{RC}	Command Period (REF to REF / ACT to ACT)		50	—	54	—	63	—	ns
t_{RAS}	Command Period (ACT to PRE)		35	100,000	36	100,000	42	100,000	ns
t_{RP}	Command Period (PRE to ACT)		15	—	18	—	20	—	ns
t_{RCD}	Active Command To Read / Write Command Delay Time		15	—	18	—	20	—	ns
t_{RRD}	Command Period (ACT [0] to ACT[1])		10	—	12	—	14	—	ns
$t_{DPL}3$	Input Data To Precharge	$\overline{CAS}$ Latency = 3	2CLK	—	2CLK	—	2CLK	—	ns
$t_{DPL}2$	Command Delay time	$\overline{CAS}$ Latency = 2	2CLK	—	2CLK	—	2CLK	—	ns
$t_{DAL}3$	Input Data To Active / Refresh	$\overline{CAS}$ Latency = 3	2CLK+t_{RP}	—	2CLK+t_{RP}	—	2CLK+t_{RP}	—	ns
$t_{DAL}2$	Command Delay time (During Auto-Precharge)	$\overline{CAS}$ Latency = 2	2CLK+t_{RP}	—	2CLK+t_{RP}	—	2CLK+t_{RP}	—	ns
t_{XSR}	Exit Self-Refresh to Active Time		55	—	60	—	70	—	ns
t_T	Transition Time		0.3	1.2	0.3	1.2	0.3	1.2	ns
t_{REF}	Refresh Cycle Time (2048)		—	32	—	32	—	32	ms

Notes:

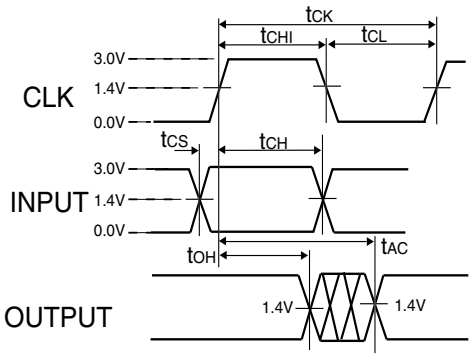
1. When power is first applied, memory operation should be started 100 µs after V_{DD} and V_{DDQ} reach their stipulated voltages. Also note that the power-on sequence must be executed before starting memory operation.
2. Measured with t_T = 1 ns. If clock rising time is longer than 1ns, (t_T/2 - 0.5)ns should be added to the parameter.
3. The reference level is 1.4 V when measuring input signal timing. Rise and fall times are measured between V_{IH} (min.) and V_{IL} (max.).
4. Access time is measured at 1.4V with the load shown in the figure that follows.
5. The time t_{HZ} (max.) is defined as the time required for the output voltage to transition by ± 200 mV from V_{OH} (min.) or V_{OL} (max.) when the output is in the high impedance state.

IS42S16100F and IS45S16100F OPERATING FREQUENCY / LATENCY RELATIONSHIPS

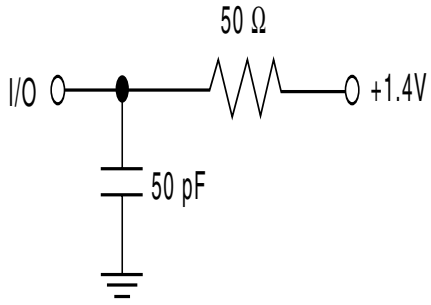
SYMBOL	PARAMETER	-5	-6	-7	UNITS
—	Clock Cycle Time	5	6	7	ns
—	Operating Frequency	200	166	143	MHz
t_{CAC}	$\overline{CAS}$ Latency	3	3	3	cycle
t_{RCD}	Active Command To Read/Write Command Delay Time	3	3	3	cycle
t_{RAC}	$\overline{RAS}$ Latency (t_{RCD} + t_{CAC})	6	6	6	cycle
t_{RC}	Command Period (REF to REF / ACT to ACT)	10	9	9	cycle
t_{RAS}	Command Period (ACT to PRE)	7	6	6	cycle
t_{RP}	Command Period (PRE to ACT)	3	3	3	cycle
t_{RRD}	Command Period (ACT[0] to ACT [1])	2	2	2	cycle
t_{CCD}	Column Command Delay Time (READ, READA, WRIT, WRITA)	1	1	1	cycle
t_{DPL}	Input Data To Precharge Command Delay Time	2	2	2	cycle
t_{DAL}	Input Data To Active/Refresh Command Delay Time (During Auto-Precharge)	5	5	5	cycle
t_{RBD}	Burst Stop Command To Output in HIGH-Z Delay Time (Read)	3	3	3	cycle
t_{WBD}	Burst Stop Command To Input in Invalid Delay Time (Write)	0	0	0	cycle
t_{RQL}	Precharge Command To Output in HIGH-Z Delay Time (Read)	3	3	3	cycle
t_{WDL}	Precharge Command To Input in Invalid Delay Time (Write)	0	0	0	cycle
t_{PQL}	Last Output To Auto-Precharge Start Time (Read)	-2	–2	–2	cycle
t_{QMD}	DQM To Output Delay Time (Read)	2	2	2	cycle
t_{DMD}	DQM To Input Delay Time (Write)	0	0	0	cycle
t_{MCD}	Mode Register Set To Command Delay Time	2	2	2	cycle

AC TEST CONDITIONS (Input/Output Reference Level: 1.4V)

Input



Output Load



IS42VS16100F ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS(1)

Symbol	Parameters		Rating	Unit
$V_{DD\ MAX}$	Maximum Supply Voltage		–0.5 to +2.6	V
$V_{DDQ\ MAX}$	Maximum Supply Voltage for Output Buffer		–0.5 to +2.6	V
V_{IN}	Input Voltage		–0.5 to +2.6	V
V_{OUT}	Output Voltage		–0.5 to +2.6	V
$P_{D\ MAX}$	Allowable Power Dissipation		1	W
I_{CS}	Output Shorted Current		50	mA
T_{OPR}	Operating Temperature	Com Ind.	0 to +70 -40 to +85	°C °C
T_{STG}	Storage Temperature		–55 to +150	°C

DC RECOMMENDED OPERATING CONDITIONS(2)

Commercial (T_A = 0°C to +70°C), Industrial (T_A = -40°C to +85°C)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_{DD}, V_{DDQ}	Supply Voltage		1.7	1.8	1.9	V
V_{IH}	Input High Voltage(3)		0.8 x V_{DDQ}	—	V_{DDQ} + 0.3	V
V_{IL}	Input Low Voltage(4)		-0.3	—	+0.3	V
I_{IL}	Input Leakage Current	0V ≤ V_{IN} ≤ V_{DD}, with pins other than the tested pin at 0V	-1.0		1.0	µA
I_{OL}	Output Leakage Current	Output is disabled, 0V ≤ V_{OUT} ≤ V_{DD}	-1.5		1.5	µA
V_{OH}	Output High Voltage Level	I_{OH} = –0.1 mA	0.9 x V_{DDQ}		—	V
V_{OL}	Output Low Voltage Level	I_{OL} = +0.1 mA	—		0.2	V

CAPACITANCE CHARACTERISTICS(1,2) (T_A = 0°C to +25°C, V_{DD} = V_{DDQ} = 1.8V ± 0.15V, f = 1 MHz)

Symbol	Parameter	Min.	Max.	Unit
$C_{IN}1$	Input Capacitance: CLK	2.5	4.0	pF
$C_{IN}2$	Input Capacitance: (A0-A11, CKE, $\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$, LDQM, UDQM)	2.5	5.0	pF
CI/O	Data Input/Output Capacitance: DQ0-DQ15	4.0	6.5	pF

Notes:

1. Stress greater than those listed under ABSOLUTE MAXIMUM RATINGS may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.
2. All voltages are referenced to Vss.
3. V_{IH} (max) = V_{DDQ} + 1.2V with a pulse width ≤ 3 ns.
4. V_{IL} (min) = -1.2V with a pulse width ≤ 3 ns.

IS42VS16100F DC ELECTRICAL CHARACTERISTICS

(Recommended Operation Conditions unless otherwise noted.)

Symbol	Parameter	Test Condition		-75	-10	Unit
I_{CC1}	Operating Current(1,2)	One Bank Operation, Burst Length=1	$\overline{CAS}$ Latency = 3	45	35	mA mA
		$t_{RC} \geq t_{RC}$ (min) I_{OUT} = 0mA	$\overline{CAS}$ Latency = 2	50	40	mA
I_{CC2P}	Precharge Standby Current (In Power-Down Mode)	CKE ≤ V_{IL} (MAX)	$t_{CK} = t_{CK}$ (min)	0.3	0.3	mA
I_{CC2PS}	Precharge Standby Current (In Power-Down and Clock Suspend Mode)	CKE ≤ V_{IL} (MAX) CLK ≤ V_{IL} (MAX)	$t_{CK} = \infty$	0.3	0.3	mA
I_{CC2N}	Precharge Standby Current(3) (In Non Power-Down Mode)	CKE ≥ V_{IH} (MIN) $\overline{CS}$ ≥ V_{IH} (MIN)	$t_{CK} = t_{CK}$ (min)	25	20	mA
I_{CC2NS}	Precharge Standby Current (In Non Power-Down and Clock Suspend Mode)	CKE ≥ V_{IH} (MIN) CLK ≤ V_{IL} (MAX)	$t_{CK} = \infty$ Inputs are stable	10	10	mA
I_{CC3P}	Active Standby Current (In Power-Down Mode)	CKE ≤ V_{IL} (MAX)	$t_{CK} = t_{CK}$ (min)	3	3	mA
I_{CC3PS}	Active Standby Current (In Power-Down and Clock Suspend Mode)	CKE ≤ V_{IL} (MAX) CLK ≤ V_{IL} (MAX)	$t_{CK} = \infty$ Inputs are stable	3	3	mA
I_{CC3N}	Active Standby Current(3) (In Non Power-Down Mode)	CKE ≥ V_{IH} (MIN) $\overline{CS}$ ≥ V_{IH} (MIN)	$t_{CK} = t_{CK}$ (min)	30	25	mA
I_{CC3NS}	Active Standby Current (In Non Power-Down and Clock Suspend Mode)	CKE ≥ V_{IH} (MIN) CLK ≤ V_{IL} (MAX)	$t_{CK} = \infty$ Inputs are stable	10	10	mA
I_{CC4}	Operating Current (In Burst Mode)(1,3)	Both Banks activated Page Burst I_{OUT} = 0mA	$t_{CK} = t_{CK}$ (MIN)	60	50	mA mA
I_{CC5}	Auto-Refresh Current	$t_{RC} = t_{RC}$ (MIN)		50	40	mA
I_{CC6}	Self-Refresh Current	CKE ≤ 0.2V		180	180	µA

Notes:

1. These are the values at the minimum cycle time. Since the currents are transient, these values decrease as the cycle time increases. Also note that a bypass capacitor of at least 0.01 µF should be inserted between V_{DD} and Vss for each memory chip to suppress power supply voltage noise (voltage drops) due to these transient currents.
2. I_{CC1} and I_{CC4} depend on the output load. The maximum values for I_{CC1} and I_{CC4} are obtained with the output open state.
3. Inputs changed once every two clocks.

IS42VS16100F AC CHARACTERISTICS[1,2,3,6]

Symbol	Parameter		-75 Min.	-75 Max.	-10 Min.	-10 Max.	Units
$t_{CK}3$	Clock Cycle Time	$\overline{CAS}$ Latency = 3	7.5	—	10	—	ns
$t_{CK}2$		$\overline{CAS}$ Latency = 2	10	—	12	—	ns
$t_{AC}3$	Access Time From CLK[4]	$\overline{CAS}$ Latency = 3	—	6	—	7	ns
$t_{AC}2$		$\overline{CAS}$ Latency = 2	—	8	—	8	ns
t_{CHI}	CLK HIGH Level Width		2.5	—	3	—	ns
t_{CL}	CLK LOW Level Width		2.5	—	3	—	ns
$t_{OH}3$	Output Data Hold Time	$\overline{CAS}$ Latency = 3	2	—	2	—	ns
$t_{OH}2$		$\overline{CAS}$ Latency = 2	2	—	2	—	ns
t_{LZ}	Output LOW Impedance Time		0	—	0	—	ns
$t_{HZ}3$	Output HIGH Impedance Time[5]	$\overline{CAS}$ Latency = 3	—	6	—	7	ns
$t_{HZ}2$		$\overline{CAS}$ Latency = 2	—	8	—	8	ns
t_{DS}	Input Data Setup Time		2	—	2	—	ns
t_{DH}	Input Data Hold Time		1	—	1	—	ns
t_{AS}	Address Setup Time		2	—	2	—	ns
t_{AH}	Address Hold Time		1	—	1	—	ns
t_{CKS}	CKE Setup Time		2	—	2	—	ns
t_{CKH}	CKE Hold Time		1	—	1	—	ns
t_{CKA}	CKE to CLK Recovery Delay Time		1CLK+3	—	1CLK+3	—	ns
t_{CS}	Command Setup Time ($\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$, DQM)		2	—	2	—	ns
t_{CH}	Command Hold Time ($\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$, DQM)		1	—	1	—	ns
t_{RC}	Command Period (REF to REF / ACT to ACT)		75	—	100	—	ns
t_{RAS}	Command Period (ACT to PRE)		45	100,000	60	100,000	ns
t_{RP}	Command Period (PRE to ACT)		20	—	24	—	ns
t_{RCD}	Active Command To Read / Write Command Delay Time		20	—	24	—	ns
t_{RRD}	Command Period (ACT [0] to ACT[1])		15	—	20	—	ns
$t_{DPL}3$	Input Data To Precharge Command Delay time	$\overline{CAS}$ Latency = 3	2CLK	—	2CLK	—	ns
$t_{DPL}2$		$\overline{CAS}$ Latency = 2	2CLK	—	2CLK	—	ns
$t_{DAL}3$	Input Data To Active / Refresh Command Delay time (During Auto-Precharge)	$\overline{CAS}$ Latency = 3	2CLK+t_{RP}	—	2CLK+t_{RP}	—	ns
$t_{DAL}2$		$\overline{CAS}$ Latency = 2	2CLK+t_{RP}	—	2CLK+t_{RP}	—	ns
t_T	Transition Time		0.5	1.2	0.5	1.2	ns
t_{REF}	Refresh Cycle Time (2048)		—	32	—	32	ms

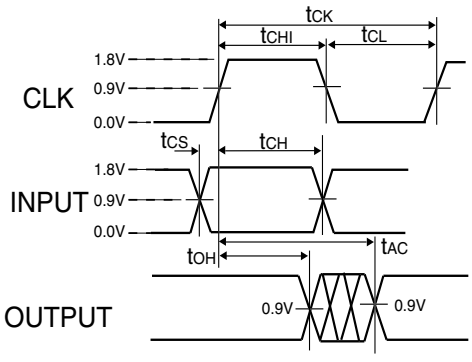
Notes:
1. The power-on sequence must be executed before starting memory operation.
2. Measured with t_T = 1.0 ns. If clock rising time is longer than 1ns, (t_T/2 - 0.5)ns should be added to the parameter.
3. The reference level is 0.9V when measuring input signal timing. Rise and fall times are measured between V_{IH} (min.) and V_{IL} (max.).
4. Access time is measured at 0.9V with the load shown in the figure below.
5. The time t_{HZ} (max.) is defined as the time required for the output voltage to become high impedance.
6. Not all parameters are tested at the wafer level, but the parameters have been previously characterized.

IS42VS16100F OPERATING FREQUENCY / LATENCY RELATIONSHIPS

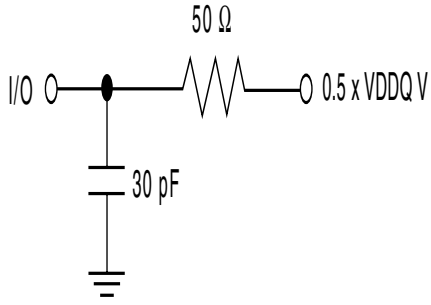
SYMBOL	PARAMETER		-75	-10	-10	UNITS
—	Clock Cycle Time		7.5	10	12	ns
—	Operating Frequency		133	100	83	MHz
t_{CAC}	$\overline{CAS}$ Latency		3	3	2	cycle
t_{RCD}	Active Command To Read/Write Command Delay Time		3	3	2	cycle
t_{RAC}	$\overline{RAS}$ Latency (t_{RCD} + t_{CAC})		6	6	4	cycle
t_{RC}	Command Period (REF to REF / ACT to ACT)		10	10	8	cycle
t_{RAS}	Command Period (ACT to PRE)		6	6	5	cycle
t_{RP}	Command Period (PRE to ACT)		3	3	2	cycle
t_{RRD}	Command Period (ACT[0] to ACT [1])		2	2	2	cycle
t_{CCD}	Column Command Delay Time (READ, READA, WRIT, WRITA)		1	1	1	cycle
t_{DPL}	Input Data To Precharge Command Delay Time		2	2	2	cycle
t_{DAL}	Input Data To Active/Refresh Command Delay Time (During Auto-Precharge)		5	5	4	cycle
t_{RBD}	Burst Stop Command To Output in HIGH-Z Delay Time (Read)	$\overline{CAS}$ Latency = 3 $\overline{CAS}$ Latency = 2	3 —	3 —	— 2	cycle
t_{WBD}	Burst Stop Command To Input in Invalid Delay Time (Write)		0	0	0	cycle
t_{RQL}	Precharge Command To Output in HIGH-Z Delay Time (Read)	$\overline{CAS}$ Latency = 3 $\overline{CAS}$ Latency = 2	3 —	3 —	— 2	cycle
t_{WDL}	Precharge Command To Input in Invalid Delay Time (Write)		0	0	0	cycle
t_{PQL}	Last Output To Auto-Precharge Start Time (Read)	$\overline{CAS}$ Latency = 3 $\overline{CAS}$ Latency = 2	-2 —	–2 —	— -1	cycle
t_{QMD}	DQM To Output Delay Time (Read)		2	2	2	cycle
t_{DMD}	DQM To Input Delay Time (Write)		0	0	0	cycle
t_{MRD}	Mode Register Set To Command Delay Time		2	2	2	cycle

AC TEST CONDITIONS (Input/Output Reference Level: 0.9V)

Input

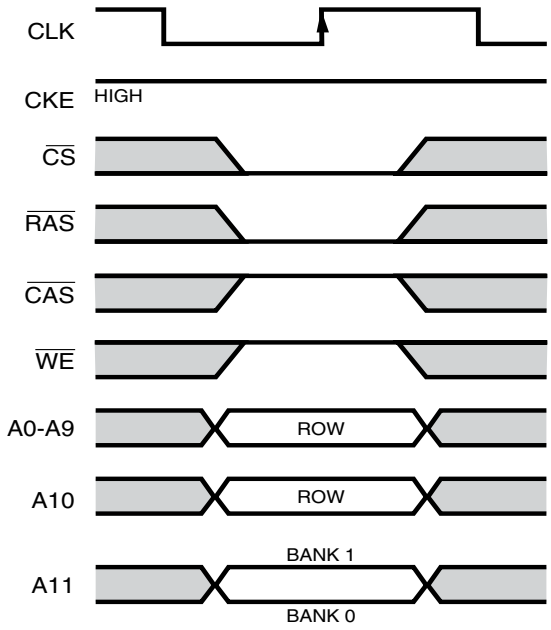


Output Load

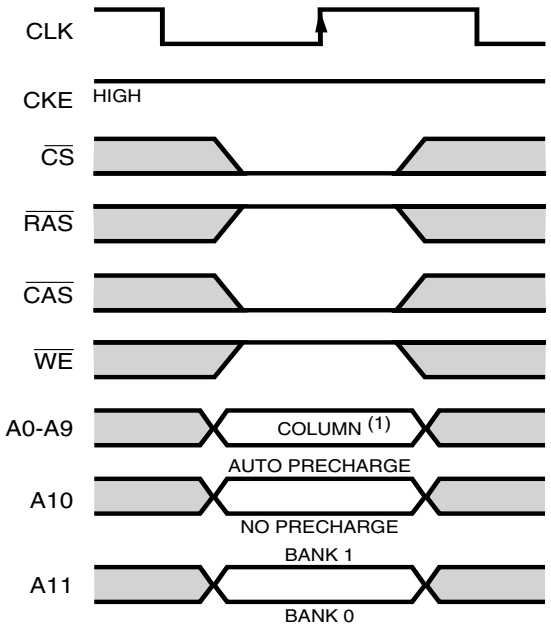


COMMANDS

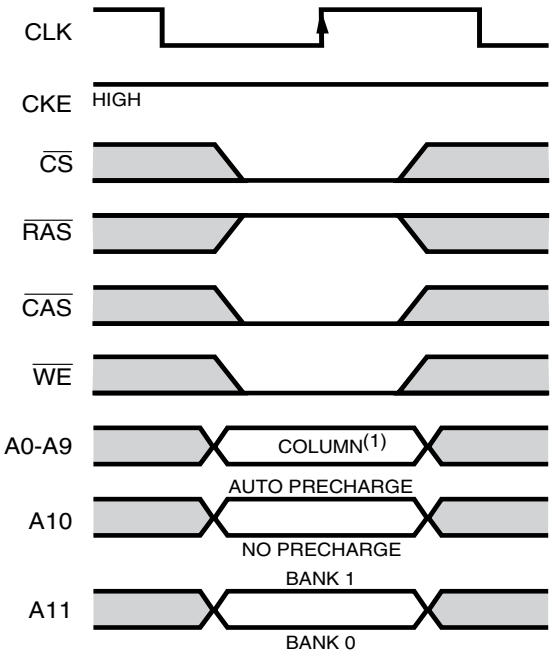
Active Command



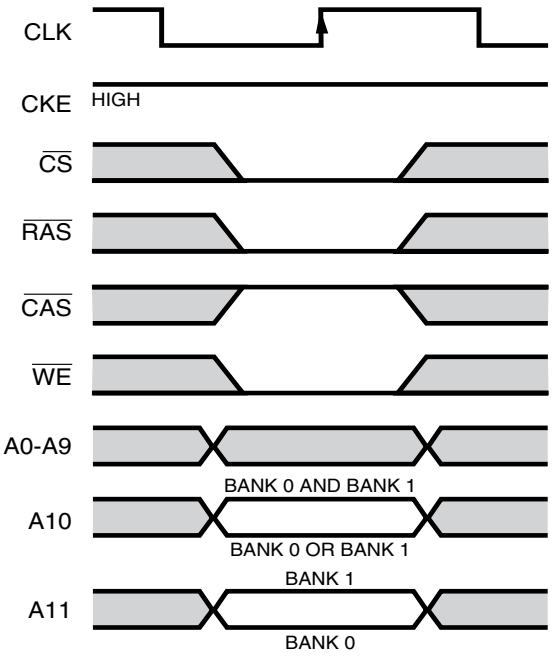
Read Command



Write Command



Precharge Command

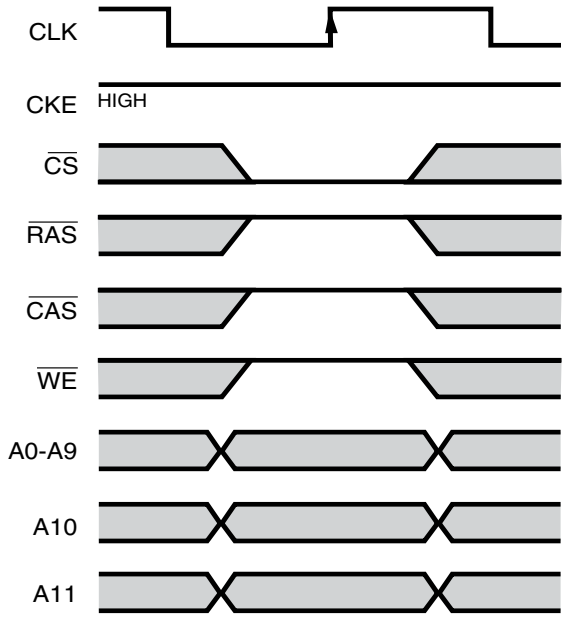


Don't Care

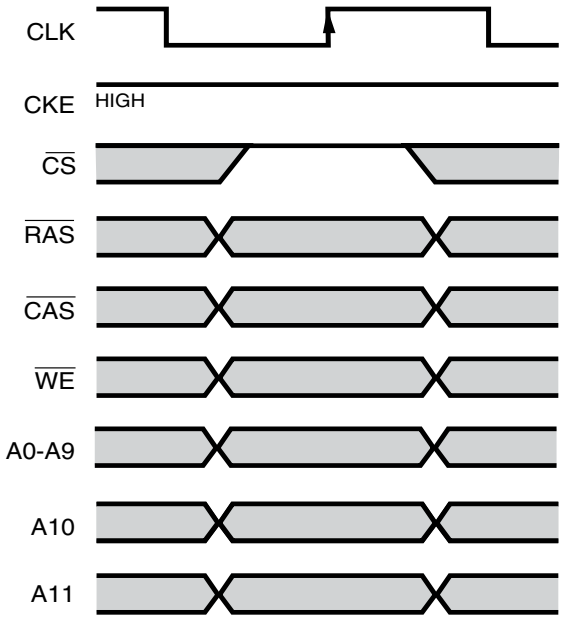
Notes:
1. A8-A9 = Don't Care.

COMMANDS (cont.)

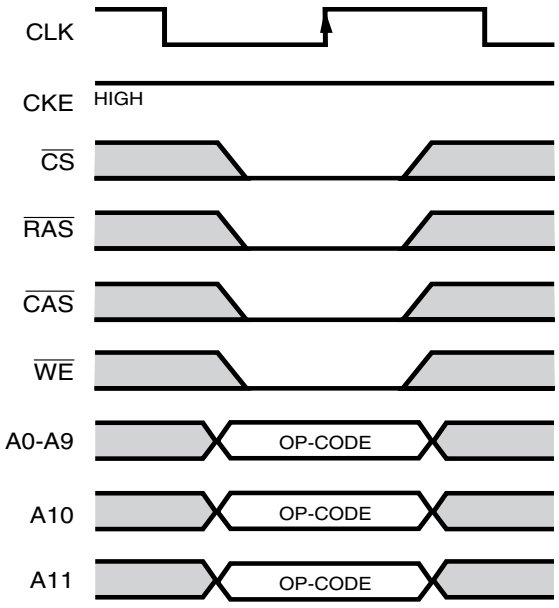
No-Operation Command



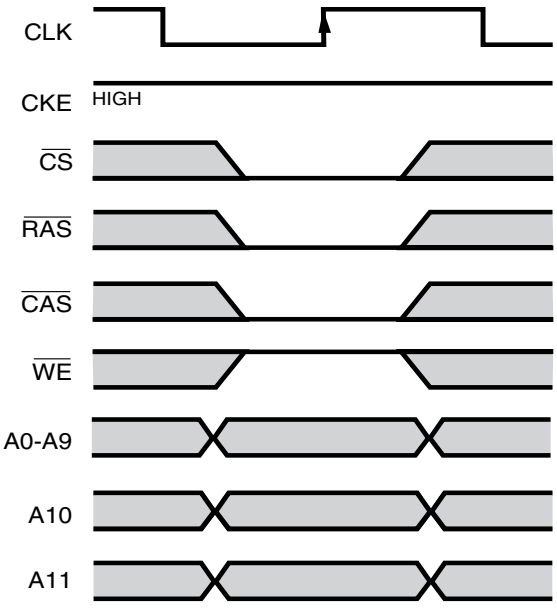
Device Deselect Command



Mode Register Set Command



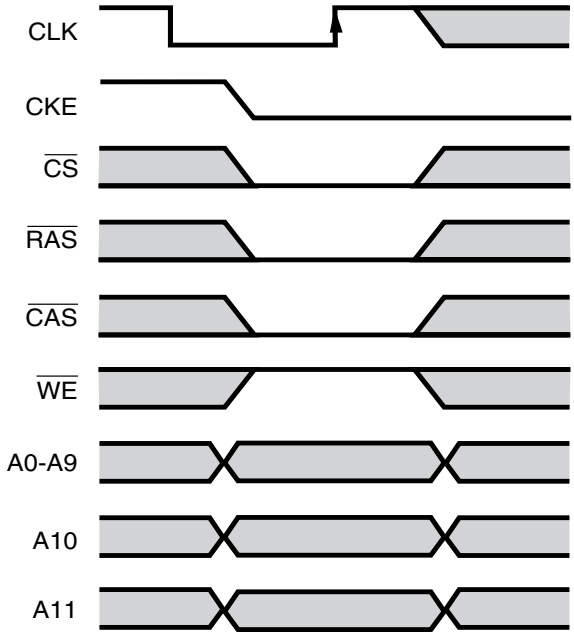
Auto-Refresh Command



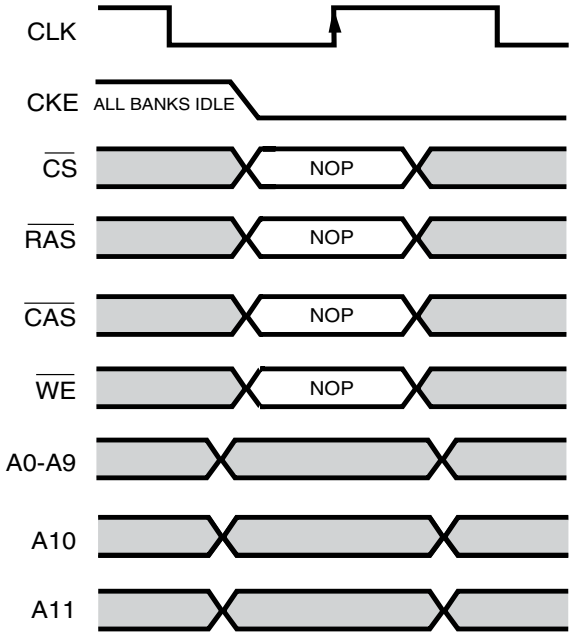
Don't Care

COMMANDS (cont.)

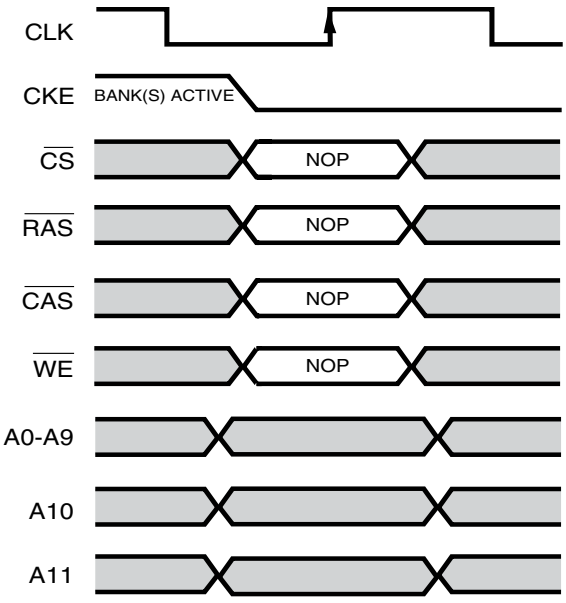
Self-Refresh Command



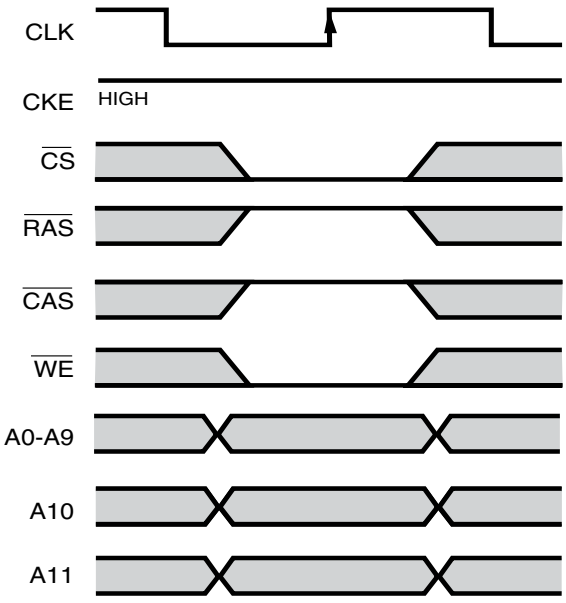
Power Down Command



Clock Suspend Command



Burst Stop Command



Mode Register Set Command

($\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$ = LOW)

The IS42/45S16100F and IS42VS16100F product incorporates a register that defines the device operating mode. This command functions as a data input pin that loads this register from the pins A0 to A11. When power is first applied, the stipulated power-on sequence should be executed and then the SDRAM should be initialized by executing a mode register set command.

Note that the mode register set command can be executed only when both banks are in the idle state (i.e. deactivated).

Another command cannot be executed after a mode register set command until after the passage of the period t_{MCD}, which is the period required for mode register set command execution.

Active Command

($\overline{CS}$, $\overline{RAS}$ = LOW, $\overline{CAS}$, $\overline{WE}$= HIGH)

The SDRAM includes two banks of 2048 rows each. This command selects one of the two banks according to the A11 pin and activates the row selected by the pins A0 to A10.

This command corresponds to the fall of the $\overline{RAS}$ signal from HIGH to LOW in conventional DRAMs.

Precharge Command

($\overline{CS}$, $\overline{RAS}$, $\overline{WE}$ = LOW, $\overline{CAS}$ = HIGH)

This command starts precharging the bank selected by pins A10 and A11. When A10 is HIGH, both banks are precharged at the same time. When A10 is LOW, the bank selected by A11 is precharged. After executing this command, the next command for the selected bank(s) is executed after passage of the period t_{RP}, which is the period required for bank precharging.

This command corresponds to the $\overline{RAS}$ signal from LOW to HIGH in conventional DRAMs

Read Command

($\overline{CS}$, $\overline{CAS}$ = LOW, $\overline{RAS}$, $\overline{WE}$ = HIGH)

This command selects the bank specified by the A11 pin and starts a burst read operation at the start address specified by pins A0 to A9. Data is output following $\overline{CAS}$ latency.

The selected bank must be activated before executing this command.

When the A10 pin is HIGH, this command functions as a read with auto-precharge command. After the burst read completes, the bank selected by pin A11 is precharged. When the A10 pin is LOW, the bank selected by the A11 pin remains in the activated state after the burst read completes.

Write Command

($\overline{CS}$, $\overline{CAS}$, $\overline{WE}$ = LOW, $\overline{RAS}$ = HIGH)

When burst write mode has been selected with the mode register set command, this command selects the bank specified by the A11 pin and starts a burst write operation at the start address specified by pins A0 to A9. This first data must be input to the DQ pins in the cycle in which this command.

The selected bank must be activated before executing this command.

When A10 pin is HIGH, this command functions as a write with auto-precharge command. After the burst write completes, the bank selected by pin A11 is precharged. When the A10 pin is low, the bank selected by the A11 pin remains in the activated state after the burst write completes.

After the input of the last burst write data, the application must wait for the write recovery period (t_{DPL}, t_{DAL}) to elapse according to $\overline{CAS}$ latency.

Auto-Refresh Command

($\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$ = LOW, $\overline{WE}$, CKE = HIGH)

This command executes the auto-refresh operation. The row address and bank to be refreshed are automatically generated during this operation.

Both banks must be placed in the idle state before executing this command.

The stipulated period (t_{RC}) is required for a single refresh operation, and no other commands can be executed during this period.

The device goes to the idle state after the internal refresh operation completes.

This command must be executed at least 2048 times every 32 ms.

This command corresponds to CBR auto-refresh in conventional DRAMs.

Self-Refresh Command

($\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, CKE = LOW, $\overline{WE}$ = HIGH)

This command executes the self-refresh operation. The row address to be refreshed, the bank, and the refresh interval are generated automatically internally during this operation. The self-refresh operation is started by dropping the CKE pin from HIGH to LOW. The self-refresh operation continues as long as the CKE pin remains LOW and there is no need for external control of any other pins. The self-refresh operation is terminated by raising the CKE pin from LOW to HIGH. The next command cannot be executed until the device internal recovery period (t_{RC}) has elapsed. After the self-refresh, since it is impossible to determine the address of the last row to be refreshed, an auto-refresh should immediately be performed for all addresses (2048 cycles).

Both banks must be placed in the idle state before executing this command.

Burst Stop Command

($\overline{CS}$, $\overline{WE}$, = LOW, $\overline{RAS}$, $\overline{CAS}$ = HIGH)

The command forcibly terminates burst read and write operations. When this command is executed during a burst read operation, data output stops after the $\overline{CAS}$ latency period has elapsed.

No Operation

($\overline{CS}$, = LOW, $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$ = HIGH)

This command has no effect on the device.

Device Deselect Command

($\overline{CS}$ = HIGH)

This command does not select the device for an object of operation. In other words, it performs no operation with respect to the device.

Power-Down Command

(CKE = LOW, $\overline{CS}$ = HIGH)

When both banks are in the idle (inactive) state, or when at least one of the banks is not in the idle (inactive) state, this command can be used to suppress device power dissipation by reducing device internal operations to the minimal level in order to retain data content. Power-down mode is started by dropping the CKE pin from HIGH to LOW, while satisfying the other command input conditions (see CKE Truth Table). Power-down mode continues as long as the CKE pin is held low. All pins other than the CKE pin are invalid and none of the other commands can be executed in this mode. The power-down operation is terminated by raising the CKE pin from LOW to HIGH. The next command cannot be executed until the recovery period (t_{CKA}) has elapsed.

Since this command differs from the self-refresh command described above in that the refresh operation is not performed automatically internally, the refresh operation must be performed within the refresh period (t_{REF}). Thus the maximum time that power-down mode can be held is just under the refresh cycle time.

Clock Suspend

(CKE = LOW)

This command can be used to stop the device internal clock temporarily during a read or write cycle. Clock suspend mode is started by dropping the CKE pin from HIGH to LOW. Clock suspend mode continues as long as the CKE pin is held LOW. All input pins other than the CKE pin are invalid and none of the other commands can be executed in this mode. Also note that the device internal state is maintained. Clock suspend mode is terminated by raising the CKE pin from LOW to HIGH, at which point device operation restarts. The next command cannot be executed until the recovery period (t_{CKA}) has elapsed.

Since this command differs from the self-refresh command described above in that the refresh operation is not performed automatically internally, the refresh operation must be performed within the refresh period (t_{REF}). Thus the maximum time that clock suspend mode can be held is just under the refresh cycle time.

COMMAND TRUTH TABLE[1,2]

Symbol	Command	CKE n-1	CKE n	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	DQM	A11	A10	A9-A0	I/On
MRS	Mode Register Set[3,4]	H	X	L	L	L	L	X	OP CODE			X
REF	Auto-Refresh[5]	H	H	L	L	L	H	X	X	X	X	HIGH-Z
SREF	Self-Refresh[5,6]	H	L	L	L	L	H	X	X	X	X	HIGH-Z
PRE	Precharge Selected Bank	H	X	L	L	H	L	X	BS	L	X	X
PALL	Precharge Both Banks	H	X	L	L	H	L	X	X	H	X	X
ACT	Bank Activate[7]	H	X	L	L	H	H	X	BS	Row	Row	X
WRIT	Write	H	X	L	H	L	L	X	BS	L	Column[18]	X
WRITA	Write With Auto-Precharge[8]	H	X	L	H	L	L	X	BS	H	Column[18]	X
READ	Read[8]	H	X	L	H	L	H	X	BS	L	Column[18]	X
READA	Read With Auto-Precharge[8]	H	X	L	H	L	H	X	BS	H	Column[18]	X
BST	Burst Stop[9]	H	H	L	H	H	L	X	X	X	X	X
NOP	No Operation	H	X	L	H	H	H	X	X	X	X	X
DESL	Device Deselect	H	X	H	X	X	X	X	X	X	X	X
ENB	Data Write / Output Enable	H	X	X	X	X	X	L	X	X	X	Active
MASK	Data Mask / Output Disable	H	X	X	X	X	X	H	X	X	X	HIGH-Z

DQM TRUTH TABLE[1,2]

Symbol	Command	CKE n-1	CKE n	DQM UPPER	DQM LOWER
ENB	Data Write / Output Enable	H	X	L	L
MASK	Data Mask / Output Disable	H	X	H	H
ENBU	Upper Byte Data Write / Output Enable	H	X	L	X
ENBL	Lower Byte Data Write / Output Enable	H	X	X	L
MASKU	Upper Byte Data Mask / Output Disable	H	X	H	X
MASKL	Lower Byte Data Mask / Output Disable	H	X	X	H

CKE TRUTH TABLE[1,2]

Symbol	Command	Current State	CKE n-1	CKE n	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	A11	A10	A9-A0
SPND	Start Clock Suspend Mode	Active	H	L	X	X	X	X	X	X	X
—	Clock Suspend	Other States	L	L	X	X	X	X	X	X	X
—	Terminate Clock Suspend Mode	Clock Suspend	L	H	X	X	X	X	X	X	X
REF	Auto-Refresh	Idle	H	H	L	L	L	H	X	X	X
SELF	Start Self-Refresh Mode	Idle	H	L	L	L	L	H	X	X	X
SELFX	Terminate Self-Refresh Mode	Self-Refresh	L	H	L	H	H	H	X	X	X
			L	H	H	X	X	X	X	X	X
PDWN	Start Power-Down Mode	Idle	H	L	L	H	H	H	X	X	X
			H	L	H	X	X	X	X	X	X
—	Terminate Power-Down Mode	Power-Down	L	H	H	X	X	X	X	X	X
			L	H	L	H	H	H	X	X	X

OPERATION COMMAND TABLE[1,2]

Current State	Command	Operation	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	A11	A10	A9-A0
Idle	DESL	No Operation or Power-Down[12]	H	X	X	X	X	X	X
	NOP	No Operation or Power-Down[12]	L	H	H	H	X	X	X
	BST	No Operation or Power-Down	L	H	H	L	X	X	X
	READ / READA	Illegal	L	H	L	H	V	V	V[18]
	WRIT/WRITA	Illegal	L	H	L	L	V	V	V[18]
	ACT	Row Active	L	L	H	H	V	V	V[18]
	PRE/PALL	No Operation	L	L	H	L	V	V	X
	REF/SELF	Auto-Refresh or Self-Refresh[13]	L	L	L	H	X	X	X
	MRS	Mode Register Set	L	L	L	L	OP CODE		
Row Active	DESL	No Operation	H	X	X	X	X	X	X
	NOP	No Operation	L	H	H	H	X	X	X
	BST	No Operation	L	H	H	L	X	X	X
	READ/READA	Read Start[17]	L	H	L	H	V	V	V[18]
	WRIT/WRITA	Write Start[17]	L	H	L	L	V	V	V[18]
	ACT	Illegal[10]	L	L	H	H	V	V	V[18]
	PRE/PALL	Precharge[15]	L	L	H	L	V	V	X
	REF/SELF	Illegal	L	L	L	H	X	X	X
	MRS	Illegal	L	L	L	L	OP CODE		
Read	DESL	Burst Read Continues, Row Active When Done	H	X	X	X	X	X	X
	NOP	Burst Read Continues, Row Active When Done	L	H	H	H	X	X	X
	BST	Burst Interrupted, Row Active After Interrupt	L	H	H	L	X	X	X
	READ/READA	Burst Interrupted, Read Restart After Interrupt[16]	L	H	L	H	V	V	V[18]
	WRIT/WRITA	Burst Interrupted Write Start After Interrupt[11,16]	L	H	L	L	V	V	V[18]
	ACT	Illegal[10]	L	L	H	H	V	V	V[18]
	PRE/PALL	Burst Read Interrupted, Precharge After Interrupt	L	L	H	L	V	V	X
	REF/SELF	Illegal	L	L	L	H	X	X	X
	MRS	Illegal	L	L	L	L	OP CODE		
Write	DESL	Burst Write Continues, Write Recovery When Done	H	X	X	X	X	X	X
	NOP	Burst Write Continues, Write Recovery When Done	L	H	H	H	X	X	X
	BST	Burst Write Interrupted, Row Active After Interrupt	L	H	H	L	X	X	X
	READ/READA	Burst Write Interrupted, Read Start After Interrupt[11,16]	L	H	L	H	V	V	V[18]
	WRIT/WRITA	Burst Write Interrupted, Write Restart After Interrupt[16]	L	H	L	L	V	V	V[18]
	ACT	Illegal[10]	L	L	H	H	V	V	V[18]
	PRE/PALL	Burst Write Interrupted, Precharge After Interrupt	L	L	H	L	V	V	X
	REF/SELF	Illegal	L	L	L	H	X	X	X
	MRS	Illegal	L	L	L	L	OP CODE		
Read With Auto-Precharge	DESL	Burst Read Continues, Precharge When Done	H	X	X	X	X	X	X
	NOP	Burst Read Continues, Precharge When Done	L	H	H	H	X	X	X
	BST	Illegal	L	H	H	L	X	X	X
	READ/READA	Illegal	L	H	L	H	V	V	V[18]
	WRIT/WRITA	Illegal	L	H	L	L	V	V	V[18]
	ACT	Illegal[10]	L	L	H	H	V	V	V[18]
	PRE/PALL	Illegal[10]	L	L	H	L	V	V	X
	REF/SELF	Illegal	L	L	L	H	X	X	X
	MRS	Illegal	L	L	L	L	OP CODE		

OPERATION COMMAND TABLE[1,2]

Current State	Command	Operation	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	A11	A10	A9-A0
Write With Auto-Precharge	DESL	Burst Write Continues, Write Recovery And Precharge When Done	H	X	X	X	X	X	X
	NOP	Burst Write Continues, Write Recovery And Precharge	L	H	H	H	X	X	X
	BST	Illegal	L	H	H	L	X	X	X
	READ/READA	Illegal	L	H	L	H	V	V	V[18]
	WRIT/WRITA	Illegal	L	H	L	L	V	V	V[18]
	ACT	Illegal[10]	L	L	H	H	V	V	V[18]
	PRE/PALL	Illegal[10]	L	L	H	L	V	V	X
	REF/SELF	Illegal	L	L	L	H	X	X	X
	MRS	Illegal	L	L	L	L	OPCODE		
Row Precharge	DESL	No Operation, Idle State After t_{RP} Has Elapsed	H	X	X	X	X	X	X
	NOP	No Operation, Idle State After t_{RP} Has Elapsed	L	H	H	H	X	X	X
	BST	No Operation, Idle State After t_{RP} Has Elapsed	L	H	H	L	X	X	X
	READ/READA	Illegal[10]	L	H	L	H	V	V	V[18]
	WRIT/WRITA	Illegal[10]	L	H	L	L	V	V	V[18]
	ACT	Illegal[10]	L	L	H	H	V	V	V[18]
	PRE/PALL	No Operation, Idle State After t_{RP} Has Elapsed[10]	L	L	H	L	V	V	X
	REF/SELF	Illegal	L	L	L	H	X	X	X
	MRS	Illegal	L	L	L	L	OP CODE		
Immediately Following Row Active	DESL	No Operation, Row Active After t_{RCD} Has Elapsed	H	X	X	X	X	X	X
	NOP	No Operation, Row Active After t_{RCD} Has Elapsed	L	H	H	H	X	X	X
	BST	No Operation, Row Active After t_{RCD} Has Elapsed	L	H	H	L	X	X	X
	READ/READA	Illegal[10]	L	H	L	H	V	V	V[18]
	WRIT/WRITA	Illegal[10]	L	H	L	L	V	V	V[18]
	ACT	Illegal[10,14]	L	L	H	H	V	V	V[18]
	PRE/PALL	Illegal[10]	L	L	H	L	V	V	X
	REF/SELF	Illegal	L	L	L	H	X	X	X
	MRS	Illegal	L	L	L	L	OP CODE		
Write Recovery	DESL	No Operation, Row Active After t_{DPL} Has Elapsed	H	X	X	X	X	X	X
	NOP	No Operation, Row Active After t_{DPL} Has Elapsed	L	H	H	H	X	X	X
	BST	No Operation, Row Active After t_{DPL} Has Elapsed	L	H	H	L	X	X	X
	READ/READA	Read Start	L	H	L	H	V	V	V[18]
	WRIT/WRITA	Write Restart	L	H	L	L	V	V	V[18]
	ACT	Illegal[10]	L	L	H	H	V	V	V[18]
	PRE/PALL	Illegal[10]	L	L	H	L	V	V	X
	REF/SELF	Illegal	L	L	L	H	X	X	X
	MRS	Illegal	L	L	L	L	OP CODE		

OPERATION COMMAND TABLE[1,2]

Current State	Command	Operation	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	A11	A10	A9-A0
Write Recovery	DESL	No Operation, Idle State After t_{DAL} Has Elapsed	H	X	X	X	X	X	X
With Auto-	NOP	No Operation, Idle State After t_{DAL} Has Elapsed	L	H	H	H	X	X	X
Precharge	BST	No Operation, Idle State After t_{DAL} Has Elapsed	L	H	H	L	X	X	X
	READ/READA	Illegal[10]	L	H	L	H	V	V	V[18]
	WRIT/WRITA	Illegal[10]	L	H	L	L	V	V	V[18]
	ACT	Illegal[10]	L	L	H	H	V	V	V[18]
	PRE/PALL	Illegal[10]	L	L	H	L	V	V	X
	REF/SELF	Illegal	L	L	L	H	X	X	X
	MRS	Illegal	L	L	L	L	OP CODE		
Refresh	DESL	No Operation, Idle State After t_{RP} Has Elapsed	H	X	X	X	X	X	X
	NOP	No Operation, Idle State After t_{RP} Has Elapsed	L	H	H	H	X	X	X
	BST	No Operation, Idle State After t_{RP} Has Elapsed	L	H	H	L	X	X	X
	READ/READA	Illegal	L	H	L	H	V	V	V[18]
	WRIT/WRITA	Illegal	L	H	L	L	V	V	V[18]
	ACT	Illegal	L	L	H	H	V	V	V[18]
	PRE/PALL	Illegal	L	L	H	L	V	V	X
	REF/SELF	Illegal	L	L	L	H	X	X	X
	MRS	Illegal	L	L	L	L	OP CODE		
Mode Register	DESL	No Operation, Idle State After t_{MCD} Has Elapsed	H	X	X	X	X	X	X
Set	NOP	No Operation, Idle State After t_{MCD} Has Elapsed	L	H	H	H	X	X	X
	BST	No Operation, Idle State After t_{MCD} Has Elapsed	L	H	H	L	X	X	X
	READ/READA	Illegal	L	H	L	H	V	V	V[18]
	WRIT/WRITA	Illegal	L	H	L	L	V	V	V[18]
	ACT	Illegal	L	L	H	H	V	V	V[18]
	PRE/PALL	Illegal	L	L	H	L	V	V	X
	REF/SELF	Illegal	L	L	L	H	X	X	X
	MRS	Illegal	L	L	L	L	OP CODE		

Notes:

1. H: HIGH level input, L: LOW level input, X: "Don't Care" input, V: Valid data input
2. All input signals are latched on the rising edge of the CLK signal.
3. Both banks must be placed in the inactive (idle) state in advance.
4. The state of the A0 to A11 pins is loaded into the mode register as an OP code.
5. The row address is generated automatically internally at this time. The DQ pin and the address pin data is ignored.
6. During a self-refresh operation, all pin data (states) other than CKE is ignored.
7. The selected bank must be placed in the inactive (idle) state in advance.
8. The selected bank must be placed in the active state in advance.
9. This command is valid only when the burst length set to full page.
10. This is possible depending on the state of the bank selected by the A11 pin.
11. Time to switch internal busses is required.
12. The SDRAM can be switched to power-down mode by dropping the CKE pin LOW when both banks in the idle state. Input pins other than CKE are ignored at this time.
13. The SDRAM can be switched to self-refresh mode by dropping the CKE pin LOW when both banks in the idle state. Input pins other than CKE are ignored at this time.
14. Possible if t_{RRD} is satisfied.
15. Illegal if t_{RAS} is not satisfied.
16. The conditions for burst interruption must be observed. Also note that the SDRAM will enter the pre charged state immediately after the burst operation completes if auto-precharge is selected.
17. Command input becomes possible after the period t_{RCD} has elapsed. Also note that the SDRAM will enter the precharged state immediately after the burst operation completes if auto-precharge is selected.
18. A8,A9 = don't care.

CKE RELATED COMMAND TRUTH TABLE(1)

Current State	Operation	CKE n-1	CKE n	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	A11	A10	A9-A0
Self-Refresh	Undefined	H	X	X	X	X	X	X	X	X
	Self-Refresh Recovery(2)	L	H	H	X	X	X	X	X	X
	Self-Refresh Recovery(2)	L	H	L	H	H	X	X	X	X
	Illegal(2)	L	H	L	H	L	X	X	X	X
	Illegal(2)	L	H	L	L	X	X	X	X	X
	Maintain Self-Refresh	L	L	X	X	X	X	X	X	X
Self-Refresh Recovery	Idle State After t_{RC} Has Elapsed	H	H	H	X	X	X	X	X	X
	Idle State After t_{RC} Has Elapsed	H	H	L	H	H	X	X	X	X
	Illegal	H	H	L	H	L	X	X	X	X
	Illegal	H	H	L	L	X	X	X	X	X
	Power-Down on the Next Cycle	H	L	H	X	X	X	X	X	X
	Power-Down on the Next Cycle	H	L	L	H	H	X	X	X	X
	Illegal	H	L	L	H	L	X	X	X	X
	Illegal	H	L	L	L	X	X	X	X	X
	Clock Suspend Termination on the Next Cycle (2)	L	H	X	X	X	X	X	X	X
	Maintain Clock Suspend	L	L	X	X	X	X	X	X	X
Power-Down	Undefined	H	X	X	X	X	X	X	X	X
	Power-Down Mode Termination, Idle After That Termination(2)	L	H	X	X	X	X	X	X	X
	Maintain Power-Down Mode	L	L	X	X	X	X	X	X	X
Both Banks Idle	No Operation	H	H	H	X	X	X	X	X	X
	See the Operation Command Table	H	H	L	H	X	X	X	X	X
	Bank Active Or Precharge	H	H	L	L	H	X	X	X	X
	Auto-Refresh	H	H	L	L	L	H	X	X	X
	Mode Register Set	H	H	L	L	L	L	OP CODE		
	See the Operation Command Table	H	L	H	X	X	X	X	X	X
	See the Operation Command Table	H	L	L	H	X	X	X	X	X
	See the Operation Command Table	H	L	L	L	H	X	X	X	X
	Self-Refresh(3)	H	L	L	L	L	H	X	X	X
	See the Operation Command Table	H	L	L	L	L	L	OP CODE		
	Power-Down Mode(3)	L	X	X	X	X	X	X	X	X
Other States	See the Operation Command Table	H	H	X	X	X	X	X	X	X
	Clock Suspend on the Next Cycle(4)	H	L	X	X	X	X	X	X	X
	Clock Suspend Termination on the Next Cycle	L	H	X	X	X	X	X	X	X
	Maintain Clock Suspend	L	L	X	X	X	X	X	X	X

Notes:

1. H: HIGH level input, L: LOW level input, X: "Don't Care" input
2. The CLK pin and the other input are reactivated asynchronously by the transition of the CKE level from LOW to HIGH. The minimum setup time (t_{CKA}) required before all commands other than mode termination must be satisfied.
3. Both banks must be set to the inactive (idle) state in advance to switch to power-down mode or self-refresh mode.
4. The input must be command defined in the operation command table.

TWO BANKS OPERATION COMMAND TRUTH TABLE(1,2)

Operation	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	A11	A10	A9-A0	Previous State BANK 0	Previous State BANK 1	Next State BANK 0	Next State BANK 1
DESL	H	X	X	X	X	X	X	Any	Any	Any	Any
NOP	L	H	H	H	X	X	X	Any	Any	Any	Any
BST	L	H	H	L	X	X	X	R/W/A	I/A	A	I/A
								I	I/A	I	I/A
								I/A	R/W/A	I/A	A
								I/A	I	I/A	I
READ/READA	L	H	L	H	H	H	CA(3)	I/A	R/W/A	I/A	RP
					H	H	CA(3)	R/W	A	A	RP
					H	L	CA(3)	I/A	R/W/A	I/A	R
					H	L	CA(3)	R/W	A	A	R
					L	H	CA(3)	R/W/A	I/A	RP	I/A
					L	H	CA(3)	A	R/W	RP	A
					L	L	CA(3)	R/W/A	I/A	R	I/A
					L	L	CA(3)	A	R/W	R	A
WRIT/WRITA	L	H	L	L	H	H	CA(3)	I/A	R/W/A	I/A	WP
					H	H	CA(3)	R/W	A	A	WP
					H	L	CA(3)	I/A	R/W/A	I/A	W
					H	L	CA(3)	R/W	A	A	W
					L	H	CA(3)	R/W/A	I/A	WP	I/A
					L	H	CA(3)	A	R/W	WP	A
					L	L	CA(3)	R/W/A	I/A	W	I/A
					L	L	CA(3)	A	R/W	W	A
ACT	L	L	H	H	H	RA	RA	Any	I	Any	A
					L	RA	RA	I	Any	A	Any
PRE/PALL	L	L	H	L	X	H	X	R/W/A/I	I/A	I	I
					X	H	X	I/A	R/W/A/I	I	I
					H	L	X	I/A	R/W/A/I	I/A	I
					H	L	X	R/W/A/I	I/A	R/W/A/I	I
					L	L	X	R/W/A/I	I/A	I	I/A
					L	L	X	I/A	R/W/A/I	I	R/W/A/I
REF	L	L	L	H	X	X	X	I	I	I	I
MRS	L	L	L	L	OPCODE			I	I	I	I

Notes:

1. H: HIGH level input, L: LOW level input, X: HIGH or LOW level input, RA: Row Address, CA: Column Address
2. The device state symbols are interpreted as follows:

I	Idle (inactive state)
A	Row Active State
R	Read
W	Write
RP	Read With Auto-Precharge
WP	Write With Auto-Precharge
Any	Any State

3. CA: A8,A9 = don't care.

SIMPLIFIED STATE TRANSITION DIAGRAM (One Bank Operation)