NEC

MOS INTEGRATED CIRCUIT

μPD482444, 482445

4M-Bit Dual Port Graphics Buffer

256K-WORD BY 16-BIT

Description

The μPD482444 and μPD482445 have a random access port and a serial access port. The random access port has a 4M-bit (262, 144 words × 16 bits) memory cell array structure. The serial access port can perform clock operations of up to 50 MHz from the 8K-bit data register (512 words × 16 bits).

To simplify the graphics system design, the split data transfer function and binary boundary jump function have been adopted so that the number of split data registers can be programmed with the software during serial read/write operations.

The μPD482445 is provided with the hyper page mode, an improved version of the fast page mode of the μPD482444. The random access port can input and output data by $\overline{\text{CAS}}$ clock operations of up to 33 MHz. The power supply voltage is either 5 V ± 10 % (μPD482444, 482445) or 3.3 V ± 0.3 V (μPD482445L).

Features

Dual port structure (Random access port, Serial access port)

● Random access port (262, 144-word × 16-bit structure)

μPD482444

	μPD482444-60	μPD482444-70
$\overline{\text{RAS}}$ access time	60 ns(MAX.)	70 ns(MAX.)
Fast page mode cycle time	35 ns(MIN.)	40 ns(MIN.)

μPD482445

	μPD482445-60	μPD482445-70 μPD482445L-A70
$\overline{\text{RAS}}$ access time	60 ns(MAX.)	70 ns(MAX.)
Hyper page mode cycle time	30 ns(MIN.)	35 ns(MIN.)

- Block write function (8 columns) (Write-per-bit can be specified.)
- Mask write (Write-per-bit function)
- 512 refresh cycles /8 ms
- $\overline{\text{CAS}}$ before $\overline{\text{RAS}}$ refresh, $\overline{\text{RAS}}$ only refresh, Hidden refresh

● Serial access port (512 words × 16 bits organization)

- Serial read/write cycle time

μPD482444-60 μPD482445-60	μPD482444-70 μPD482445-70, 482445L-A70
20 ns(MIN.)	22 ns(MIN.)

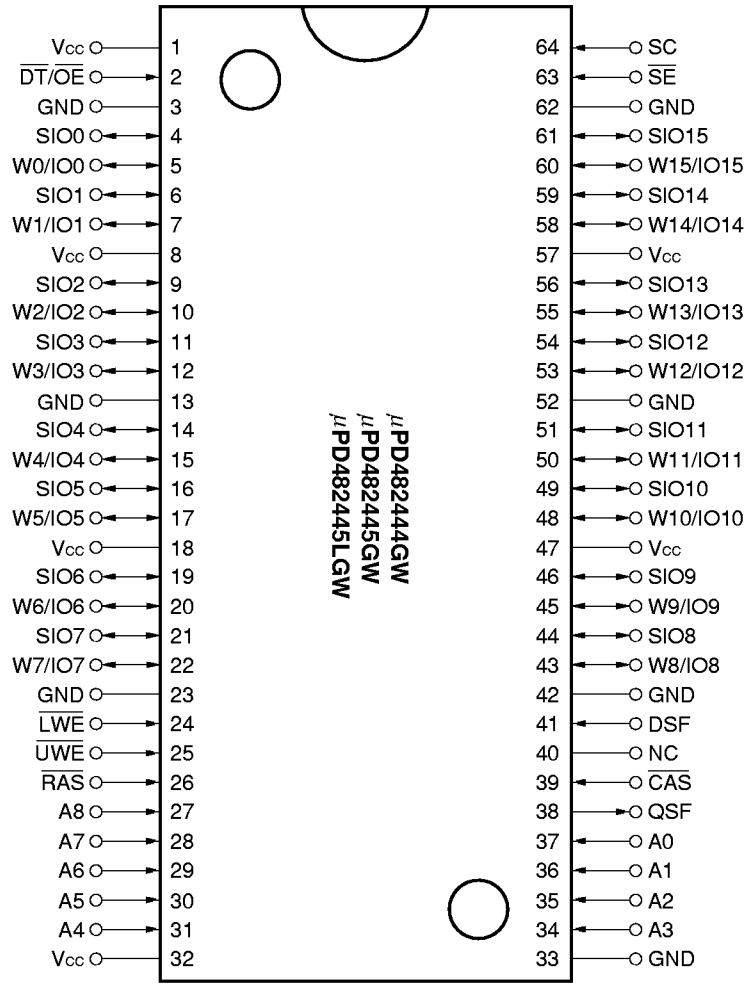
- Serial data read/write
- Split buffer data transfer
- Binary boundary jump function

Ordering Information

Part Number	$\overline{RAS}$ Access Time ns (MAX.)	Package	Power Supply Voltage	Page Mode
μPD482444GW-60	60	64-pin plastic shrink SOP (525 mil)	5 V ± 10 %	Fast page mode
μPD482444GW-70	70			
μPD482445GW-60	60	64-pin plastic shrink SOP (525 mil)	5 V ± 10 %	Hyper page mode
μPD482445GW-70	70			
μPD482445LGW-A70	70		3.3 V ± 0.3 V	

Pin Configurations (Marking Side)

64-Pin Plastic Shrink SOP (525 mil)

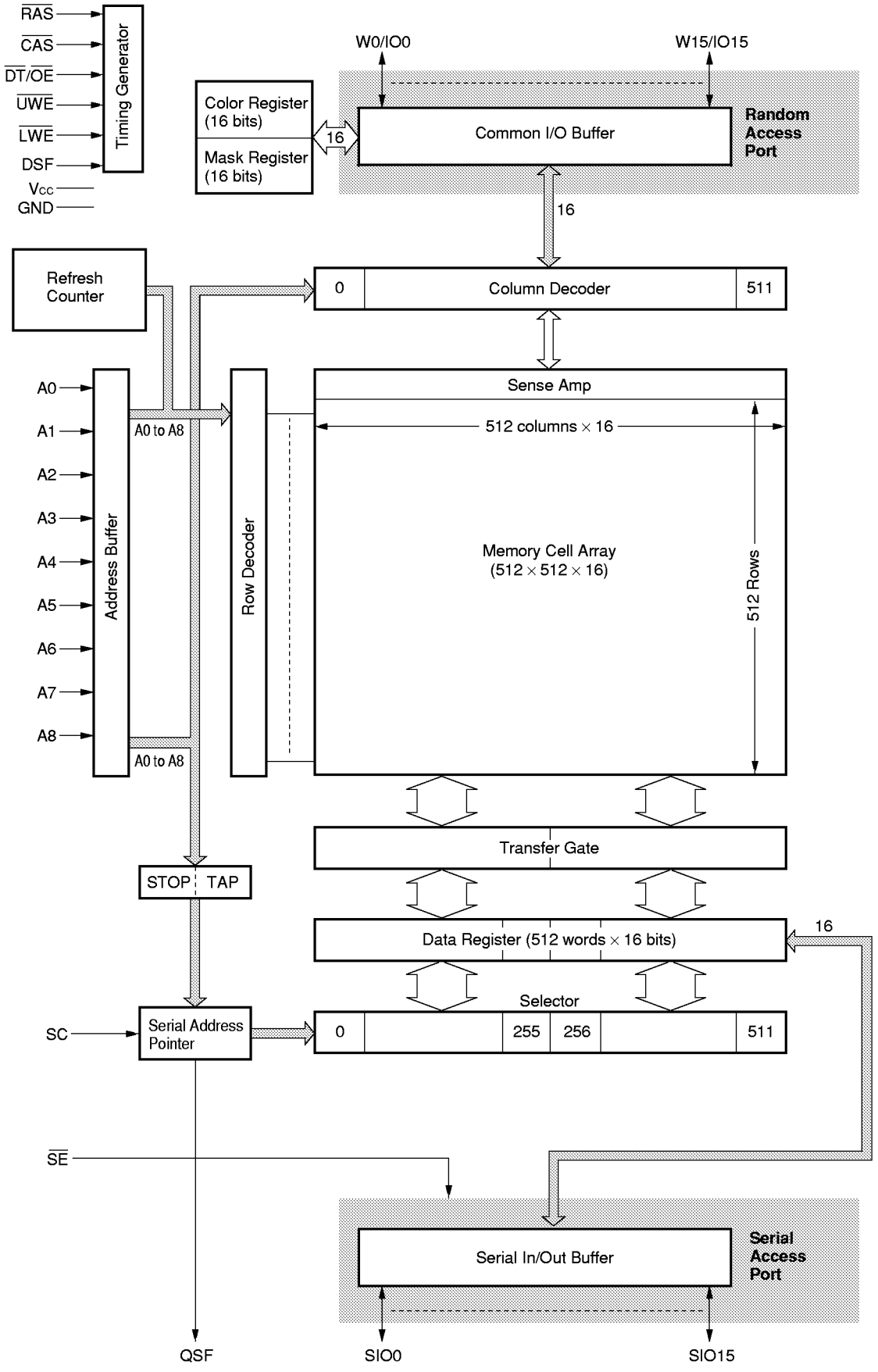


A0 to A8	:	Address inputs
W0 to W15/IO0 to IO15	:	Mask data selects/Data inputs and outputs
SIO0 to SIO15	:	Serial data inputs and outputs
$\overline{RAS}$	:	Row address strobe
$\overline{CAS}$	:	Column address strobe
$\overline{DT/OE}$	:	Data transfer/Output enable
$\overline{UWE}$, $\overline{LWE}$	:	Write-per-bit/Write enable
$\overline{SE}$	:	Serial data input/Output enable
SC	:	Serial clock
QSF	:	Special function output
DSF	:	Special function enable
V_{CC}	:	Power supply voltage
GND	:	Ground
NC[Note]	:	No connection

Note Some signals can be applied because this pin is not connected to the inside of the chip.

[MEMO]

Block Diagram



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1. Pin Functions

This product is equipped with the $\overline{RAS}$, $\overline{CAS}$, $\overline{UWE}$, $\overline{LWE}$, $\overline{DT}/\overline{OE}$, A0 to A8, DSF, SC, $\overline{SE}$ inputs, QSF output, and W0 to W15/IO0 to IO15, SIO0 to SIO15 input/output pins.

(1/3)

Pin Name	Input/ Output	Function
$\overline{RAS}$ (Row address strobe)	Input	This signal latches the row addresses (A0 to A8), selects the corresponding word line, and activates the sense amplifier. It also refreshes the memory cell array of the one line (8,192 bits) selected from the row addresses (A0 to A8). It also serves as the signal which selects the following operations. • Write-per-bit • Split data transfer • $\overline{CAS}$ before $\overline{RAS}$ refresh
$\overline{CAS}$ (Column address strobe)		This signal latches the column addresses (A0 to A8), selects the digit line connecting the sense amplifier, and activates the output circuit which outputs data to the random access port. It also serves as the signal which selects the following operations. • Read/write • Block write • Color register set • Mask register set
A0 to A8 (Address inputs)		These are the address input pins, TAP register input pins, and STOP register input pins. **Address Input** This is a 9-bit address bus. It inputs a total of 18 bits of the address signal, starting from the upper 9 bits (row address) and then followed by the lower 9 bits (column bits) (address multiplex method). Using these, one word memory cells (16 bits) are selected from the 262,144 words × 16 bits memory cell array. During use, specify the row address, activate the $\overline{RAS}$ signal, latch the row address, switch to the column address, and activate the $\overline{CAS}$ signal. After activating the $\overline{RAS}$ and $\overline{CAS}$ signals, each address signal is taken into the device. For this reason, the address input setup time (t_{ASR}, t_{ASC}) and hold time (t_{RAH}, t_{CAH}) are specified for activating the $\overline{RAS}$ and $\overline{CAS}$ signals. **TAP Register Input** In the data transfer cycle, this TAP register input pin functions as the address input pin which selects the memory cell for transferring (9 bits are latched at the falling edge of $\overline{RAS}$) and the TAP register data input pin which specifies the start addresses of the serial read/write operation after data transfer (9 bits are latched at the falling edge of the $\overline{CAS}$). **STOP Register Input** This pin functions as the STOP register input pin when the STOP register is set (STOP register data (9 bits) are latched at the falling edge of the $\overline{RAS}$.)

(2/3)

Pin Name	Input/ Output	Function
$\overline{DT}/\overline{OE}$ (Data transfer/ output enable)	Input	These are the data transfer control signal and read operation control signal respectively. They have different functions in the data transfer cycle and read cycle. **Data transfer control signal (In data transfer cycle)** The data transfer cycle is initiated when a low level is input to this pin at the falling edge of $\overline{RAS}$. **Read operations control signal (In read cycle)** Read operation is performed when this signal, and the $\overline{RAS}$ and $\overline{CAS}$ signals are activated. The input/output pin is high impedance when this signal is not activated. When the $\overline{UWE}$ and $\overline{LWE}$ signals are activated while the $\overline{DT}/\overline{OE}$ signals are activated, the $\overline{DT}/\overline{OE}$ signals are invalid in the memory and read operations cannot be performed.
$\overline{UWE}$, $\overline{LWE}$ (Write enable)		These are the write operation control signal and mask write cycle (write-per-bit function) mask data input control signal, respectively. $\overline{UWE}$ controls the upper bytes (W8 to W15/IO8 to IO15) and $\overline{LWE}$ controls the lower bytes (W0 to W7/IO0 to IO7) of the input/output pins. When this signal, $\overline{RAS}$ and $\overline{CAS}$ signals are activated, write operations or mask write can be performed. These mode are determined by the level of $\overline{UWE}$ and $\overline{LWE}$ at the falling edge of $\overline{RAS}$. • High level .....8 or 16-bit write cycle • Low level .....Mask write cycle (Write-per-bit)
DSF (Special function enable)		This signal controls the selection of functions. The selection of functions is determined by the level of this signal at the falling edge of the $\overline{RAS}$ and $\overline{CAS}$. The functions will change as follows when this signal is high level. • The data transfer cycle changes to a split data transfer cycle. • The write cycle of each $\overline{CAS}$ clock changes to the block write cycle.
W0 to W15/IO0 to IO15 (Mask data selects/ Data inputs, outputs)	Input/ Output	These are normally 16-bit data bus and are used for inputting and outputting data. (IO0 to IO15). Function as the mask data input pins (W0 to W15) in the mask write cycle (write-per-bit function). Write operations can be performed only for W0 to W15 that are input with a high level at the falling edge of $\overline{RAS}$ (new mask data). Functions as the column selection data input pin in the block write cycle.

(3/3)

Pin Name	Input/ Output	Function
SC (Serial clock)	Input	This pin inputs the clock which controls the serial access port operation. **Serial Read** The data of the data register which is synchronized with the rising edge of the SC are output from the SIO0 to SIO15 pins and kept until the next SC rising edge. **Serial Write** The data from the SIO0 to SIO15 pins are latched at the rising edge of the SC and written in the data register.
$\overline{SE}$ (Serial data input/ output enable)		This is a control pin for the serial access port input/output buffer. It controls data output during serial reading and controls data input during serial writing. By inputting the serial clock, the serial pointer will operate even if $\overline{SE}$ has not been activated (high level input).
SIO0 to SIO15 (Serial data inputs/ outputs)	Input/ Output	These are the serial data input and output pins of the serial access port.
QSF (Special function output)	Output	This is a position discrimination pin of the serial pointer (upper side or lower side). Which side is being serial accessed (upper side or lower side) can be discriminated according to the output of this pin. • High level ..... Upper side (Addresses 256 to 511) • Low level ..... Lower side (Addresses 0 to 255)

2. Random Access Port Operations

The operation mode is determined by the $\overline{CAS}$, $\overline{DT}/\overline{OE}$, $\overline{UWE}$, $\overline{LWE}$, and DSF level at the falling edge of $\overline{RAS}$ and DSF level at the falling edge of $\overline{CAS}$.

Table 2-1. Operation Mode

$\overline{RAS}$ Falling Edge					$\overline{CAS}$ Falling Edge	Operation Mode	
$\overline{CAS}$	$\overline{DT}/\overline{OE}$	$\overline{UWE}$	$\overline{LWE}$	DSF	DSF		
H	H	H	H	L	L	Read/Write Cycle	Read/Write cycle
H	H	H	H	L	H		Block write cycle
H	H	L	L	L	L		Mask write cycle[Note 1]
H	H	L	H	L	L		Upper byte mask write cycle[Note 1]
H	H	H	L	L	L		Lower byte mask write cycle[Note 1]
H	H	L	L	L	H		Block mask write cycle[Note 1]
H	H	L	H	L	H		Upper byte block mask write cycle[Note 1]
H	H	H	L	L	H		Lower byte block mask write cycle[Note 1]
H	H	H	H	H	H		Color register set cycle
H	H	H	H	H	L		Write mask register set cycle
H	L	H	H	L	×	Data Transfer Cycle	Single read data transfer cycle
H	L	H	H	H	×		Split read data transfer cycle
H	L	L	L	L	×		Single write data transfer cycle[Note 1]
H	L	L	L	H	×		Split write data transfer cycle[Note 1]
L	×	×	×	L	×	Refresh Cycle	$\overline{CAS}$ before $\overline{RAS}$ refresh cycle (Option reset)[Note 1, 2]
L	×	H	H	H	×		$\overline{CAS}$ before $\overline{RAS}$ refresh cycle (No reset)
L	×	L	L	H	×		$\overline{CAS}$ before $\overline{RAS}$ refresh cycle (STOP register set)[Note 2]
H	H	×	×	×	×		$\overline{RAS}$ only refresh cycle

Notes 1. Observe the following conditions when using the new mask data or old mask data in these cycles.

(1) Old mask data

Can be used after setting the mask data using the write mask register set cycle.

(2) New mask data

Can be used after setting the mask data using the $\overline{CAS}$ before $\overline{RAS}$ refresh cycle (Option reset cycle).

2. The STOP register is set to "FFH (11111111)" by the optional reset cycle.

Remark H : High level, L : Low level, × : High level or low level

2.1 Random Read Cycle

This product has a common 16-bit input/output pin. To output data, specify the address using the $\overline{RAS}$ and $\overline{CAS}$ clocks and then set $\overline{DT}/\overline{OE}$ to low level.

The data output will be kept until one of the following conditions is set.

(1) Set $\overline{RAS}$ and $\overline{CAS}$ to high level
(2) Set $\overline{DT}/\overline{OE}$ to high level
(3) Set $\overline{UWE}$ and $\overline{LWE}$ to low level ($\overline{UWE}$ controls the upper bytes, $\overline{LWE}$ controls the lower bytes)

The read cycle and data transfer cycle are differentiated according to the level of $\overline{DT}/\overline{OE}$ at the falling edge of the $\overline{RAS}$ clock. If $\overline{DT}/\overline{OE}$ is set to low level at the falling edge of the $\overline{RAS}$ clock, data transfer cycle operations will be initiated. Therefore, to set the read cycle, input a high level above t_{DHH} (MIN.) to $\overline{DT}/\overline{OE}$ from the falling edge of the $\overline{RAS}$ clock, and then input a low level.

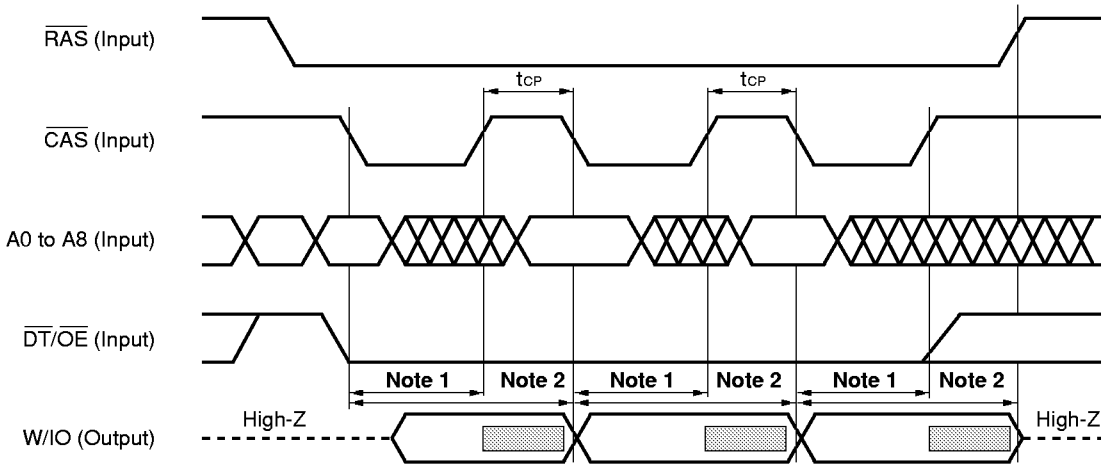
Caution Set the DSF to low level at the falling edge of $\overline{RAS}$. If set to high level, the memory cell data cannot be output.

2.1.1 Extended Read Data Output (μPD482445, 482445L)

The μPD482445 and μPD482445L adopt the hyper page mode cycle which is a faster read/write cycle than the fast page mode of the μPD482444 (Hyper page mode cycle time: 30 ns (MIN.)).

With this cycle, the read data output can be kept until the next $\overline{CAS}$ cycle, and because the output is extended, the minimum cycle can easily be used. For example, by fixing $\overline{DT}/\overline{OE}$ at low level after dropping $\overline{RAS}$ and executing the hyper page read cycle, each time the column address is latched at the falling edge of $\overline{CAS}$, the data output will be updated and kept until the next falling edge of $\overline{CAS}$. As a result, the output will be extended only during $\overline{CAS}$ precharge time (t_{CP}) as compared to the normal fast page mode.

Figure 2-1. Extended Data Output of Hyper Page Mode



Notes 1. Time during which the output data is kept in the fast page read cycle.

2. Time during which the output data is kept in the hyper page read cycle (▨ part: Extended data output).

2.2 Random Write Cycle (Early Write, Late Write)

There are three types of random write cycles-the early write and late write. To use these cycles, activate the $\overline{RAS}$ and $\overline{CAS}$ clocks and set $\overline{UWE}$ and $\overline{LWE}$ to low level. In addition, as this product has two write enables, data input can be controlled for every 8 bits (upper byte and lower byte). $\overline{UWE}$ controls the upper bytes (W8 to W15/IO8 to IO15) while $\overline{LWE}$ controls the lower bytes (W0 to W7/IO0 to IO7). Byte write cycle can therefore be performed by controlling $\overline{UWE}$ and $\overline{LWE}$.

The random write cycle, regardless of the word/byte write cycle, latches the word data (16 bits) input to the data bus. By inputting a low level to $\overline{UWE}$ (or $\overline{LWE}$) during the byte write cycle, the latched word (16 bits) data will be written only in the upper byte (or lower byte) and the data of the unselected lower byte (or upper byte) will be ignored. In the same write cycle, by inputting a low level to $\overline{LWE}$ (or $\overline{UWE}$) later, the ignored lower byte (or upper byte) data can be written. By controlling the $\overline{UWE}$ and $\overline{LWE}$ pins, the word data (16 bits) in the same cycle can be written in one byte (8 bits).

The $\overline{UWE}$ and $\overline{LWE}$ also control the mask data for the write-per-bit function (mask write cycle). Therefore, when performing the normal write cycle which does not use the write-per-bit function, set these pins to high level at the falling edge of the $\overline{RAS}$ clock.

2.2.1 Early Write Cycle

The early write cycle controls data writing according to the $\overline{CAS}$ clock.

To execute this cycle, set $\overline{UWE}$ and $\overline{LWE}$ to low level earlier than the $\overline{CAS}$ clock. The write data is taken into the device at the falling edge of the $\overline{CAS}$ clock.

2.2.2 Late Write Cycle

The late write cycle controls data writing according to the $\overline{WE}$ clock.

To execute this cycle, set $\overline{UWE}$ and $\overline{LWE}$ to low level later than the $\overline{CAS}$ clock. The write data is taken into the device at the falling edge of $\overline{UWE}$ and $\overline{LWE}$. To set the output to high impedance at this time, keep $\overline{DT}/\overline{OE}$ at high level until $\overline{UWE}$ and $\overline{LWE}$ are input.

2.3 Read Modify Write Cycle

The read modify write cycle performs data reading and writing in one $\overline{RAS}$ and $\overline{CAS}$ cycle.

To execute this cycle, delay $\overline{UWE}$ and $\overline{LWE}$ from the late write cycle by t_{RWD} (MIN.), t_{CWD} (MIN.), and t_{AWD} (MIN.). Follow the t_{OEZ} and t_{OED} specifications so that the output data and input data do not clash in the data bus. The data after modification can be input after more than t_{OED} (MIN.) from the rising edge of $\overline{DT}/\overline{OE}$.

2.4 Fast Page Mode Cycle (μPD482444)

The μPD482444 adopt the fast page mode. This mode accesses memory cells in the same row array in about 1/3 of the time taken by the normal random read/write cycle. This fast page mode cycle is executed by repeating the $\overline{CAS}$ clock cycle more than two times while the $\overline{RAS}$ clock is being activated. In this mode read, write and read modify write cycles are available for each of the consecutive $\overline{CAS}$ cycles within the same $\overline{RAS}$ cycle.

2.5 Hyper Page Mode Cycle (μPD482445, 482445L)

The μPD482445 and μPD482445L adopt a hyper page mode cycle which is a faster read/write cycle than the fast page mode of the μPD482444 (Hyper page mode cycle time: 30 ns (MIN.)).

In this cycle, because the read data output is kept until the following $\overline{CAS}$ cycle and as a result, the output is extended, the minimum cycle can easily be used. The output is extended compared to the normal fast page mode of μPD482444. Refer to **2.1.1 Extended Read Data Output**.

2.6 Block Write Cycle

This cycle writes the color register data in 128-bit or 64-bit memory cell in one cycle. The memory cell range in which data can be written in one block write cycle is eight continuous columns on one row address (8-column × 16 · IO = 128 bits or 8-column × 8 · IO = 64 bits).

Any column of the eight columns can be selected and writing prohibited. Determine whether to write or prohibit writing according to the data selected for column.

2.6.1 Free Column Selection

Determine which column to select according to the W/IO pin to which the data selected for the column is to be input.

The eight columns (1st to 8th) correspond to W0 to W15/IO0 to IO15 to which the data selected for column will be input (The following table shows the 1st to 8th columns specified by A0, A1, and A2 and the corresponding W/IO pins to which the data selected will be input.).

2.6.2 Column Select Data

Input column select data for every eight columns at the upper 64 bits and lower 64 bits (a total of 16 columns). The data will be written if the column select data is “1”. Writing will be prohibited if the column select data is “0”.

2.6.3 Execution of Block Write Cycle

At the falling edge of the slowest signal ($\overline{CAS}$, $\overline{UWE}$, or $\overline{LWE}$), input the "1" column select data or "0" column select data to W0 to W15/IO0 to IO15 corresponding to columns 1st to 8th.

By using the write-per-bit (new mask data/old mask data) function, only the required W/IO can be selected and written.

Table 2-2. I/O Pins Input with Column Select Data Corresponding to Columns 1st to 8th

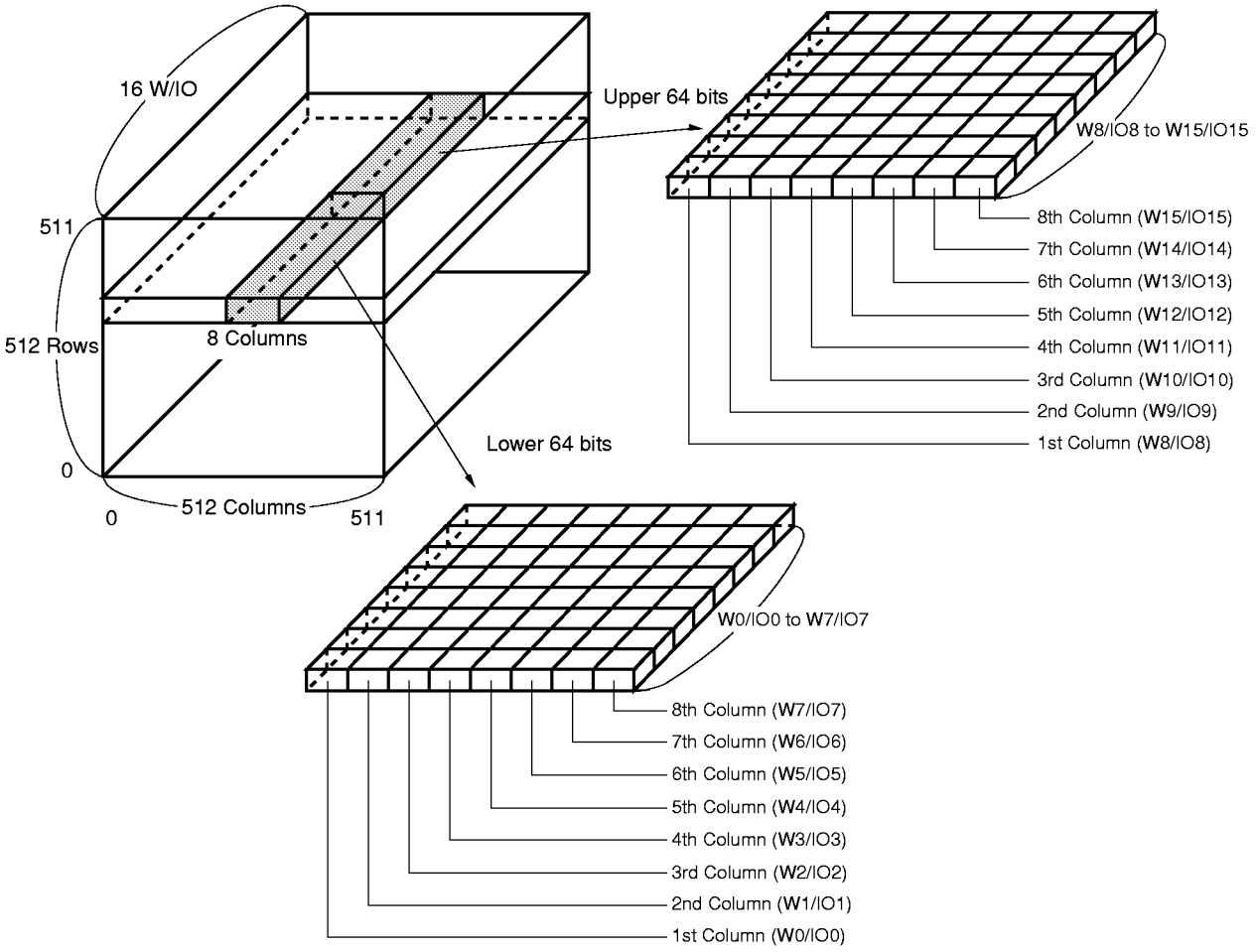
Column Select Data of Lower Byte (IO0 to IO7)

Selected 8 Columns	Column Address and Corresponding W/IO Pin				Column Select Data	Writing
	A2	A1	A0	IO		
1st column	0	0	0	IO0	1	Yes
					0	No
2nd column	0	0	1	IO1	1	Yes
					0	No
3rd column	0	1	0	IO2	1	Yes
					0	No
4th column	0	1	1	IO3	1	Yes
					0	No
5th column	1	0	0	IO4	1	Yes
					0	No
6th column	1	0	1	IO5	1	Yes
					0	No
7th column	1	1	0	IO6	1	Yes
					0	No
8th column	1	1	1	IO7	1	Yes
					0	No

Column Select Data of Upper Byte (IO8 to IO15)

Selected 8 Columns	Column Address and Corresponding W/IO Pin				Column Select Data	Writing
	A2	A1	A0	IO		
1st column	0	0	0	IO8	1	Yes
					0	No
2nd column	0	0	1	IO9	1	Yes
					0	No
3rd column	0	1	0	IO10	1	Yes
					0	No
4th column	0	1	1	IO11	1	Yes
					0	No
5th column	1	0	0	IO12	1	Yes
					0	No
6th column	1	0	1	IO13	1	Yes
					0	No
7th column	1	1	0	IO14	1	Yes
					0	No
8th column	1	1	1	IO15	1	Yes
					0	No

Figure 2-2. Memory Cell Range That Can be Written in Block Write Cycle



Remarks 1. ▨ is the memory cell range that can be written in one block write cycle.

2. ( ) is the W/IO pin input with the column select data.

2.7 Register Set Cycle (Color Register, Write Mask Register)

This cycle writes data in the color register and write mask register. To execute the register set cycle, set $\overline{CAS}$, $\overline{DT/OE}$, $\overline{UWE}$, $\overline{LWE}$ and DSF to high level at the falling edge of $\overline{RAS}$. Determine which register to select according to the DSF level at the falling edge of $\overline{CAS}$.

The register set cycle also serves as the $\overline{RAS}$ only refresh cycle.

Table 2-3. Register Selection

DSF level at $\overline{CAS}$ falling edge	Selected register
High level	Color register
Low level	Write mask register

Caution After selecting the write mask register and writing the mask data, the write-per-bit function in the mask write cycle will be set for the old mask register. Refer to 2.8.1 Write-Per-Bit Function.

2.8 Mask Write Cycle

Cycles that use the write-per-bit function during the random write cycle, flash write cycle, block write cycle, write data transfer cycle, are called mask write cycles. In the fast page/hyper page mode write cycle, the mask data cannot be changed during the $\overline{CAS}$ cycle.

2.8.1 Write-Per-Bit Function

The write-per-bit function writes data using the mask data only in the required IO-pin. It writes when the mask data is "1" and prohibits writing when the data is "0".

Table 2-4. Mask Data Selection

W Pin	Mask Data	Writing
W0 to W15	1	Yes
	0	No

2.8.2 Selecting Mask Data

There are two ways of selecting mask data. One is the new mask data method and the other is the old mask data method.

With the new mask data method, new mask data is set in the cycle writing. With the old mask data, mask data set in the write mask register is used.

(1) New Mask Data Method

To switch to the mode using new mask data, set the DSF to low level at the falling edge of $\overline{CAS}$ in the $\overline{CAS}$ before $\overline{RAS}$ refresh cycle.

As a result, the write-per-bit function can be used using the new mask data from the next mask write cycle.

(2) Old Mask Data Method

To switch to the mode using old mask data, set the DSF to low level at the falling edge of $\overline{CAS}$ in the write mask register set cycle, and write the mask data in the write mask register.

As a result, the write-per-bit function can be used using the old mask data from the next mask write cycle.

2.8.3 Execution of Mask Write Cycle

To execute the write-per-bit function, select the new mask data method or old mask data method, and set $\overline{UWE}$ and $\overline{LWE}$ to low level at the falling edge of $\overline{RAS}$ of each write cycle ($\overline{UWE}$ controls the upper byte (W8 to W15/IO8 to IO15) and $\overline{LWE}$ controls the lower byte (W0 to W7/IO0 to IO7).). At this time, input the mask data to the W pin in the write cycle using the new mask data. In the write cycle using the old mask data, as the mask data set to the write mask register will be used, there is no need to input the mask data to the W pin.

This function is valid only at the falling edge of $\overline{RAS}$. In the fast page/hyper page mode write cycle, the mask data determined in the first $\overline{RAS}$ cycle for moving onto the next fast page/hyper page mode will be valid while the fast page/hyper page mode write cycle continues.

2.9 Refresh Cycle

The refresh cycle of this product consists of the $\overline{CAS}$ before $\overline{RAS}$ refresh cycle and refresh cycle using external address inputs ($\overline{RAS}$ only refresh and read/write refresh). The refresh period is the same as the 2M-bit dual port graphics buffer (× 8), 512 cycles/8 ms.

2.9.1 Refresh Cycle Using External Address Input ($\overline{RAS}$ Only Refresh and Read/Write Refresh)

By specifying the row address using the 9 bits between A0 to A8 at the falling edge of $\overline{RAS}$, setting $\overline{CAS}$ to high level, and keeping $\overline{CAS}$ at high level while $\overline{RAS}$ is low level, the memory cells on the specified row address (512 × 16 bits) can be refreshed. At this time, refresh is executed, W0 to W15/IO0 to IO15 pins are kept at high impedance, and information such as memory contents, register data, function settings, etc. are all also kept.

At the falling edge of $\overline{RAS}$, all cycles whose $\overline{CAS}$ are high level input the external address. Therefore, in addition to the read/write cycle operations, etc. refresh operations similar to the $\overline{RAS}$ only refresh operations will be performed. For this reason, in systems in which addresses in the memory are always increased or decreased, it may not be necessary to perform refresh again.

When several devices exist on one bus, data will clash in the bus during the above read/write operations unless each device is equipped with a buffer. Consequently, as it is necessary to set the I/O line to high impedance beforehand during refresh, normally the $\overline{RAS}$ only refresh operation is used.

2.9.2 $\overline{CAS}$ Before $\overline{RAS}$ Refresh Cycle (Including Hidden Refresh)

When $\overline{CAS}$ is set to low level at the falling edge of $\overline{RAS}$, the refresh address is supplied from the internal refresh address counter. The internal refresh address counter is increased automatically each time this refresh cycle is executed.

During this refresh cycle, functions of random access port and serial access port are selected as follows according to the DSF, $\overline{UWE}$, and $\overline{LWE}$ levels at the falling edge of $\overline{RAS}$.

(1) When DSF is low level: Optional reset

All STOP register data become "1" and the mask write cycle switches to the new mask data method.

(2) When DSF is high level and $\overline{UWE}$, $\overline{LWE}$ are low level: STOP register set

The STOP register data is input from the A0 to A8 pins at the falling edge of $\overline{RAS}$.

(3) When DSF, $\overline{UWE}$, and $\overline{LWE}$ are high level: No reset

Only refresh operations are performed and the function selection state is kept.

In all cases, the W/IO pin is kept at high impedance. When $\overline{CAS}$ and $\overline{DT}/\overline{OE}$ are kept low level while the mode is changed to the $\overline{CAS}$ before $\overline{RAS}$ refresh cycle following the read cycle, and $\overline{RAS}$ is activated, the hidden refresh cycle will be initiated. In this cycle, the W/IO pin does not become high impedance and the data read in the former read cycle will be kept as it is.

Because internal memory operations are equivalent to $\overline{CAS}$ before $\overline{RAS}$ refresh, no external addresses are required.

Like $\overline{CAS}$ before $\overline{RAS}$ refresh, in the hidden cycle, functions will be selected according to the level of DSF, $\overline{UWE}$, and $\overline{LWE}$ at the falling edge of $\overline{RAS}$. Operations are guaranteed when DSF is low level and when DSF, $\overline{UWE}$, and $\overline{LWE}$ are high level.

3. Serial Access Port Operations

There are two types of data transfer cycles-data transfer from the random access port to the serial access port (read data transfer) and data transfer from the serial access port to the random access port (write data transfer). There are also two types of data transfer methods-single data transfer and split data transfer.

To set the data transfer cycle, input high level to $\overline{CAS}$ and input low level to $\overline{DT}/\overline{OE}$ at the falling edge of $\overline{RAS}$.

The data transfer type differs according to the input levels of $\overline{UWE}$, $\overline{LWE}$, and DSF at the falling edge of $\overline{RAS}$.

Table 3-1. Serial Access Port Operation Mode

At $\overline{RAS}$ Falling Edge				Data Transfer Type	Transfer Direction	
$\overline{CAS}$	$\overline{DT}/\overline{OE}$	$\overline{UWE}$, $\overline{LWE}$	DSF		Transfer Source	Transfer Destination
H	L	H	L	Single read data transfer	Random access port	Serial access port
H	L	H	H	Split read data transfer		
H	L	L	L	Single mask write data transfer[Note]	Serial access port	Random access port
H	L	L	H	Split mask write data transfer[Note]		

Note Write-per-bit function can be specified.

Remark H: High level, L: Low level

3.1 Single Data Transfer Method

With this method, 512 words × 16 bits (whole memory range of serial access port) data is transferred at one time. This method can be used in both write data transfer and read data transfer.

3.1.1 Single Read Data Transfer Cycle

This cycle transfers the 8K-bit (512 words × 16 bits) data of the random access port to the serial access port in one cycle.

(a) Setting of Single Read Data Transfer Cycle

To set the data transfer cycle, input a high level to $\overline{CAS}$, $\overline{UWE}$, and $\overline{LWE}$ and low level to $\overline{DT}/\overline{OE}$ and DSF at the falling edge of $\overline{RAS}$.

Using the row address input to A0 to A8 at the falling edge of $\overline{RAS}$, the memory cells (512 words × 16 bits) of the transfer source of the random access port can be selected. The address data input to A0 to A8 at the falling edge of $\overline{CAS}$ will be latched as the TAP register data. Refer to **3.4 TAP Register**.

(b) Execution of Single Read Data Transfer Cycle

To execute the data transfer cycle, set the single read data transfer cycle and then input a high level to $\overline{DT}/\overline{OE}$ and $\overline{RAS}$.

When SC is active (edge control), data transfer will be executed at the rising edge of $\overline{DT}/\overline{OE}$. When SC is inactive (self control), it will be executed at the rising edge of $\overline{RAS}$. At the same time, the serial address pointer jumps to the start column (TAP) of the next serial read cycle, and the TAP register will be set the empty state.

After the transfer is completed, the new serial access port data is output after t_{SCA} following the rise of the SC clock that occurs after t_{SDH} if the SC is active, and after t_{SDHR} if SC is inactive.

Caution When the single read data transfer cycle is executed while the serial access port is performing serial write operations, the serial access port will start serial read operations at the rising edge of $\overline{RAS}$. Refer to 4. Electrical Characteristics Read Data Transfer Cycle (Serial Write → Serial Read Switching) Timings.

3.1.2 Single Mask Write Data Transfer Cycle

This cycle transfers 8K-bit (512 word × 16 bits) data of the serial access port to the random access port in one cycle. Because $\overline{UWE}$ and $\overline{LWE}$ are low level at the falling edge of $\overline{RAS}$, the write-per-bit function always functions in this transfer cycle. Refer to **2.8 Mask Write Cycle**.

(a) Setting of Single Mask Write Data Transfer Cycle

To set this cycle, latch the data to be transferred to the serial access port, and then input a high level to $\overline{CAS}$ and low level to $\overline{DT/OE}$, $\overline{UWE}$, $\overline{LWE}$, and DSF at the falling edge of $\overline{RAS}$. Because the write-per-bit function functions in this transfer operation, for the new mask data method, the mask data must be supplied to W0 to W15 at the falling edge of $\overline{RAS}$, and for the old mask data method, there is no need to control the mask data.

The memory cells (512 words × 16 bits) of the transfer destination of the random access port are selected using the row address input to A0 to A8 at the falling edge of $\overline{RAS}$. The address data input to A0 to A8 at the falling edge of $\overline{CAS}$ is input as the TAP register data. Refer to **3.4 TAP Register**.

(b) Execution of Single Mask Write Data Transfer Cycle

To execute this cycle, set the single write data transfer cycle and then input high level to $\overline{RAS}$. Data will be transferred at the rising edge of $\overline{RAS}$. At the same time, the serial address pointer jumps to the start column (TAP) of the next serial write cycle, and the TAP register will be set the empty state.

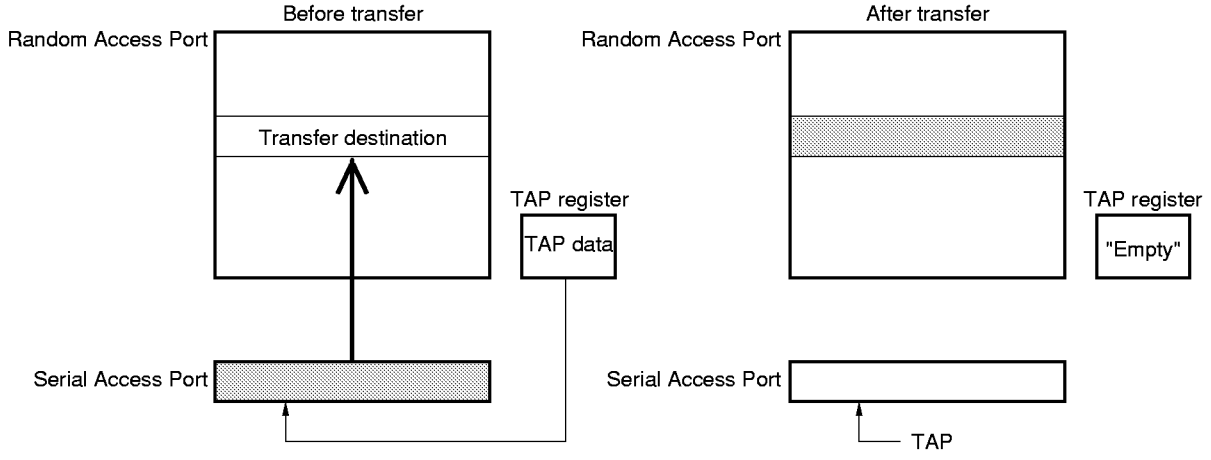
After the transfer is completed, the new serial access port data is latched at the rising edge of the SC clock that occurs after t_{SDHR}.

Caution 1. When the single mask write data transfer cycle is executed while the serial access port is performing serial read operations, the serial access port will start serial write operations at the rising edge of $\overline{RAS}$. Refer to 4. Electrical Characteristics Write Data Transfer Cycle (Serial Read → Serial Write Switching) Timings.

2. Always make $\overline{CAS}$ low level in the write data transfer cycle and latch TAP. If write data transfer is performed without setting TAP, serial access port operations cannot be ensured until either one of the following points. If the SC clock is input during this time, the serial register value also cannot be guaranteed.

- **Until the falling edge of $\overline{CAS}$ during the write data transfer cycle**
- **Until the read data transfer cycle is executed again**

Figure 3-1. Single Write Data Transfer and TAP Operation



3.2 Split Data Transfer Method

With this method, the 512 words × 16 bits (whole memory range of serial access port) data is divided into the lower column (0 to 255) and upper column (256 to 511), each consisting of 256 words × 16 bits.

Because the columns are divided into upper and lower columns with this method, data transfer can be performed on lower column (or upper column) while performing read/write operations in the upper column (or lower column). For this reason, transfer timing design is easy. This transfer method can be used in both write data transfer and read data transfer.

3.2.1 Split Read Data Transfer Cycle

This cycle divides the 8K-bit (512 words × 16 bits) data of the random access port into the lower and upper columns and transfers them to the serial access port.

In this cycle, the serial read/write can be performed in the columns to which data is not transfer.

(a) Setting of Split Read Data Transfer Cycle

To set this cycle, input a high level to $\overline{CAS}$, $\overline{UWE}$, $\overline{LWE}$ and DSF, and low level to $\overline{DT}/\overline{OE}$ at the falling edge of $\overline{RAS}$.

The memory cells (512 words × 16 bits) of the transfer source of the random access port are selected using the row address input to A0 to A8 at the falling edge of $\overline{RAS}$. And the address data input to A0 to A7 at the falling edge of $\overline{CAS}$ is latched as the TAP register data of serial access port. There is no need to control address data input to A8. Refer to **3.4 TAP Register**.

(b) Execution of Split Read Data Transfer Cycle

To execute this cycle, set the split read data transfer cycle and then input the high level to $\overline{RAS}$. Data will be transferred at the rising edge of $\overline{RAS}$. Data is transferred from the random access port to the serial access port automatically at the column side where serial access port is inactive. To confirm the transferred column side, check the output state of the QSF pin. Refer to **3.3.3 QSF Pin Output**.

When the serial address pointer comes to the jump source address specified by the STOP register, the serial address pointer jumps to the start column (TAP) of the serial read/write cycle at the inactive column side, and the TAP register will be set the empty state.

3.2.2 Split Mask Write Data Transfer Cycle

This cycle divides the 8K-bit (512 words × 16 bits) data of the serial access port into the lower and upper columns and transfers them to the random access port.

In this cycle, serial read/write can be performed for columns to which data is not transferred.

Because $\overline{\text{UWE}}$ and $\overline{\text{LWE}}$ are low level at the falling edge of $\overline{\text{RAS}}$, the write-per-bit function always functions in this transfer cycle. Refer to **2.8 Mask Write Cycle**.

(a) Setting of Split Mask Write Data Transfer Cycle

To set this data transfer cycle, input a high level to $\overline{\text{CAS}}$ and DSF and low level to $\overline{\text{DT}}/\overline{\text{OE}}$, $\overline{\text{UWE}}$, and $\overline{\text{LWE}}$ at the falling edge of $\overline{\text{RAS}}$. Because the write-per-bit function functions in this transfer operation, for the new mask data method, the mask data must be supplied to W0 to W15 at the falling edge of $\overline{\text{RAS}}$, and for the old mask data method, there is no need to control the mask data.

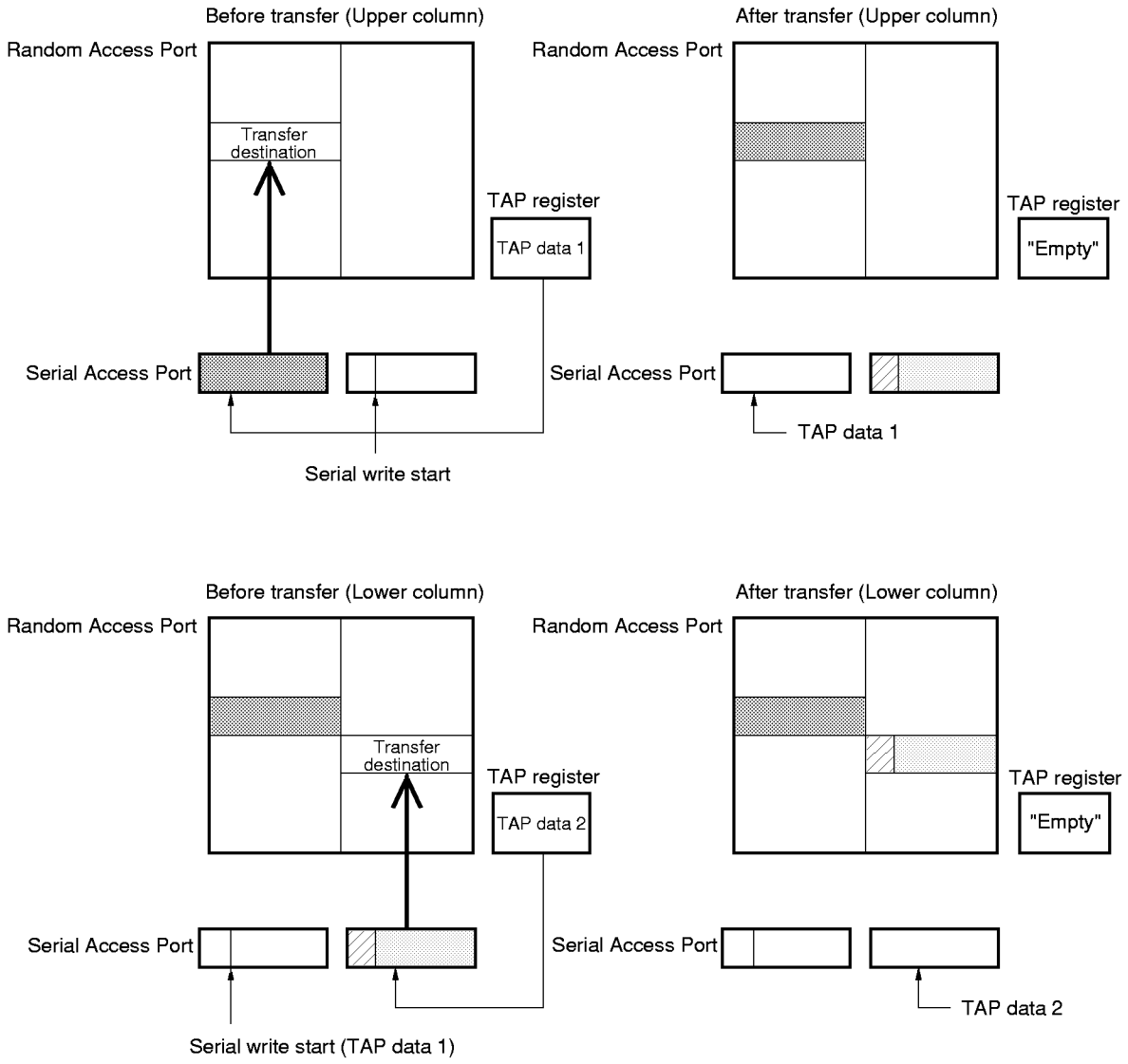
The memory cells (512 words × 16 bits) of the transfer destination of the random access port are selected using the row address input to A0 to A8 at the falling edge of $\overline{\text{RAS}}$. The address data input to A0 to A7 at the falling edge of $\overline{\text{CAS}}$ is input as the TAP register data. There is no need to control address data input to A8. Refer to **3.4 TAP Register**.

(b) Execution of Split Mask Write Data Transfer Cycle

To execute this cycle, set the split write data transfer cycle and then input high level to $\overline{\text{RAS}}$. Data will be transferred at the rising edge of $\overline{\text{RAS}}$. Data is transferred from the serial access port to the random access port automatically at the column side where the serial access port is inactive. To confirm the transferred column side, check the output state of the QSF pin. Refer to **3.3.3 QSF Pin Output**.

When the serial address pointer comes to the jump source address specified by the STOP register, the serial address pointer jumps to the start column (TAP) of the serial read/write cycle at the inactive column side, and the TAP register will be set the empty state.

Figure 3-2. Split Mask Write Data Transfer and TAP Operations



3.3 Serial Read/Write

The serial access port (512 words × 16 bits) is independent from the random access port and can perform read and write operations. The serial access port performing single data transfer and split data transfer can not perform read and write operations independently.

Caution When the power is turned on, the serial access port sets into the input (write) mode and the SIO pin is the high impedance state.

3.3.1 Serial Read Cycle

To set the serial read cycle, perform the single read data transfer cycle (The mode will not change in the split read data transfer cycle.).

Execute the single read data transfer cycle and latch the data and TAP data. By inputting a clock signal to the SC pin and inputting a low level to the $\overline{SE}$ pin, data will be output from the serial address pointer specified by TAP register. The data synchronizes with the rising edge of the SC clock and is output from the SIO0 to SIO15 pin, and the data is kept until the next rising edge of the SC clock.

(a) Reading-Jump

The $\overline{SE}$ pin controls the SIO pin output buffer independently from the SC clock. By setting the $\overline{SE}$ pin to high level even while inputting the SC clock, SIO0 to SIO15 pins become high impedance. But the operations of serial address pointer will be continued while the SC clock is being input even though reading has been prohibited from $\overline{SE}$ pin. Reading-jump of the column can be performed using this function.

3.3.2 Serial Write Cycle

To set the serial write cycle, perform the single write data transfer cycle (The mode will not change in the split write data transfer cycle.). To prevent the transfer data from being written in the memory cell of the random access port, set all bits of the mask data to "0" and control the mask data.

Execute the single write data transfer cycle and set the serial write cycle. By inputting the clock signal to the SC pin and inputting a low level to the $\overline{SE}$ pin, data can be latched from the serial address pointer specified by TAP register. The data synchronizes with the rising edge of the SC clock and is input from SIO0 to SIO15 pins. Be sure to follow the specifications for the setup time (t_{SES}) and hold time (t_{SEH}) of $\overline{SE}$ pin for the SC clock.

(a) Writing-Jumps (Intermittent Writing)

The $\overline{SE}$ pin controls writing operations independently from the SC clock. By setting the $\overline{SE}$ pin to high level even while inputting the SC clock, writing will not be executed. But the operations of serial address pointer will be continued while the SC clock is being input even though writing has been prohibited from $\overline{SE}$ pin. These functions enable writing-jumps (intermittent writing) to be performed. The masked data is kept as the old data.

3.3.3 QSF Pin Output

QSF pin determines whether the serial address pointer is at the upper column side (addresses 256 to 511) or the lower column side (addresses 0 to 255) at the rising edge of the following SC clock during serial read or write. In other words, it outputs the uppermost bit (A8) of the column address of the serial address pointer.

During split data transfer cycle, data is transferred at the column side where serial access port is inactive.

The following table shows the QSF pin output state and the access pointer of following SC clocks.

QSF Output	Access Address of Following SC clock	Transfer Destination (Split Data Transfer Method)
Low level	Addresses 0 to 255	Addresses 256 to 511
High level	Addresses 256 to 511	Addresses 0 to 255

3.4 TAP (Top Access Point) Register

The TAP register is a data register which specifies the start address (first serial address point = TAP) of the serial read or serial write.

Set data to this register each time a transfer cycle is executed.

3.4.1 Setting of TAP Register

The data input to A0 to A8 (A0 to A7: Split data transfer) at the falling edge of $\overline{CAS}$ during the setting of a transfer cycle is set as the TAP register data. By executing the transfer cycle, the start address of the following serial read (or write) operations is specified by the data of the TAP register and the TAP register will be kept in the empty state until the TAP regis-ter is set again.

In the split data transfer cycle, because the inactive serial access port column addresses are specified by the data of the TAP register automatically, there is no need to control the A8 data.

Caution When the TAP register is empty, the address following the 511 serial address point will be 0. In addition, because the serial address pointer will not jump to the column specified by the STOP register, the binary boundary jump function cannot be used. Refer to 3.6 Binary Boundary Jump Function.

3.5 STOP Register

The STOP register is a data register which determines the column of the jump source when jumping to a different column side (lower column or upper column) in the split data transfer cycle. Five types of columns can be selected for starting jump (jumping is possible at 2, 4, 8, 16, and 32 points). The following table shows the correspondence between the column at the jump source and data of the STOP register.

Once set, the STOP register data is kept until it is set again.

3.5.1 Setting of STOP Register

To set the STOP register, set $\overline{UWE}$ and $\overline{LWE}$ to low level at the falling edge of $\overline{RAS}$ in the $\overline{CAS}$ before $\overline{RAS}$ refresh cycle. The data input to A0 to A7 will be input as the STOP register data.

Table 3-2. STOP Register Data and Jump Source Column

STOP Register Data					Division	Bit Width	Jump Source Bit Column (Decimal Number)
A7	A6	A5	A4	A3 to A0			
1	1	1	1	1	1/2	256	255
							511
0	1	1	1	1	1/4	128	127, 255
							383, 511
0	0	1	1	1	1/8	64	63, 127, 191, 255
							319, 383, 447, 511
0	0	0	1	1	1/16	32	31, 63, 95, 127, 159, 191, 223, 255
							287, 319, 351, 383, 415, 447, 479, 511
0	0	0	0	1	1/32	16	15, 31, 47, 63, 79, 95, 111, 127, 143, 159, 175, 191, 207, 223, 239, 255
							271, 287, 303, 319, 335, 351, 367, 383, 399, 415, 431, 447, 463, 479, 495, 511

Remark A8: Don't care.

Caution When the power is supplied, all STOP register data will be undefined.

3.6 Binary Boundary Jump Function

This function causes the serial address pointer jump to the TAP specified by the TAP register when the pointer moves to a column specified by the STOP register (split data transfer).

This function cannot be used when the jump destination address is not set (TAP register is empty).

This function facilitates tile map application which divides the screen into tiles and manages data for each tile.

3.6.1 Usage of Binary Boundary Jump Function

After setting the STOP register, execute the single read (or write) data transfer and initialize the serial access port. The initialization process will switch the serial access port read (or write) operations, set TAP, set the serial access port data, and set the TAP register to empty. By inputting the serial clock in this state, the serial access port will read (or write) operations from TAP in ascending order of address. Because the TAP register is in the empty state, the address at the jump source set by the STOP register will be ignored, and the serial address pointer will move on.

When the column to be jumped approaches, execute split data transfer and set new TAP data in the TAP register. The serial pointer will jump at the desired jump source address. Jump can be controlled freely by repeating these operations.

3.7 Special Operations

3.7.1 Serial Address Set Operations

Because the serial address counter is undefined when the power up, the serial access port operations when the SC clock is input are not guaranteed. Execute single read (or write) transfer after turning on the power. The serial access port will be initialized, enabling serial access port operations to be performed.

3.7.2 Lap Around Operations

If all the data of the register is read (write) during data transfer while the serial read (write) cycle is being executed, the serial pointer will repeat 0 to 511.

3.7.3 Cycle After Power On

Execute the dummy cycle eight times more than 100 μs after V_{CC} reaches the specified voltage in the recommended operation conditions.

If $\overline{RAS}$, $\overline{CAS}$, $\overline{DT}/\overline{OE}$, $\overline{UWE}$, $\overline{LWE}$ are kept at high level when the power is turned on, the following will be set automatically.

- Serial access port ..... Input mode, SIO: High impedance
- Color register ..... Undefined
- Mask register ..... Undefined
- TAP register ..... Undefined
- STOP register ..... Undefined

4. Electrical Characteristics

4.1 μPD482444, 482445 (Power Supply Voltage V_{CC} = 5 V ± 10 %)

Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
Pin voltage	V_T	–1.0 to +7.0	V
Supply voltage	V_{CC}	–1.0 to +7.0	V
Output current	I_O	50	mA
Power dissipation	P_D	1.5	W
Operating ambient temperature	T_A	0 to 70	°C
Storage temperature	T_{stg}	–55 to +125	°C

Caution Exposing the device to stress above those listed in Absolute Maximum Ratings could cause permanent damage. The device is not meant to be operated under conditions outside the limits in the operational sections of this characteristics. Exposure to Absolute Maximum rating conditions for extended periods may affect device reliability.

Recommended Operating Conditions

Parameter	Symbol	MIN.	TYP.	MAX.	Unit
Supply voltage	V_{CC}	4.5	5.0	5.5	V
High level input voltage	V_{IH}	2.4		5.5	V
Low level input voltage	V_{IL}	–1.0		+0.8	V
Operating ambient temperature	T_A	0		70	°C

DC Characteristics 1 (Recommended operating conditions unless otherwise noted)

Parameter	Symbol	Test conditions	MIN.	TYP.	MAX.	Unit
Input leakage current	I_{IL}	V_{IN} = 0 V to 5.5 V, Other inputs are 0 V	–10		+10	μA
Output leakage current	I_{OL}	W/IO, SIO, QSF are inactive, V_{OUT} = 0 V to 5.5 V	–10		+10	μA
Random access port high level output voltage	V_{OH} (R)	I_{OH} (R) = –1.0mA	2.4			V
Random access port low level output voltage	V_{OL} (R)	I_{OL} (R) = 2.1mA			0.4	V
Serial access port high level output voltage	V_{OH} (S)	I_{OH} (S) = –1.0mA	2.4			V
Serial access port low level output voltage	V_{OL} (S)	I_{OL} (S) = 2.1mA			0.4	V

Capacitance (T_A = 25 °C, f = 1MHz)

Parameter	Symbol	Test conditions	MIN.	TYP.	MAX.	Unit
Input Capacitance	C_{I1}	$\overline{RAS}$, $\overline{CAS}$, $\overline{UWE}$, $\overline{LWE}$, $\overline{DT/OE}$, DSF, $\overline{SE}$, SC			8	pF
	C_{I2}	A0 to A8			5	
Input/Output Capacitance	C_{IO}	W/IO (0 to 15), SIO (0 to 15)			7	pF
Output Capacitance	C_O	QSF			7	pF

DC Characteristics 2 (Recommended operating conditions unless otherwise noted)[Note 1]

Random Access Port	Serial Access Port		Symbol	μPD482444-60 μPD482445-60		μPD482444-70 μPD482445-70		Unit	Conditions
	Standby	Active		MIN.	MAX.	MIN.	MAX.		
Random Read/Write Cycle $\overline{RAS}$, $\overline{CAS}$ cycle, $t_{RC} = t_{RC}$ (MIN.), I_O = 0mA	O		I_{CC1}		110		95	mA	
		O	I_{CC7}		130		110		
Standby $\overline{RAS} = \overline{CAS} = V_{IH}$, D_{OUT} = high impedance	O		I_{CC2}		10		10	mA	Note 2
		O	I_{CC8}		50		45	mA	Note 2
$\overline{RAS}$ only refresh cycle $\overline{RAS}$ cycle, $\overline{CAS} = V_{IH}$, $t_{RC} = t_{RC}$ (MIN.)	O		I_{CC3}		100		85	mA	Note 3
		O	I_{CC9}		140		120		
Fast/Hyper page mode cycle $\overline{RAS} = V_{IL}$, $\overline{CAS}$ cycle, $t_{PC} = t_{PC}$ (MIN.) or $t_{HPC} = t_{HPC}$ (MIN.)	O		I_{CC4}		120		105	mA	Notes 4, 5
		O	I_{CC10}		150		130		
$\overline{CAS}$ before $\overline{RAS}$ refresh cycle $t_{RC} = t_{RC}$ (MIN.)	O		I_{CC5}		100		95	mA	
		O	I_{CC11}		130		120		
Data transfer cycle $t_{RC} = t_{RC}$ (MIN.)	O		I_{CC6}		120		105	mA	
		O	I_{CC12}		150		130		
Color/Mask write register set cycle $t_{RC} = t_{RC}$ (MIN.)	O		I_{CC13}		90		80	mA	
		O	I_{CC14}		120		105		
Flash write cycle $t_{RC} = t_{RC}$ (MIN.)	O		I_{CC15}		90		80	mA	
		O	I_{CC16}		120		105		
Block write cycle $t_{RC} = t_{RC}$ (MIN.)	O		I_{CC17}		110		100	mA	
		O	I_{CC18}		140		125		
Fast/Hyper page mode block write cycle $t_{PC} = t_{PC}$ (MIN.) or $t_{HPC} = t_{HPC}$ (MIN.)	O		I_{CC19}		135		120	mA	
		O	I_{CC20}		155		135		Notes 4, 5

Notes 1. No load on W/IO, SIO, QSF. The current consumption actually used depends on the output load and operating frequency of each pin.

2. A change in row addresses must not occur more than once in $t_{RC} = t_{RC}$ (MIN.).

3. When the address input is set to V_{IH} or V_{IL} during the t_{RAS} period.

4. Value when the address in t_{PC} one cycle is changed once when μPD482444 $t_{PC} = t_{PC}$ (MIN.).

5. Value when the address in t_{HPC} one cycle is changed once when μPD482445 $t_{HPC} = t_{HPC}$ (MIN.).

4.2 μPD482445L (Power Supply Voltage V_{CC} = 3.3 V ± 0.3 V)

Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
Pin voltage	V_T	–1.0 to +4.6	V
Supply voltage	V_{CC}	–1.0 to +4.6	V
Output current	I_O	20	mA
Power dissipation	P_D	1.0	W
Operating ambient temperature	T_A	0 to 70	°C
Storage temperature	T_{stg}	–55 to +125	°C

Caution Exposing the device to stress above those listed in Absolute Maximum Ratings could cause permanent damage. The device is not meant to be operated under conditions outside the limits in the operational sections of this characteristics. Exposure to Absolute Maximum rating conditions for extended periods may affect device reliability.

Recommended Operating Conditions

Parameter	Symbol	MIN.	TYP.	MAX.	Unit
Supply voltage	V_{CC}	3.0	3.3	3.6	V
High level input voltage	V_{IH}	2.0		V_{CC} + 0.3	V
Low level input voltage	V_{IL}	–0.3		+0.8	V
Operating ambient temperature	T_A	0		70	°C

DC Characteristics 1 (Recommended operating conditions unless otherwise noted)

Parameter	Symbol	Test conditions	MIN.	TYP.	MAX.	Unit
Input leakage current	I_{IL}	V_{IN} = 0 V to 3.6 V, Other inputs are 0 V	–5		+5	μA
Output leakage current	I_{OL}	W/IO, SIO, QSF are inactive V_{OUT} = 0 V to 3.6 V	–5		+5	μA
Random access port high level output voltage	V_{OH} (R)	I_{OH} (R) = –1.0mA	2.4			V
Random access port low level output voltage	V_{OL} (R)	I_{OL} (R) = 2.0mA			0.4	V
Serial access port high level output voltage	V_{OH} (S)	I_{OH} (S) = –1.0mA	2.4			V
Serial access port low level output voltage	V_{OL} (S)	I_{OL} (S) = 2.0mA			0.4	V

Capacitance (T_A = 25 °C, f = 1MHz)

Parameter	Symbol	Test conditions	MIN.	TYP.	MAX.	Unit
Input Capacitance	C_{I1}	$\overline{RAS}$, $\overline{CAS}$, $\overline{UWE}$, $\overline{LWE}$, $\overline{DT}/\overline{OE}$, DSF, $\overline{SE}$, SC			8	pF
	C_{I2}	A0 to A8			5	
Input/Output Capacitance	C_{IO}	W/IO (0 to 15), SIO (0 to 15)			7	pF
Output Capacitance	C_O	QSF			7	pF

DC Characteristics 2 (Recommended operating conditions unless otherwise noted)[Note 1]

Random Access Port	Serial Access Port		Symbol	μPD482445L-A70		Unit	Condition
	Standby	Active		MIN.	MAX.		
Random Read/Write Cycle $\overline{RAS}$, $\overline{CAS}$ cycle, $t_{RC} = t_{RC}$ (MIN.), I_O = 0mA	O		I_{CC1}		75	mA	
		O	I_{CC7}		110		
Standby $\overline{RAS} = \overline{CAS} = V_{IH}$, D_{OUT} = high impedance	O		I_{CC2}		7	mA	Note 2
		O	I_{CC8}		35	mA	Note 2
$\overline{RAS}$ only refresh cycle $\overline{RAS}$ cycle, $\overline{CAS} = V_{IH}$, $t_{RC} = t_{RC}$ (MIN.)	O		I_{CC3}		75	mA	Note 3
		O	I_{CC9}		110		
Hyper page mode cycle $\overline{RAS} = V_{IL}$, $\overline{CAS}$ cycle, $t_{HPC} = t_{HPC}$ (MIN.)	O		I_{CC4}		85	mA	Note 4
		O	I_{CC10}		120		
$\overline{CAS}$ before $\overline{RAS}$ refresh cycle $t_{RC} = t_{RC}$ (MIN.)	O		I_{CC5}		85	mA	
		O	I_{CC11}		120		
Data transfer cycle $t_{RC} = t_{RC}$ (MIN.)	O		I_{CC6}		95	mA	
		O	I_{CC12}		130		
Color/Mask write register set cycle $t_{RC} = t_{RC}$ (MIN.)	O		I_{CC13}		70	mA	
		O	I_{CC14}		105		
Flash write cycle $t_{RC} = t_{RC}$ (MIN.)	O		I_{CC15}		70	mA	
		O	I_{CC16}		105		
Block write cycle $t_{RC} = t_{RC}$ (MIN.)	O		I_{CC17}		90	mA	
		O	I_{CC18}		125		
Hyper page mode block write cycle $t_{HPC} = t_{HPC}$ (MIN.)	O		I_{CC19}		100	mA	Note 4
		O	I_{CC20}		135		

Notes 1. No load on W/IO, SIO, QSF. The current consumption actually used depends on the output load and operating frequency of each pin.

2. A change in row addresses must not occur more than once in $t_{RC} = t_{RC}$ (MIN.).

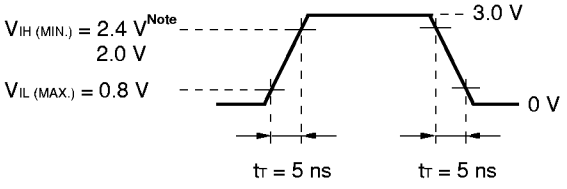
3. When the address input is set to V_{IH} or V_{IL} during the t_{RAS} period.

4. Value when the address in t_{HPC} one cycle is changed once when μPD482445L $t_{HPC} = t_{HPC}$ (MIN.).

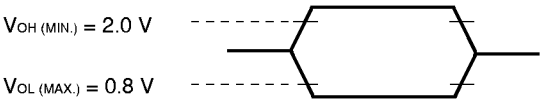
4.3 AC Characteristics (Recommended operating conditions unless otherwise noted)

- All applied voltages are referenced to GND.
- After supplying power, initialize the internal circuitry by waiting for at least 100 μs after $V_{CC} \geq 4.5$ V (μPD482444, 482445), $V_{CC} \geq 3.0$ V (μPD482445L), then supplying at least 8 $\overline{RAS}$ clock cycles. The $\overline{RAS}$ clock only requires t_{RC}, t_{RAS}, and t_{RP} are satisfied; there is no problem if other signals are in any state.
- Measure at t_T = 5 ns
- AC characteristic measuring conditions

(1) Input voltage, timing

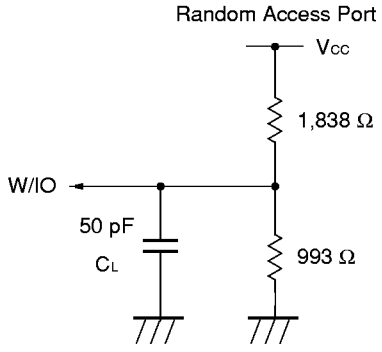


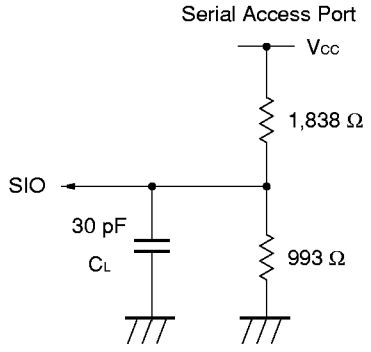
(2) Output voltage determined



Note 2.4 V: μPD482444, 482445
2.0 V: μPD482445L

(3) Output load conditions





[Common] (1/2)

Parameter	Symbol	μPD482444-60 μPD482445-60		μPD482444-70 μPD482445-70 μPD482445L-A70		Unit	Conditions
		MIN.	MAX.	MIN.	MAX.		
Random read or write cycle time	t_{RC}	110		130		ns	
Access time from $\overline{RAS}$	t_{RAC}		60		70	ns	**Note 1**
Access time from $\overline{CAS}$	t_{CAC}		18		18	ns	**Note 1**
Access time from column address	t_{AA}		30		35	ns	**Note 1**
Access time from $\overline{OE}$	t_{OEA}		18		18	ns	
$\overline{RAS}$ precharge time	t_{RP}	40		50		ns	
$\overline{CAS}$ precharge time (Non page mode)	t_{CPN}	10		10		ns	
$\overline{CAS}$ precharge time (Fast page/Hyper page mode)	t_{CP}	10		10		ns	
$\overline{CAS}$ high to $\overline{RAS}$ low precharge time	t_{CRP}	10		10		ns	
$\overline{RAS}$ high to $\overline{CAS}$ low precharge time	t_{RPC}	10		10		ns	
$\overline{RAS}$ pulse width (Non page mode)	t_{RAS}	60	10,000	70	10,000	ns	
$\overline{RAS}$ pulse width (Fast page/Hyper page mode)	t_{RASP}	60	125,000	70	125,000	ns	
$\overline{CAS}$ pulse width	t_{CAS}	15	100,000	15	100,000	ns	
$\overline{CAS}$ pulse width	t_{HCAS}	10	100,000	10	100,000	ns	
Write command pulse width	t_{WP}	12		12		ns	
$\overline{RAS}$ hold time	t_{RSH}	15		18		ns	
$\overline{CAS}$ hold time	t_{CSH}	60		70		ns	
Row address setup time	t_{ASR}	0		0		ns	
Row address hold time	t_{RAH}	15		15		ns	
Column address setup time	t_{ASC}	0		0		ns	
Column address hold time	t_{CAH}	10		10		ns	
Read command setup time	t_{RCS}	0		0		ns	
Data in setup time	t_{DS}	0		0		ns	**Note 2**
Data in hold time	t_{DH}	15		15		ns	**Note 2**
$\overline{DT}$ high setup time	t_{DHS}	0		0		ns	
$\overline{DT}$ high hold time	t_{DHH}	15		15		ns	
Write-per-bit setup time	t_{WBS}	0		0		ns	
Write-per-bit hold time	t_{WBH}	15		15		ns	
DSF setup time from $\overline{RAS}$	t_{FRS}	0		0		ns	
DSF hold time from $\overline{RAS}$	t_{FRH}	15		15		ns	
DSF setup time from $\overline{CAS}$	t_{FCS}	0		0		ns	
DSF hold time from $\overline{CAS}$	t_{FCH}	12		12		ns	

(2/2)

Parameter	Symbol	μPD482444-60 μPD482445-60		μPD482444-70 μPD482445-70 μPD482445L-A70		Unit	Conditions
		MIN.	MAX.	MIN.	MAX.		
Write-per-bit selection setup time	t_{WS}	0		0		ns	
Write-per-bit selection hold time	t_{WH}	15		15		ns	
Column address to $\overline{RAS}$ lead time	t_{RAL}	30		35		ns	
Write command to $\overline{RAS}$ lead time	t_{RWL}	20		20		ns	
Write command to $\overline{CAS}$ lead time	t_{CWL}	15		15		ns	
$\overline{RAS}$ to $\overline{CAS}$ delay time	t_{RCD}	25	40	30	50	ns	**Note 1**
$\overline{RAS}$ to column address delay time	t_{RAD}	15	30	15	35	ns	**Note 1**
Output disable time from $\overline{RAS}$ high	t_{OFR}	0	15	0	15	ns	**Notes 3, 4**
Output disable time from $\overline{CAS}$ high	t_{OFC}	0	15	0	15	ns	**Notes 3, 4**
Output disable time from $\overline{OE}$ high	t_{OEZ}	0	15	0	15	ns	**Notes 3, 4**
Output disable time from $\overline{LWE}$, $\overline{UWE}$ low	t_{WEZ}	0	15	0	15	ns	**Notes 3, 4**
Write command pulse width	t_{WPZ}	12		12		ns	**Note 4**
Transition time (Rise/Fall)	t_T	3	35	3	35	ns	
Masked byte write setup time	t_{MCS}	0		0		ns	
Masked byte write to $\overline{RAS}$ hold time	t_{MRH}	0		0		ns	
Masked byte write to $\overline{CAS}$ hold time	t_{MCH}	0		0		ns	

Notes 1. For read cycle, access time is defined as follows:

Input conditions	Access time	Access time from $\overline{RAS}$
$t_{RAD} \leq t_{RAD}$ (MAX.) and $t_{RCD} \leq t_{RCD}$ (MAX.)	t_{RAC} (MAX.)	t_{RAC} (MAX.)
$t_{RAD} > t_{RAD}$ (MAX.) and $t_{RCD} \leq t_{RCD}$ (MAX.)	t_{AA} (MAX.)	$t_{RAD} + t_{AA}$ (MAX.)
$t_{RCD} > t_{RCD}$ (MAX.)	t_{CAC} (MAX.)	$t_{RCD} + t_{CAC}$ (MAX.)

t_{RAD} (MAX.) and t_{RCD} (MAX.) are specified as reference points only; they are not restrictive operating parameters. They are used to determine which access time (t_{RAC}, t_{AA}, t_{CAC}) is to be used for finding out data will be available. Therefore, the input conditions $t_{RAD} \geq t_{RAD}$ (MAX.) and $t_{RCD} \geq t_{RCD}$ (MAX.) will not cause any operation problems.

2. These parameters are referenced to the following points.
(1) Early write cycle : The falling edge of $\overline{CAS}$
(2) Late write cycle : The falling edge of $\overline{UWE}$, $\overline{LWE}$
(3) Read modify write cycle : The falling edge of $\overline{UWE}$, $\overline{LWE}$

3. t_{SEZ}, t_{OEZ}, t_{WEZ}, t_{OFF}, t_{OFR}, and t_{OFC} define the time when the output achieves the condition of high impedance and is not referenced to V_{OH} or V_{OL}.

4. Control pins $\overline{RAS}$, $\overline{CAS}$, $\overline{DT}/\overline{OE}$, $\overline{UWE}$, $\overline{LWE}$ to set pin W/IO to high impedance. Because the timings at which $\overline{RAS}$, $\overline{CAS}$ and $\overline{DT}/\overline{OE}$ are set to high level and $\overline{UWE}$, $\overline{LWE}$ are set to low level affect the high impedance state, the specifications will change as follows. Controlling by $\overline{RAS}$ is usable in hyper page mode (μPD482445, 482445L).

Fast page mode (μPD482444)

	$\overline{RAS}$	$\overline{CAS}$	$\overline{DT}/\overline{OE}$	$\overline{UWE}$, $\overline{LWE}$	Remark
t_{OFF}	x	L → H	L	H	
t_{WEZ}	x	L	L	H → L	t_{WPZ} should be met.
t_{OEZ}	x	L	L → H	H	

Hyper page mode (μPD482445, 482445L)

	$\overline{RAS}$	$\overline{CAS}$	$\overline{DT}/\overline{OE}$	$\overline{UWE}$, $\overline{LWE}$	Remark
t_{OFR}	L → H	H	L	H	
t_{OFC}	H	L → H	L	H	
t_{WEZ}	L	L	L	H → L	t_{WPZ} should be met.
t_{OEZ}	L	L	L → H	H	

Remark H : High level
L : Low level
x : Don't care
→ : Transition

[Read cycle]

Parameter	Symbol	μPD482444-60 μPD482445-60		μPD482444-70 μPD482445-70 μPD482445L-A70		Unit	Conditions
		MIN.	MAX.	MIN.	MAX.		
Random read or write cycle time	t_{RC}	110		130		ns	
Fast page mode cycle time	t_{PC}	35		40		ns	
Hyper page mode cycle time	t_{HPC}	30		35		ns	
Access time from $\overline{RAS}$	t_{RAC}		60		70	ns	**Note 1**
Access time from $\overline{CAS}$	t_{CAC}		18		18	ns	**Note 1**
Access time from column address	t_{AA}		30		35	ns	**Note 1**
Access time from $\overline{OE}$	t_{OEA}		18		18	ns	
Access time from $\overline{CAS}$ trailing edge	t_{ACP}		30		35	ns	
$\overline{OE}$ to $\overline{RAS}$ inactive setup time	t_{OES}	0		0		ns	
Read command hold time after $\overline{RAS}$ high	t_{RRH}	0		0		ns	**Note 2**
Read command hold time after $\overline{CAS}$ high	t_{RCH}	0		0		ns	**Note 2**
Output hold time from $\overline{CAS}$	t_{DHC}	3		5		ns	
Output disable time from $\overline{RAS}$ high	t_{OFR}	0	15	0	15	ns	**Notes 3, 4**
Output disable time from $\overline{CAS}$ high	t_{OFF}	0	15	0	15	ns	**Notes 3, 4**
Output disable time from $\overline{CAS}$ high (Hyper page mode)	t_{OFC}	0	15	0	15	ns	**Notes 3, 4**
Output disable time from $\overline{OE}$ high	t_{OEZ}	0	15	0	15	ns	**Notes 3, 4**
Output disable time from $\overline{UWE}$, $\overline{LWE}$ low	t_{WEZ}	0	15	0	15	ns	**Notes 3, 4**
Write command pulse width	t_{WPZ}	12		12		ns	**Note 4**

Notes 1. For read cycle, access time is defined as follows:

Input conditions	Access time	Access time from $\overline{RAS}$
$t_{RAD} \leq t_{RAD}$ (MAX.) and $t_{RCD} \leq t_{RCD}$ (MAX.)	t_{RAC} (MAX.)	t_{RAC} (MAX.)
$t_{RAD} > t_{RAD}$ (MAX.) and $t_{RCD} \leq t_{RCD}$ (MAX.)	t_{AA} (MAX.)	$t_{RAD} + t_{AA}$ (MAX.)
$t_{RCD} > t_{RCD}$ (MAX.)	t_{CAC} (MAX.)	$t_{RCD} + t_{CAC}$ (MAX.)

t_{RAD} (MAX.) and t_{RCD} (MAX.) are specified as reference points only; they are not restrictive operating parameters. They are used to determine which access time (t_{RAC}, t_{AA}, t_{CAC}) is to be used for finding out data will be available. Therefore, the input conditions $t_{RAD} \geq t_{RAD}$ (MAX.) and $t_{RCD} \geq t_{RCD}$ (MAX.) will not cause any operation problems.

2. Either t_{RCH} (MIN.) or t_{RRH} (MIN.) should be met in read cycles.

3. t_{SEZ}, t_{OEZ}, t_{WEZ}, t_{OFF}, t_{OFR}, and t_{OFC} define the time when the output achieves the condition of high impedance and is not referenced to V_{OH} or V_{OL}.

4. Control pins $\overline{RAS}$, $\overline{CAS}$, $\overline{DT}/\overline{OE}$, $\overline{UWE}$, $\overline{LWE}$ to set pin W/IO to high impedance. Because the timings at which $\overline{RAS}$, $\overline{CAS}$ and $\overline{DT}/\overline{OE}$ are set to high level and $\overline{UWE}$, $\overline{LWE}$ are set to low level affect the high impedance state, the specifications will change as follows. Controlling by $\overline{RAS}$ is usable in hyper page mode (μPD482445, 482445L).

Fast page mode (μPD482444)

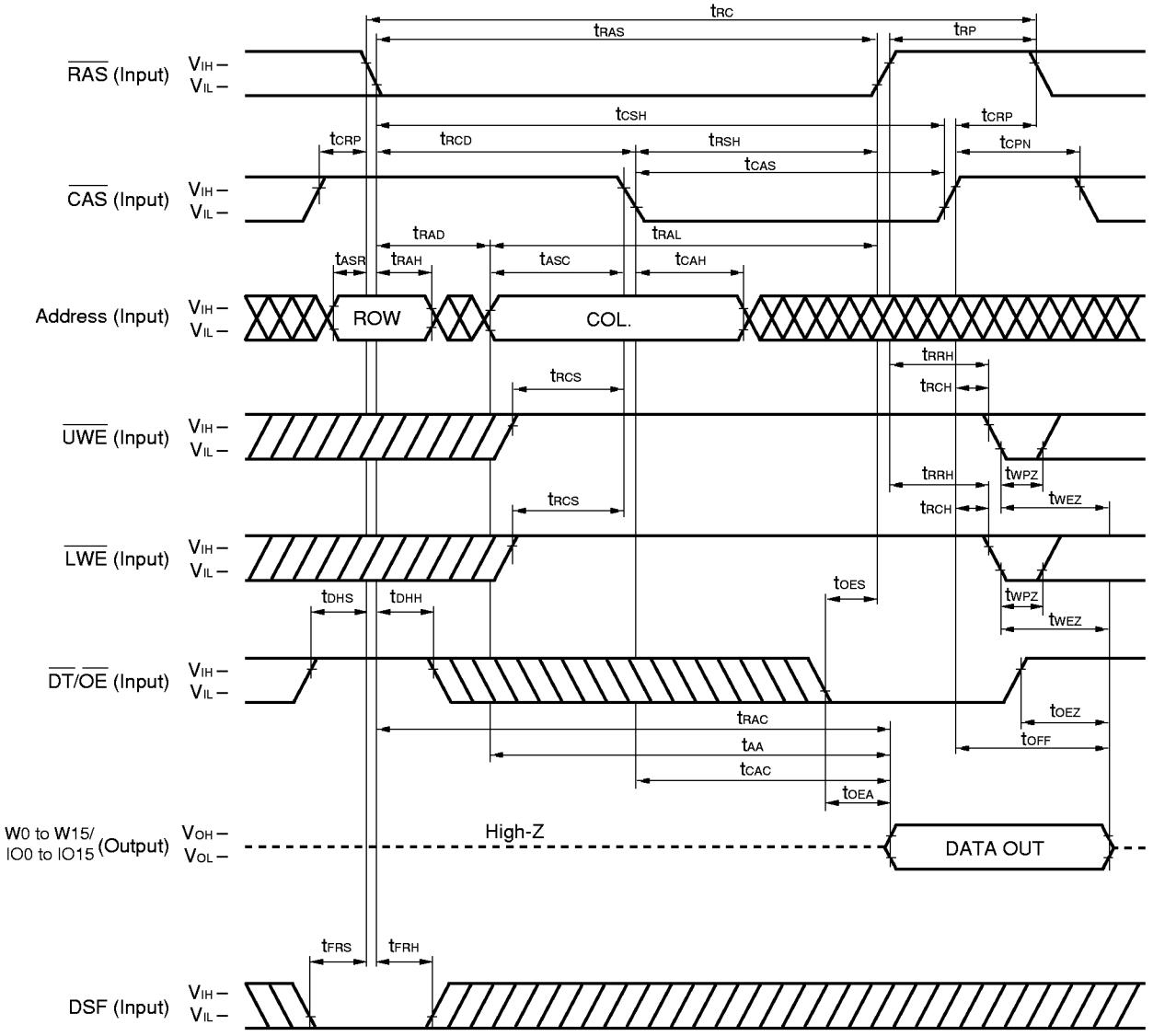
	$\overline{RAS}$	$\overline{CAS}$	$\overline{DT}/\overline{OE}$	$\overline{UWE}$, $\overline{LWE}$	Remark
t_{OFF}	x	L → H	L	H	
t_{WEZ}	x	L	L	H → L	t_{WPZ} should be met.
t_{OEZ}	x	L	L → H	H	

Hyper page mode (μPD482445, 482445L)

	$\overline{RAS}$	$\overline{CAS}$	$\overline{DT}/\overline{OE}$	$\overline{UWE}$, $\overline{LWE}$	Remark
t_{OFR}	L → H	H	L	H	
t_{OFC}	H	L → H	L	H	
t_{WEZ}	L	L	L	H → L	t_{WPZ} should be met.
t_{OEZ}	L	L	L → H	H	

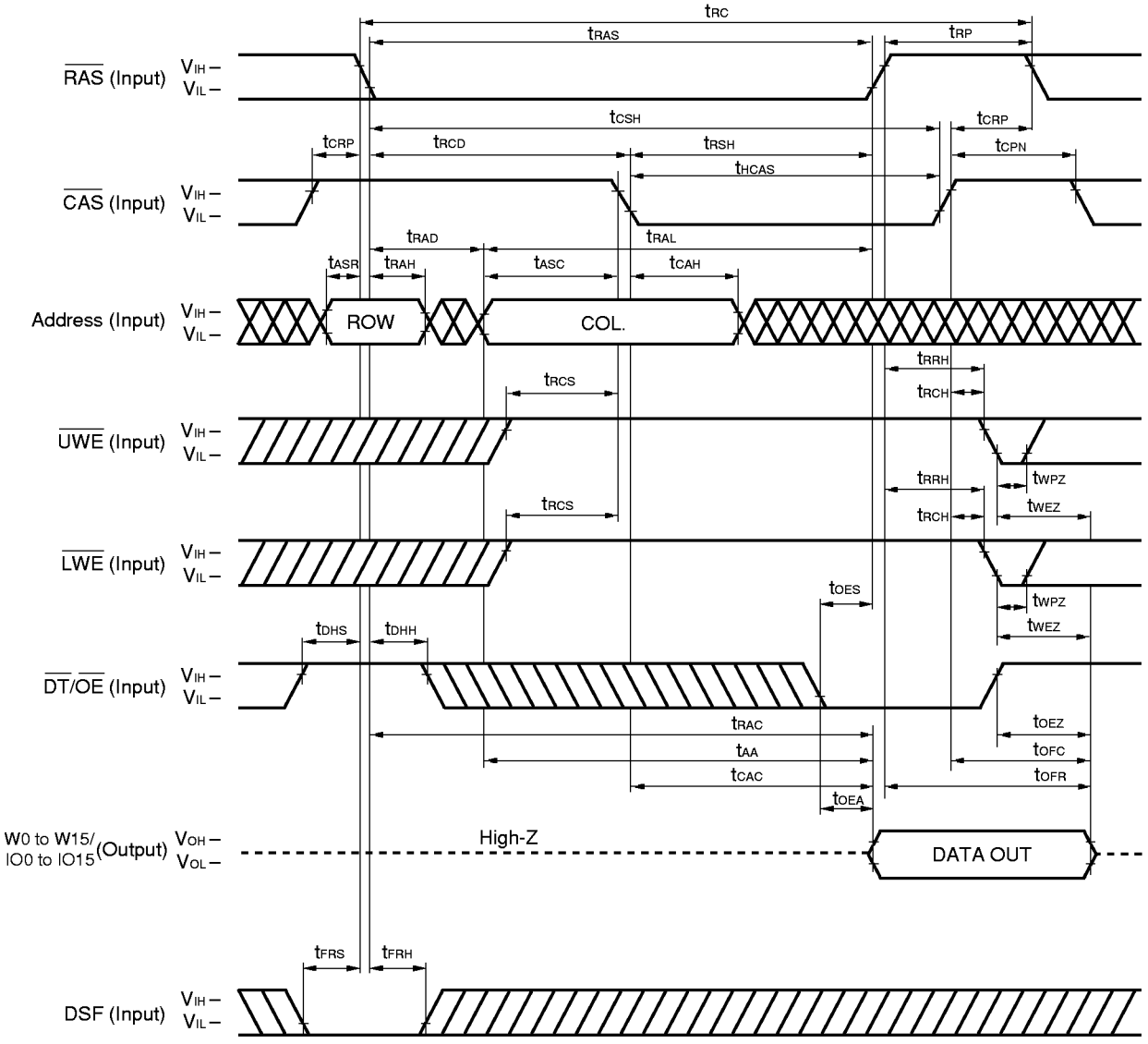
Remark H : High level
L : Low level
x : Don't care
→ : Transition

Read Cycle (μPD482444)



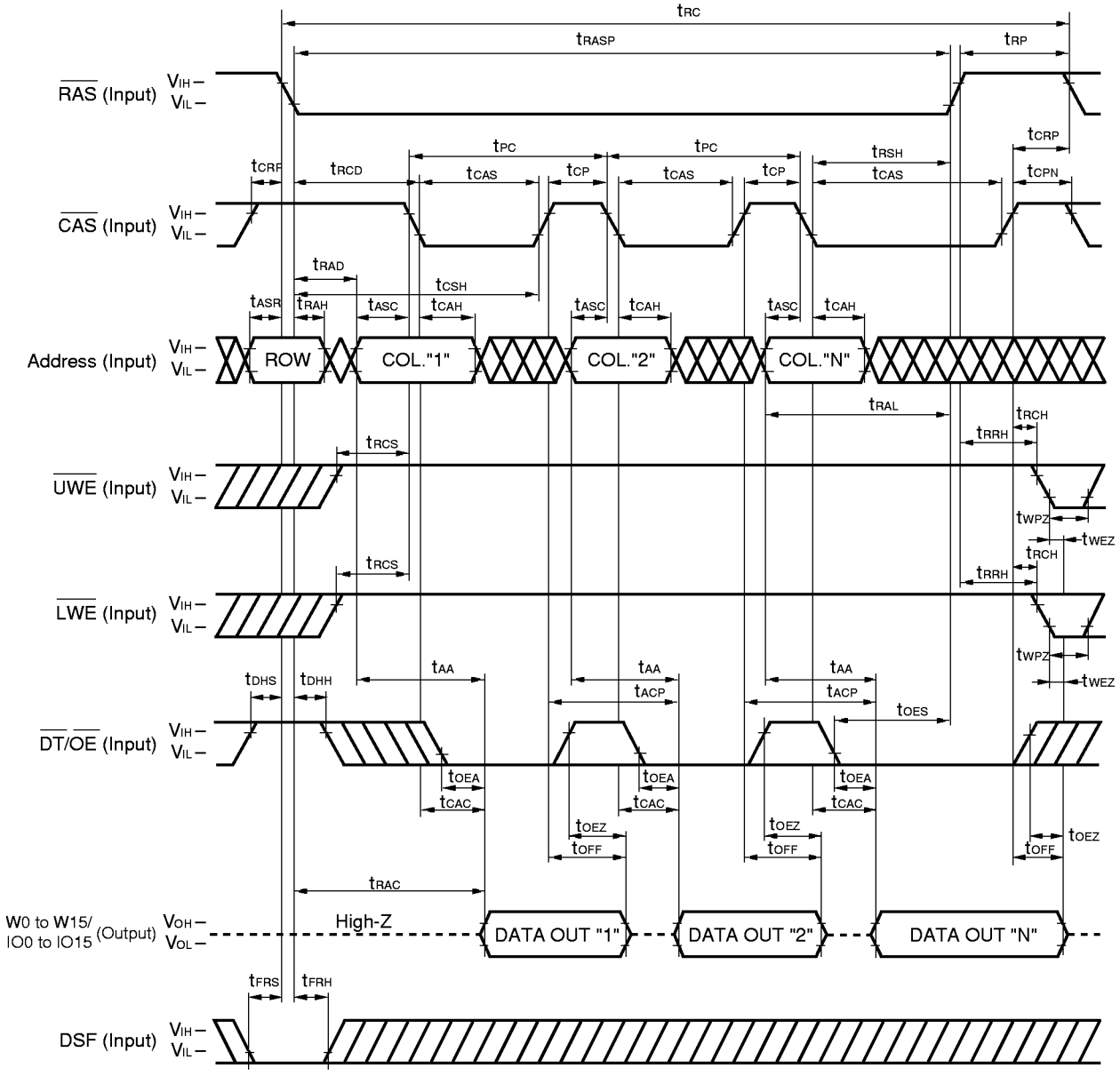
Remark Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Read Cycle (Extended data output: μPD482445, 482445L)



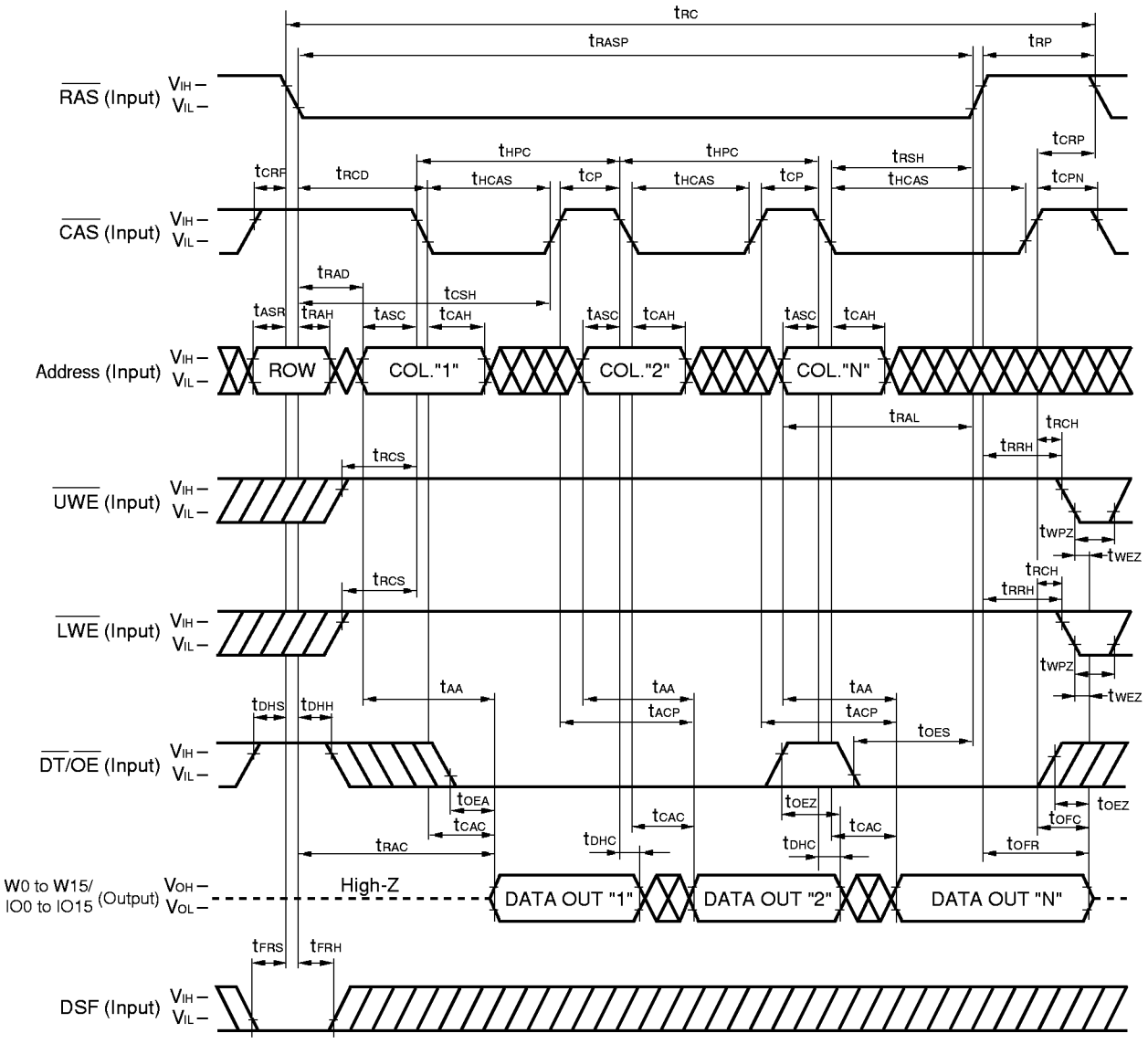
Remark Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Fast Page Mode Read Cycle (μPD482444)



Remark Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Hyper Page Mode Read Cycle (Extended data output: μPD482445, 482445L)



Remark Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

[Write cycle]

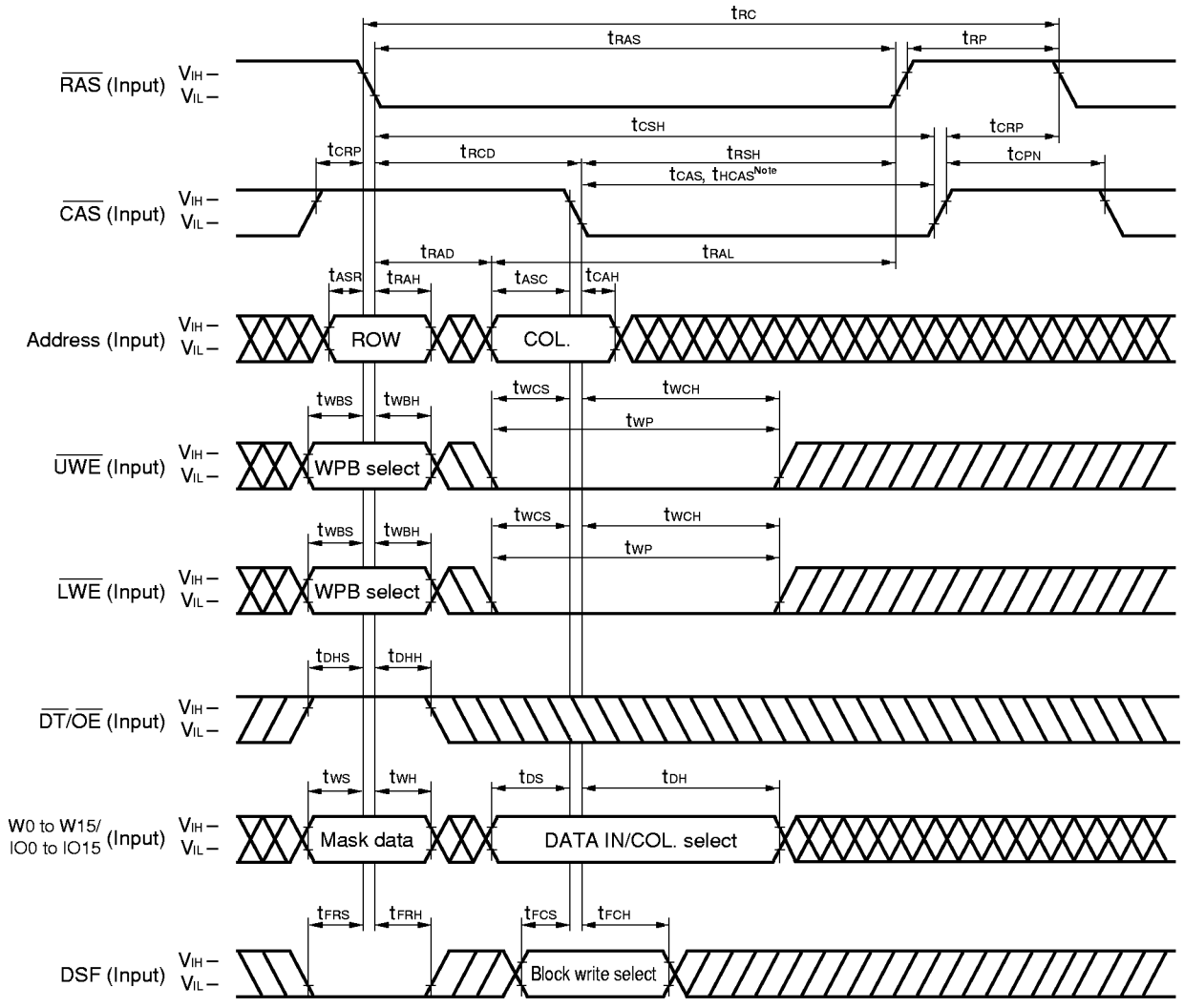
Parameter	Symbol	μPD482444-60 μPD482445-60		μPD482444-70 μPD482445-70 μPD482445L-A70		Unit	Conditions
		MIN.	MAX.	MIN.	MAX.		
Random read or write cycle time	t_{RC}	110		130		ns	
Fast page mode cycle time	t_{PC}	35		40		ns	
Hyper page mode cycle time	t_{HPC}	30		35		ns	
Write command setup time	t_{WCS}	0		0		ns	**Note**
Write command hold time	t_{WCH}	12		12		ns	
$\overline{OE}$ high hold time after $\overline{UWE}$, $\overline{LWE}$ low	t_{OEH}	0		0		ns	
Write-per-bit setup time	t_{WBS}	0		0		ns	
Write-per-bit hold time	t_{WBH}	15		15		ns	
Write-per-bit selection setup time	t_{WS}	0		0		ns	
Write-per-bit selection hold time	t_{WH}	15		15		ns	

Note $t_{WCS} \geq t_{WCS}$ (MIN.) is the condition for early write cycle to be set. D_{OUT} becomes high impedance during the cycle.

$t_{RWD} \geq t_{RWD}$ (MIN.), $t_{CWD} \geq t_{CWD}$ (MIN.), $t_{AWD} \geq t_{AWD}$ (MIN.), are conditions for read modify write cycle to be set. The data of the selected address is output to D_{OUT}.

If any of the above conditions are not met, pin W/IO will become undefined.

Early Write Cycle/Early Block Write Cycle



Note t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

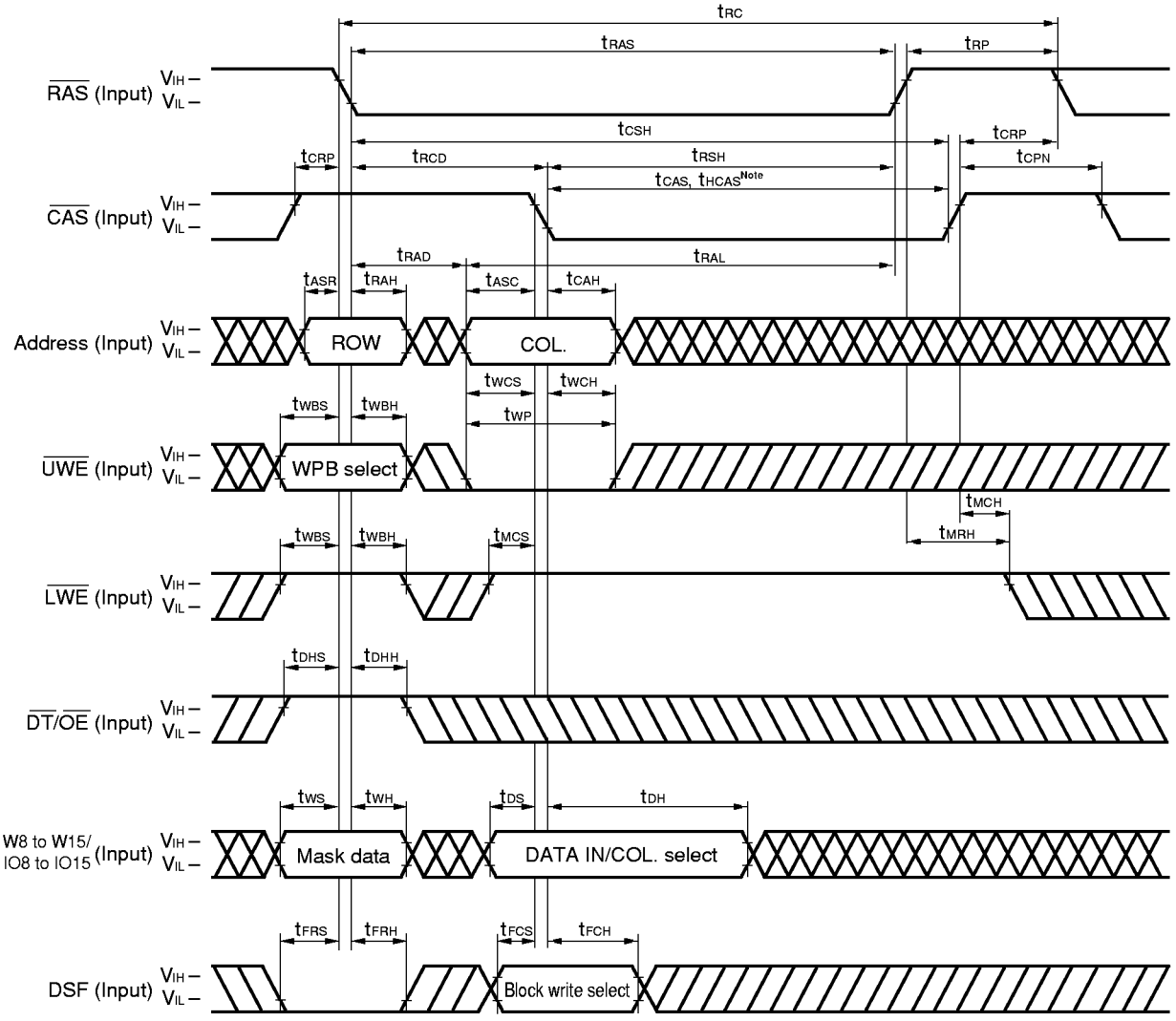
Remarks 1. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

2. WPB : Write-per-bit

3. When block write cycle is selected, input the column selection data to DATA IN.

4. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Upper Byte Early Write Cycle/Upper Byte Early Block Write Cycle



Note t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

Remarks 1. W0 to W7/IO0 to IO7 : Don't care

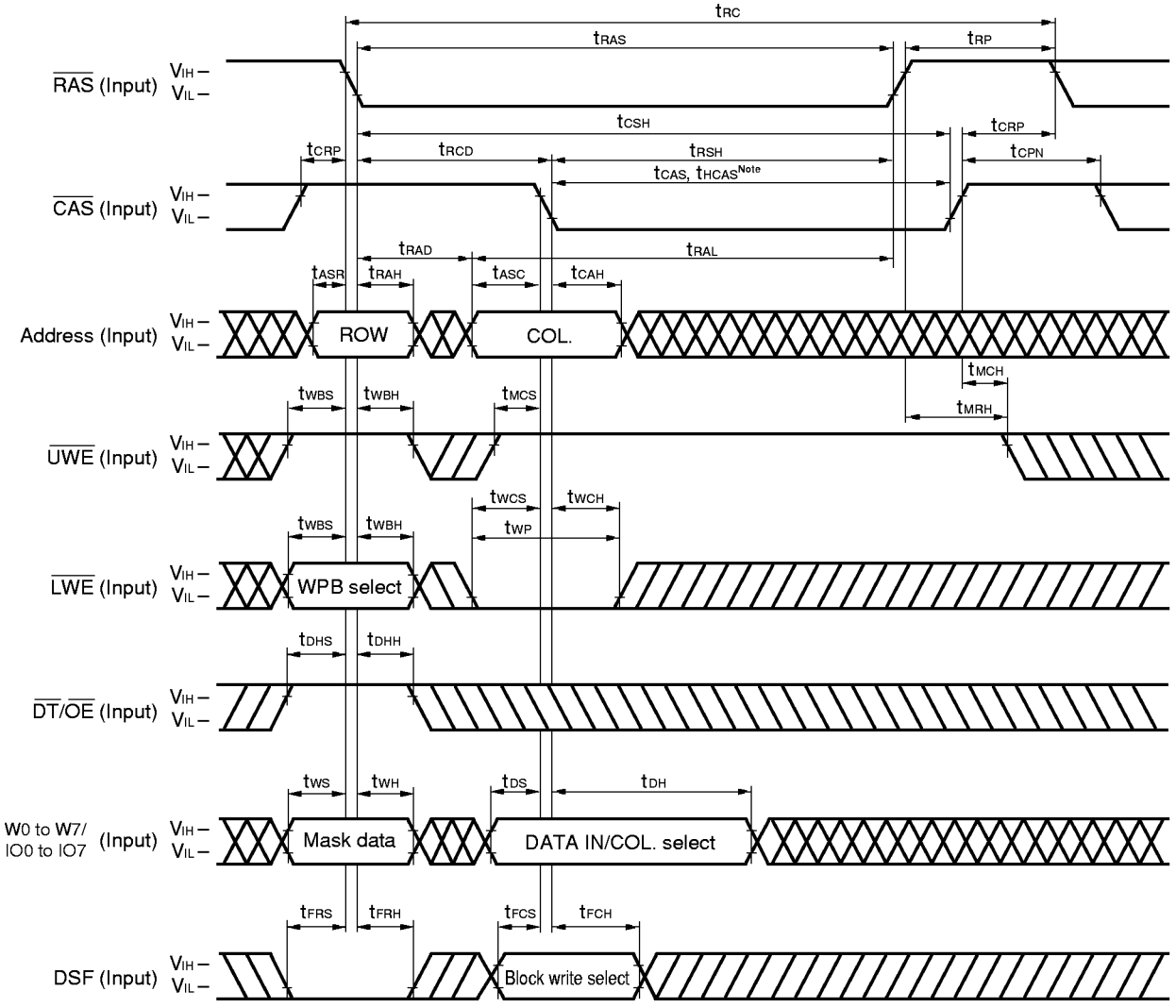
2. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

3. WPB : Write-per-bit

4. When block write cycle is selected, input the column selection data to DATA IN.

5. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Lower Byte Early Write Cycle/Lower Byte Early Block Write Cycle



Note t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

Remarks 1. W8 to W15/IO8 to IO15 : Don't care

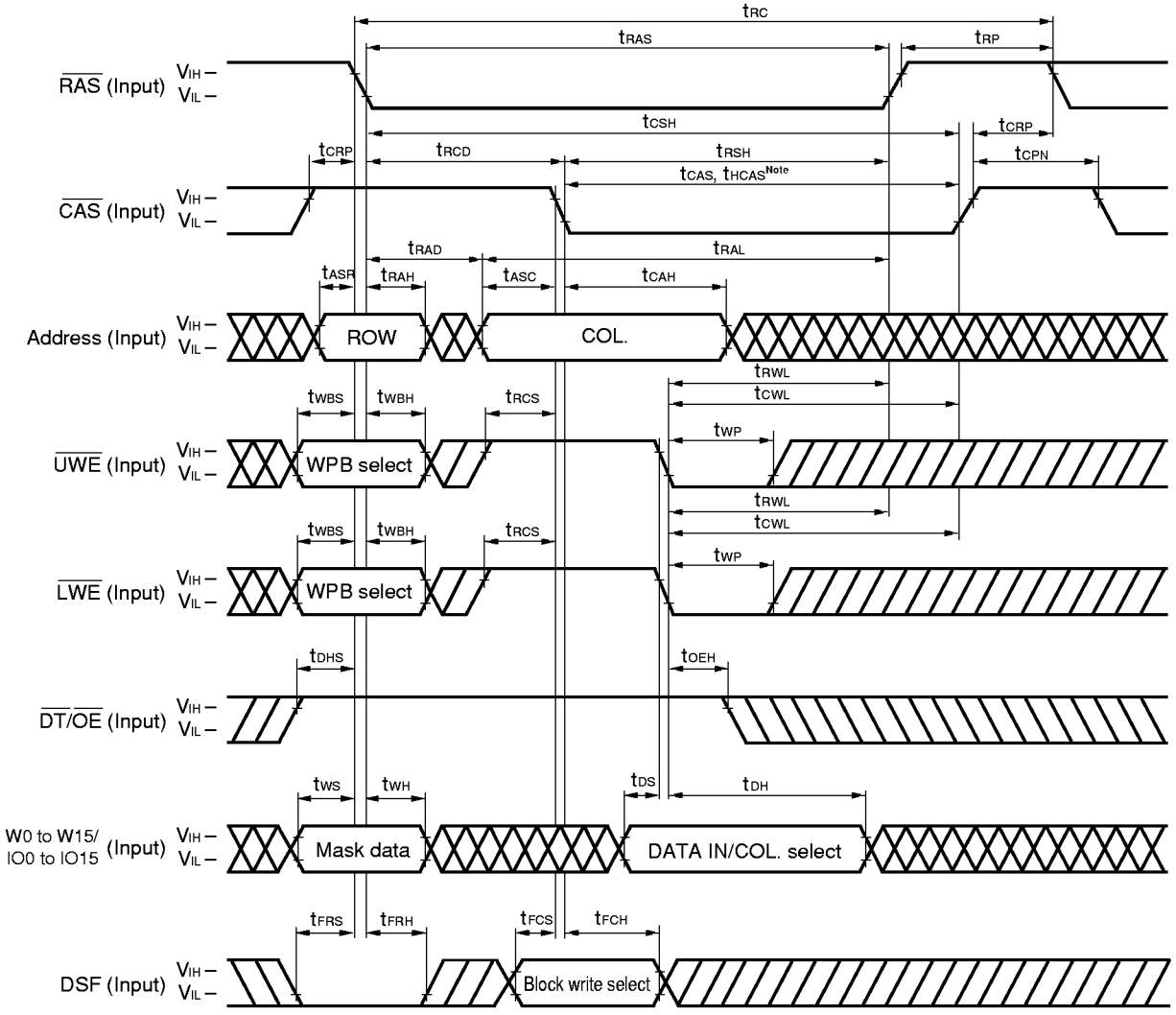
2. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

3. WPB : Write-per-bit

4. When block write cycle is selected, input the column selection data to DATA IN.

5. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Late Write Cycle/Late Block Write Cycle



Note t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

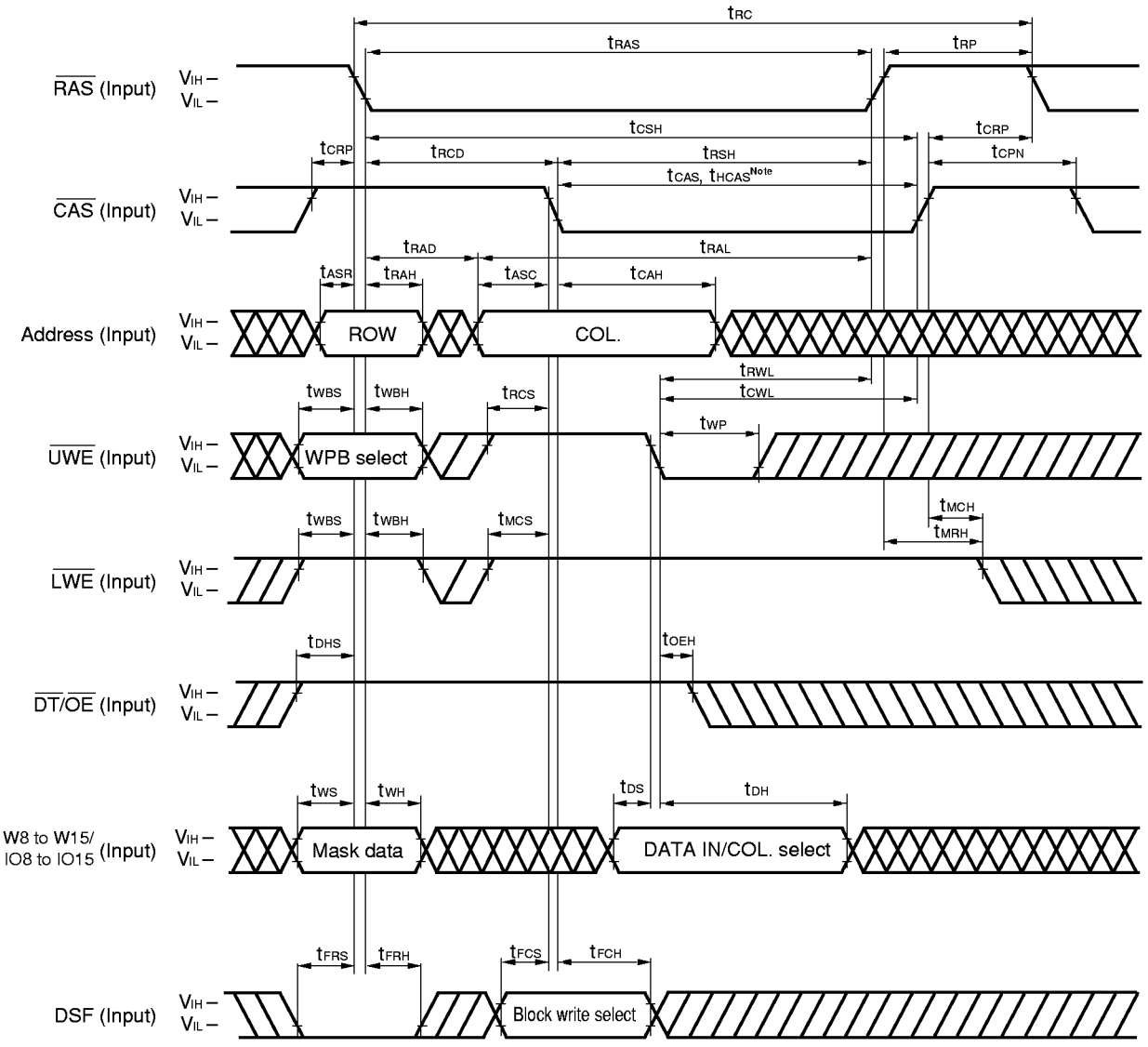
Remarks 1. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

2. WPB : Write-per-bit

3. When block write cycle is selected, input the column selection data to DATA IN.

4. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Upper Byte Late Write Cycle/Upper Byte Late Block Write Cycle



Note t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

Remarks 1. W0 to W7/IO0 to IO7 : Don't care

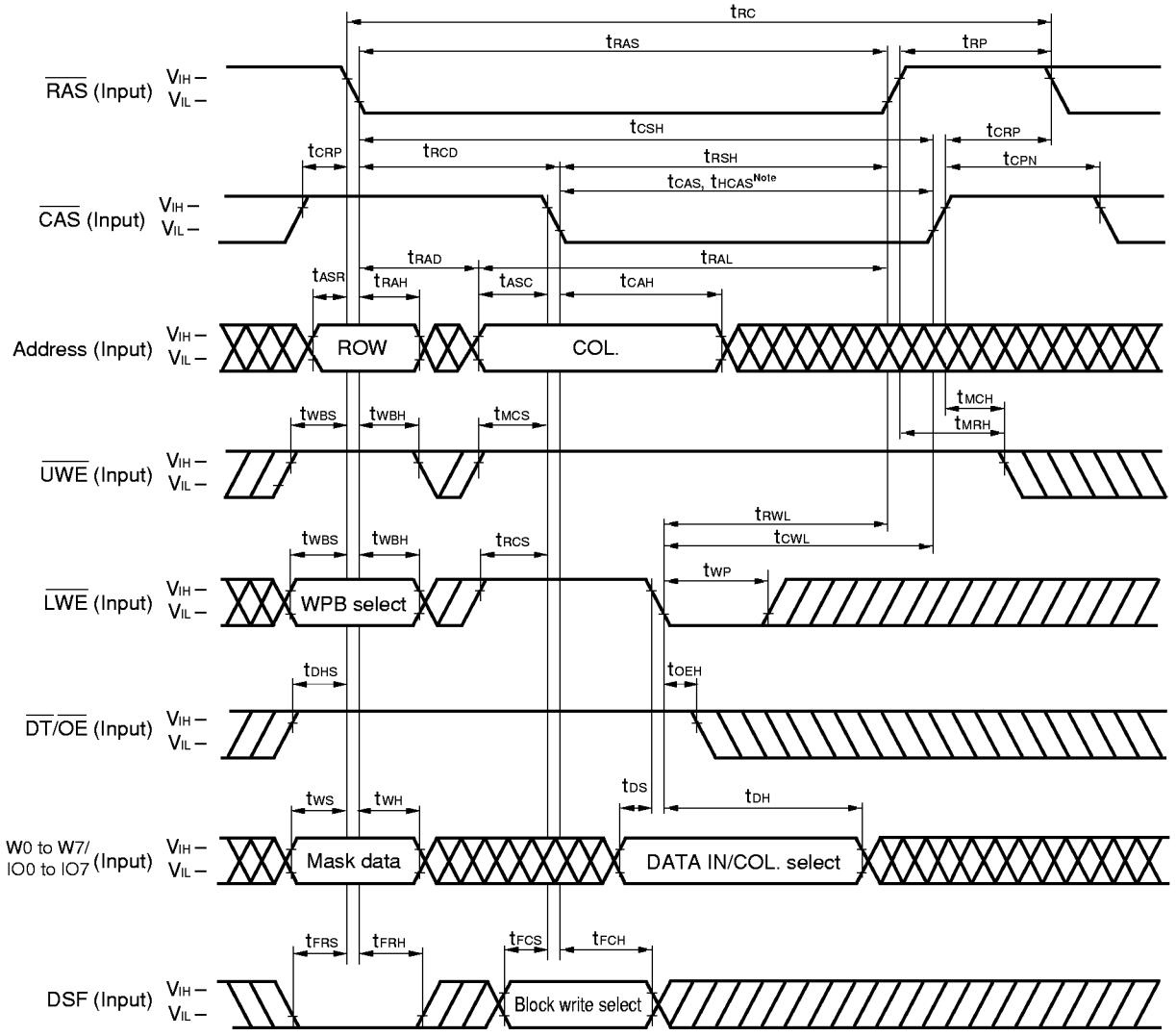
2. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

3. WPB : Write-per-bit

4. When block write cycle is selected, input the column selection data to DATA IN.

5. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Lower Byte Late Write Cycle/Lower Byte Late Block Write Cycle



Note t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

Remarks 1. W8 to W15/IO8 to IO15 : Don't care

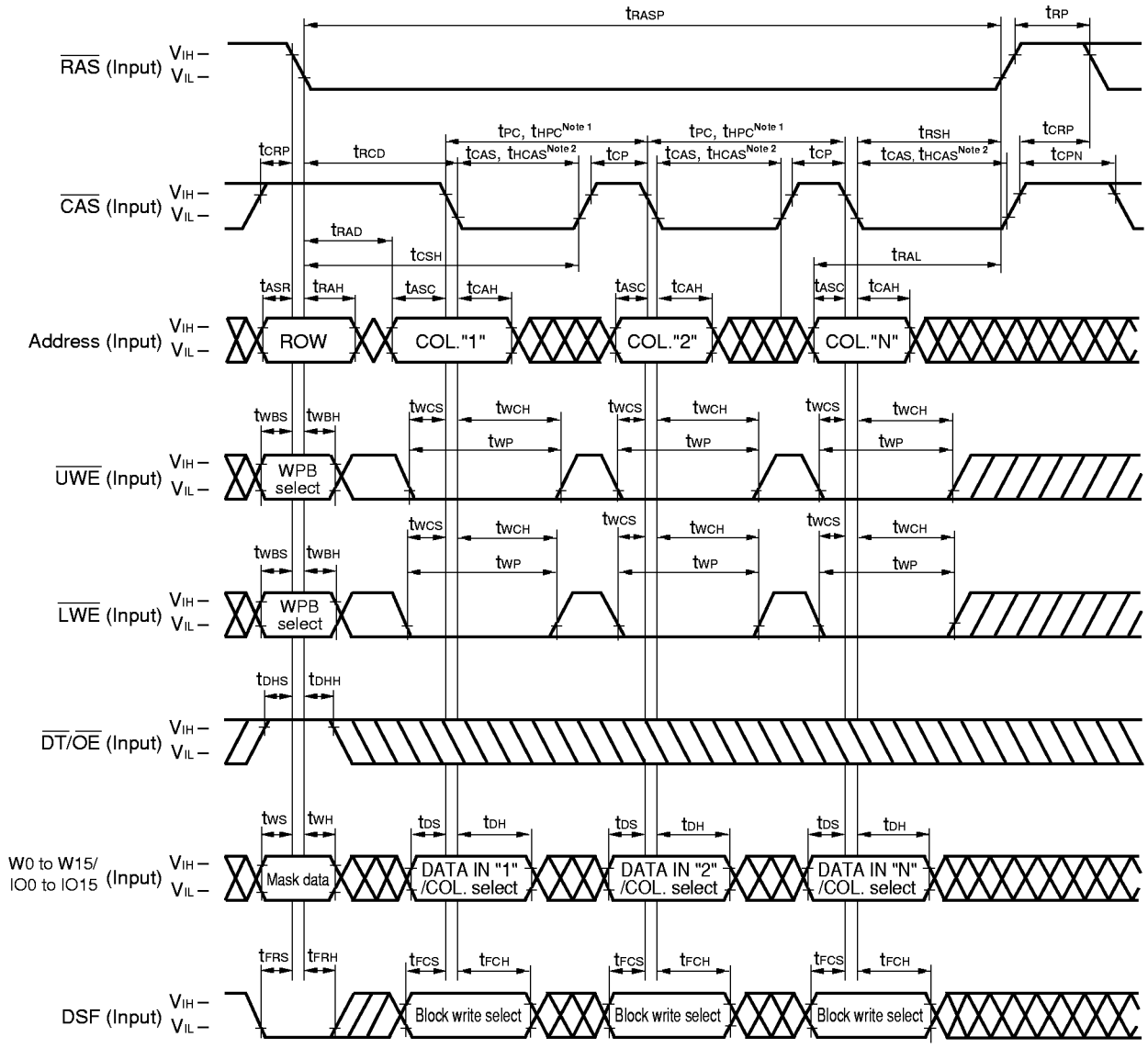
2. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

3. WPB : Write-per-bit

4. When block write cycle is selected, input the column selection data to DATA IN.

5. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Fast Page, Hyper Page Mode Early Write Cycle/Fast Page, Hyper Page Mode Early Block Write Cycle



Notes 1. t_{PC} for the μPD482444
t_{HPC} for the μPD482445, 482445L

2. t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

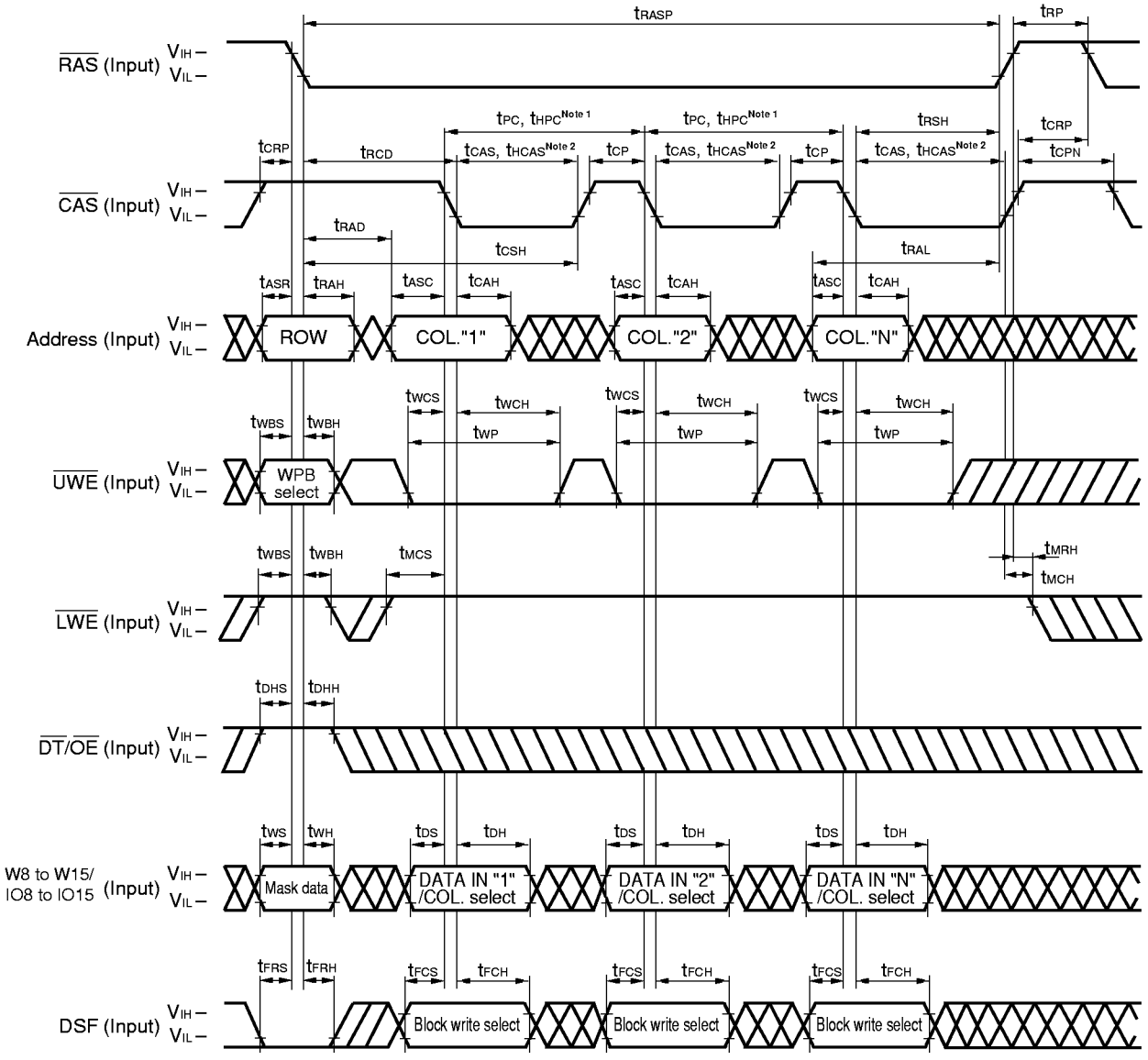
Remarks 1. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

2. WPB : Write-per-bit

3. When block write cycle is selected, input the column selection data to DATA IN.

4. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

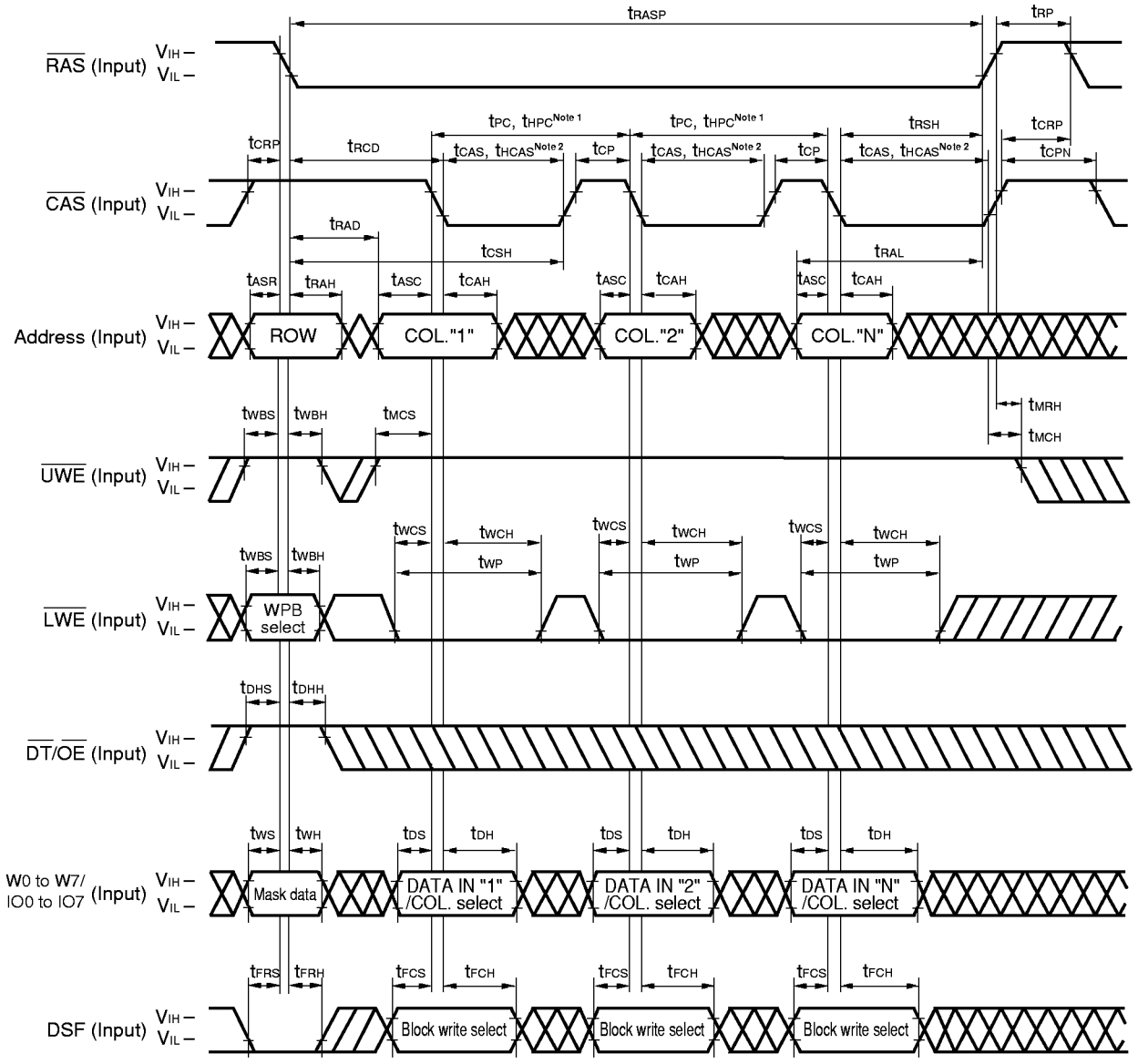
Fast Page, Hyper Page Mode Upper Byte Early Write Cycle/
Fast Page, Hyper Page Mode Upper Byte Early Block Write Cycle



Notes 1. t_{PC} for the μPD482444
t_{HPC} for the μPD482445, 482445L
2. t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

Remarks 1. W0 to W7/IO0 to IO7 : Don't care
2. When DSF is high level : Block write cycle
When DSF is low level : Write cycle
3. WPB : Write-per-bit
4. When block write cycle is selected, input the column selection data to DATA IN.
5. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Fast Page, Hyper Page Mode Lower Byte Early Write Cycle/
Fast Page, Hyper Page Mode Lower Byte Early Block Write Cycle



Notes 1. t_{PC} for the μPD482444
t_{HPC} for the μPD482445, 482445L

2. t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

Remarks 1. W8 to W15/IO8 to IO15 : Don't care

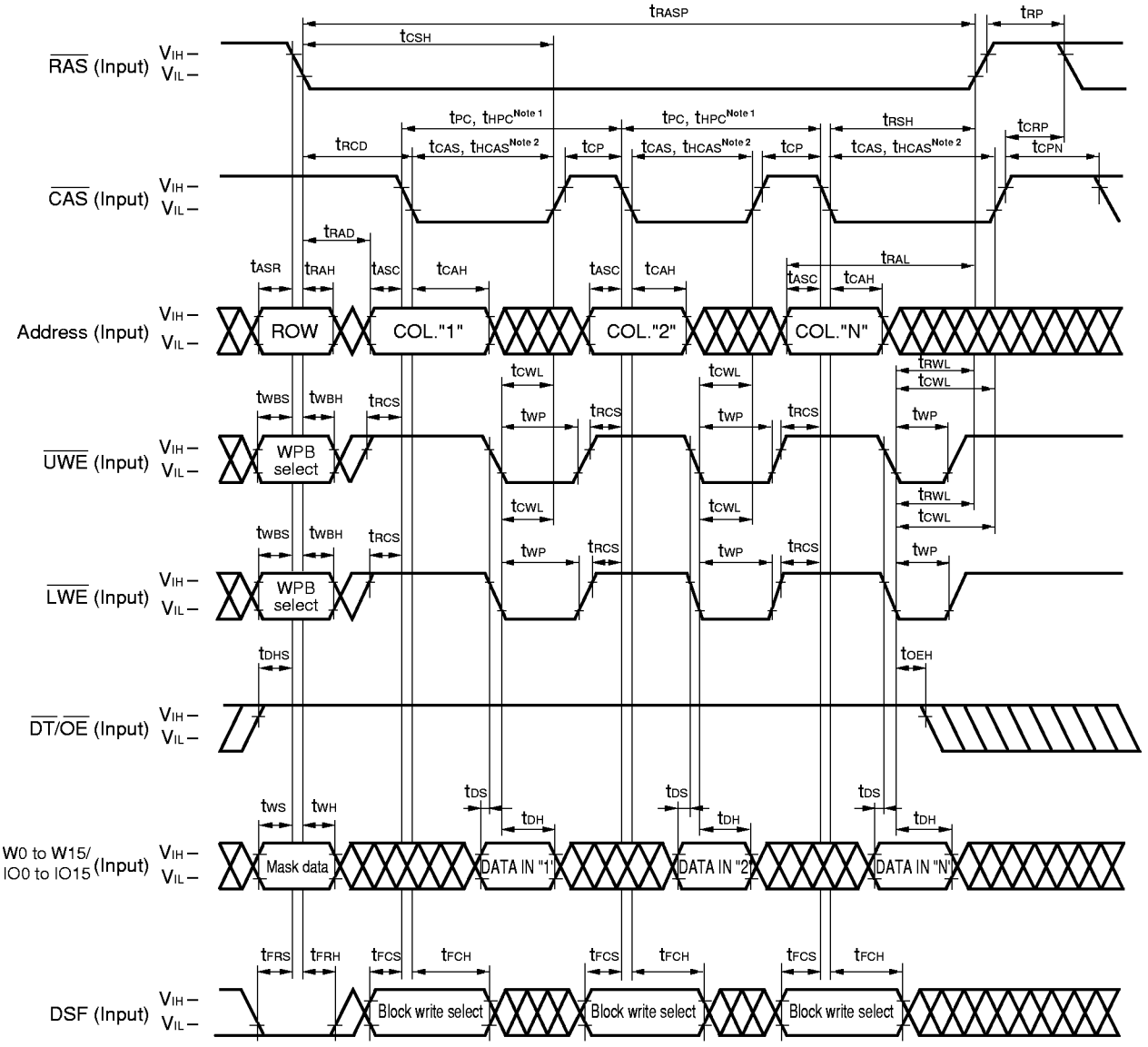
2. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

3. WPB : Write-per-bit

4. When block write cycle is selected, input the column selection data to DATA IN.

5. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Fast Page, Hyper Page Mode Late Write Cycle/Fast Page, Hyper Page Mode Late Block Write Cycle



Notes 1. t_{PC} for the μPD482444
t_{HPC} for the μPD482445, 482445L

2. t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

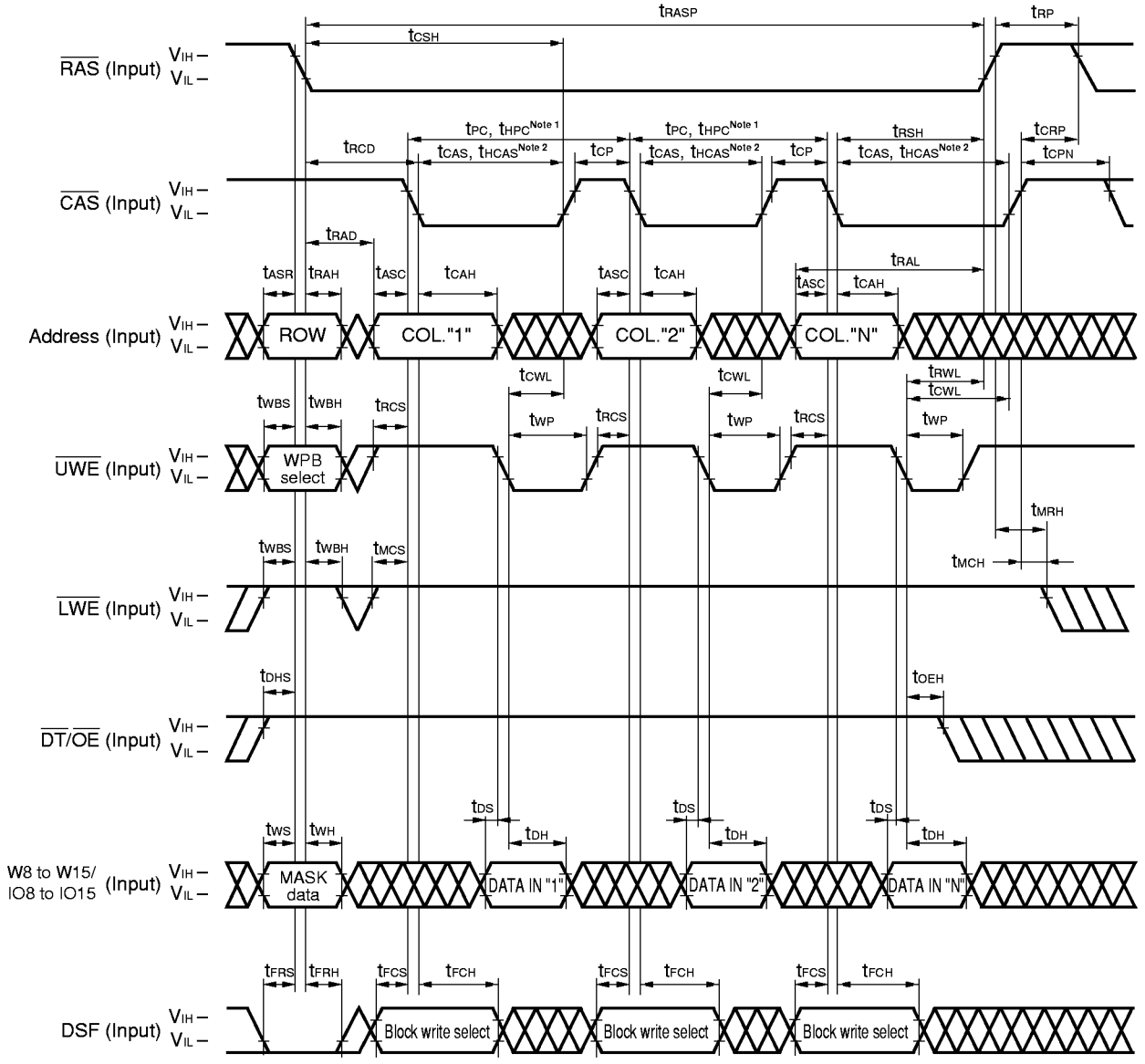
Remarks 1. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

2. WPB : Write-per-bit

3. When block write cycle is selected, input the column selection data to DATA IN.

4. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Fast Page, Hyper Page Mode Upper Byte Late Write Cycle/
Fast Page, Hyper Page Mode Upper Byte Late Block Write Cycle



Notes 1. t_{PC} for the μPD482444
t_{HPC} for the μPD482445, 482445L

2. t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

Remarks 1. W0 to W7/IO0 to IO7 : Don't care

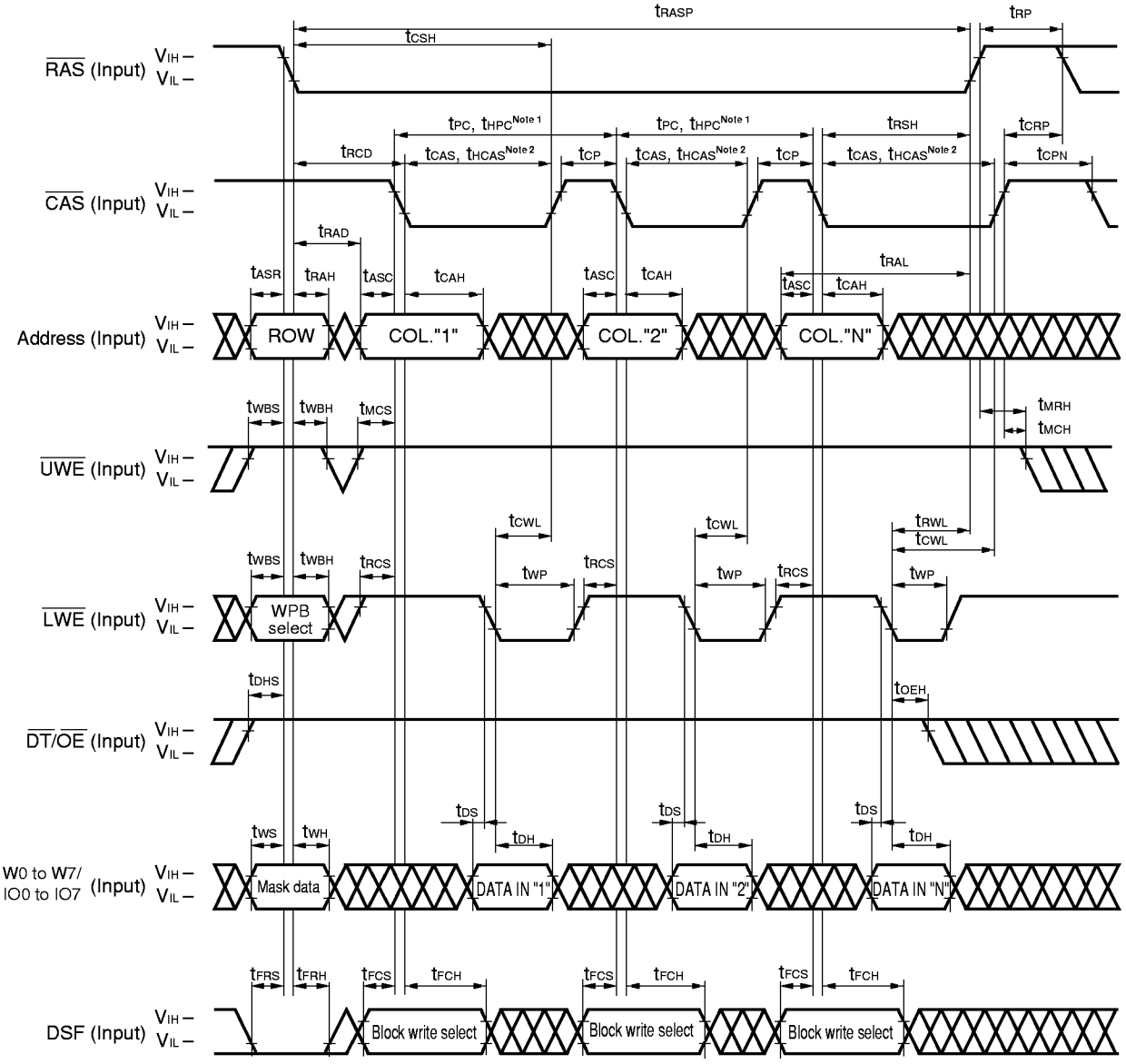
2. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

3. WPB : Write-per-bit

4. When block write cycle is selected, input the column selection data to DATA IN.

5. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Fast Page, Hyper Page Mode Lower Byte Late Write Cycle/
Fast Page, Hyper Page Mode Lower Byte Late Block Write Cycle



Notes 1. t_{PC} for the μPD482444
t_{HPC} for the μPD482445, 482445L

2. t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

Remarks 1. W8 to W15/IO8 to IO15 : Don't care

2. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

3. WPB : Write-per-bit

4. When block write cycle is selected, input the column selection data to DATA IN.

5. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

[Read modify write cycle]

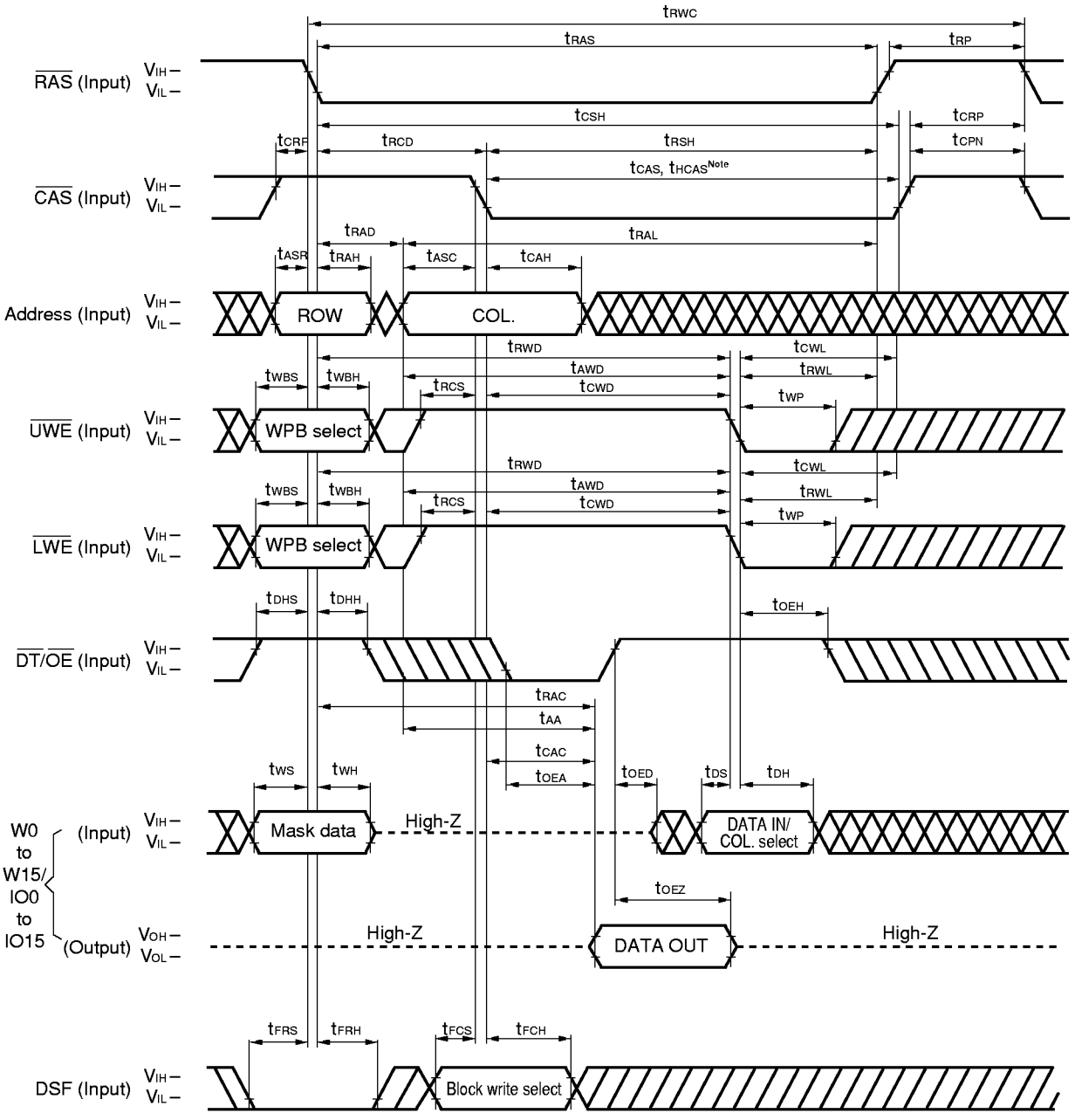
Parameter	Symbol	μPD482444-60 μPD482445-60		μPD482444-70 μPD482445-70 μPD482445L-A70		Unit	Conditions
		MIN.	MAX.	MIN.	MAX.		
Read modify write cycle time	t_{RWC}	160		180		ns	
Fast page mode read modify write cycle time	t_{PRWC}	90		95		ns	
Hyper page mode read modify write cycle time	t_{HPRWC}	80		90		ns	
Access time from $\overline{CAS}$ trailing edge	t_{ACP}		30		35	ns	
Write-per-bit setup time	t_{WBS}	0		0		ns	
Write-per-bit hold time	t_{WBH}	15		15		ns	
Write-per-bit selection setup time	t_{WS}	0		0		ns	
Write-per-bit selection hold time	t_{WH}	15		15		ns	
$\overline{OE}$ high hold time after $\overline{UWE}$, $\overline{LWE}$ low	t_{OEH}	0		0		ns	
$\overline{CAS}$ to $\overline{UWE}$, $\overline{LWE}$ delay time	t_{CWD}	40		40		ns	**Note**
$\overline{RAS}$ to $\overline{UWE}$, $\overline{LWE}$ delay time	t_{RWD}	85		90		ns	**Note**
Column address to $\overline{UWE}$, $\overline{LWE}$ delay time	t_{AWD}	55		55		ns	**Note**
$\overline{OE}$ high to data in setup delay time	t_{OED}	15		15		ns	

Note $t_{WCS} \geq t_{WCS}$ (MIN.) is the condition for early write cycle to be set. D_{OUT} becomes high impedance during the cycle.

$t_{RWD} \geq t_{RWD}$ (MIN.), $t_{CWD} \geq t_{CWD}$ (MIN.), $t_{AWD} \geq t_{AWD}$ (MIN.), are conditions for read modify write cycle to be set. The data of the selected address is output to D_{OUT}.

If any of the above conditions are not met, pin W/IO will become undefined.

Read Modify Write Cycle/Read Modify Block Write Cycle



Note t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

Remarks 1. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

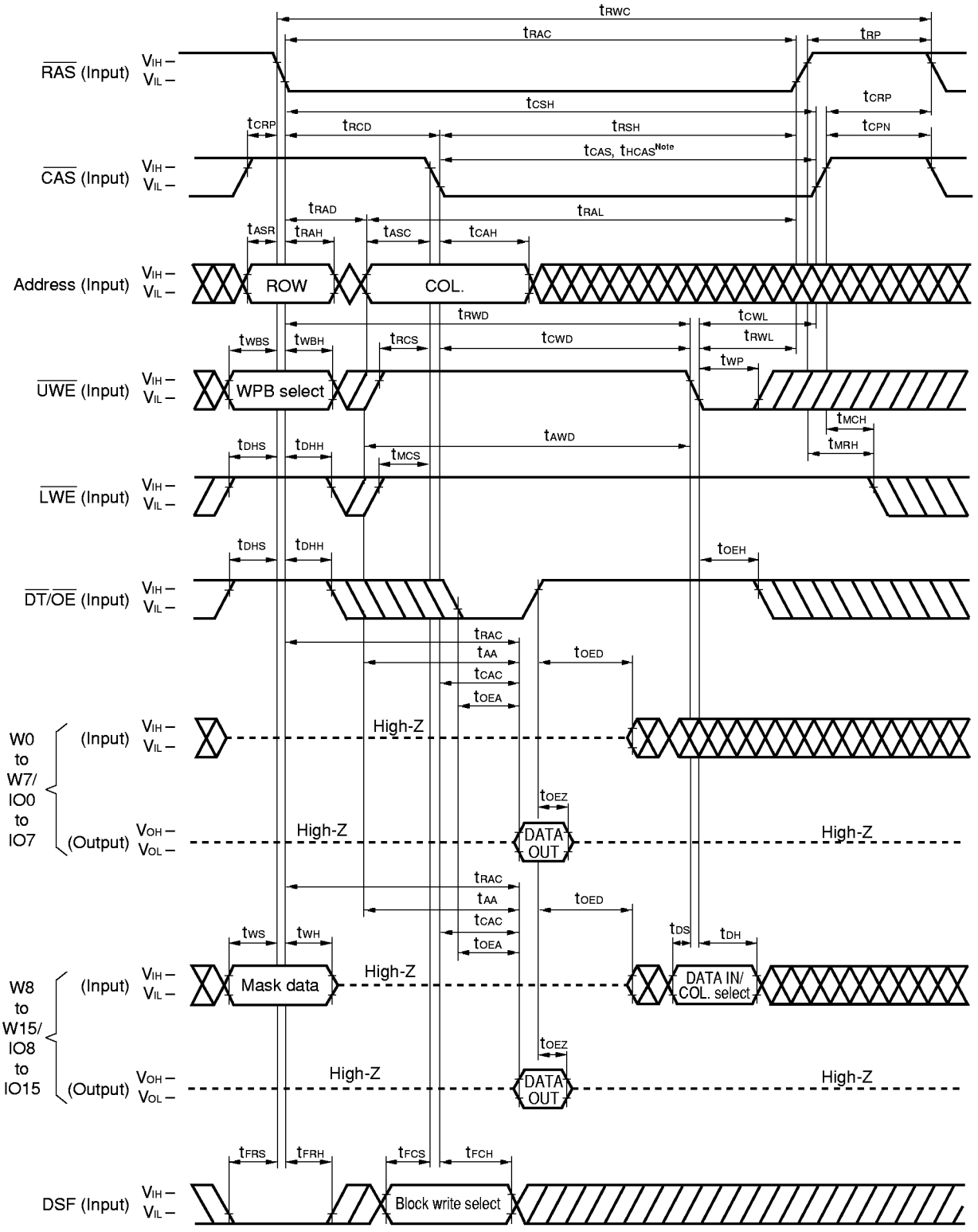
2. WPB : Write-per-bit

3. When block write cycle is selected, input the column selection data to DATA IN.

4. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

[MEMO]

Read Modify Upper Byte Write Cycle/Read Modify Upper Byte Block Write Cycle



Note t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

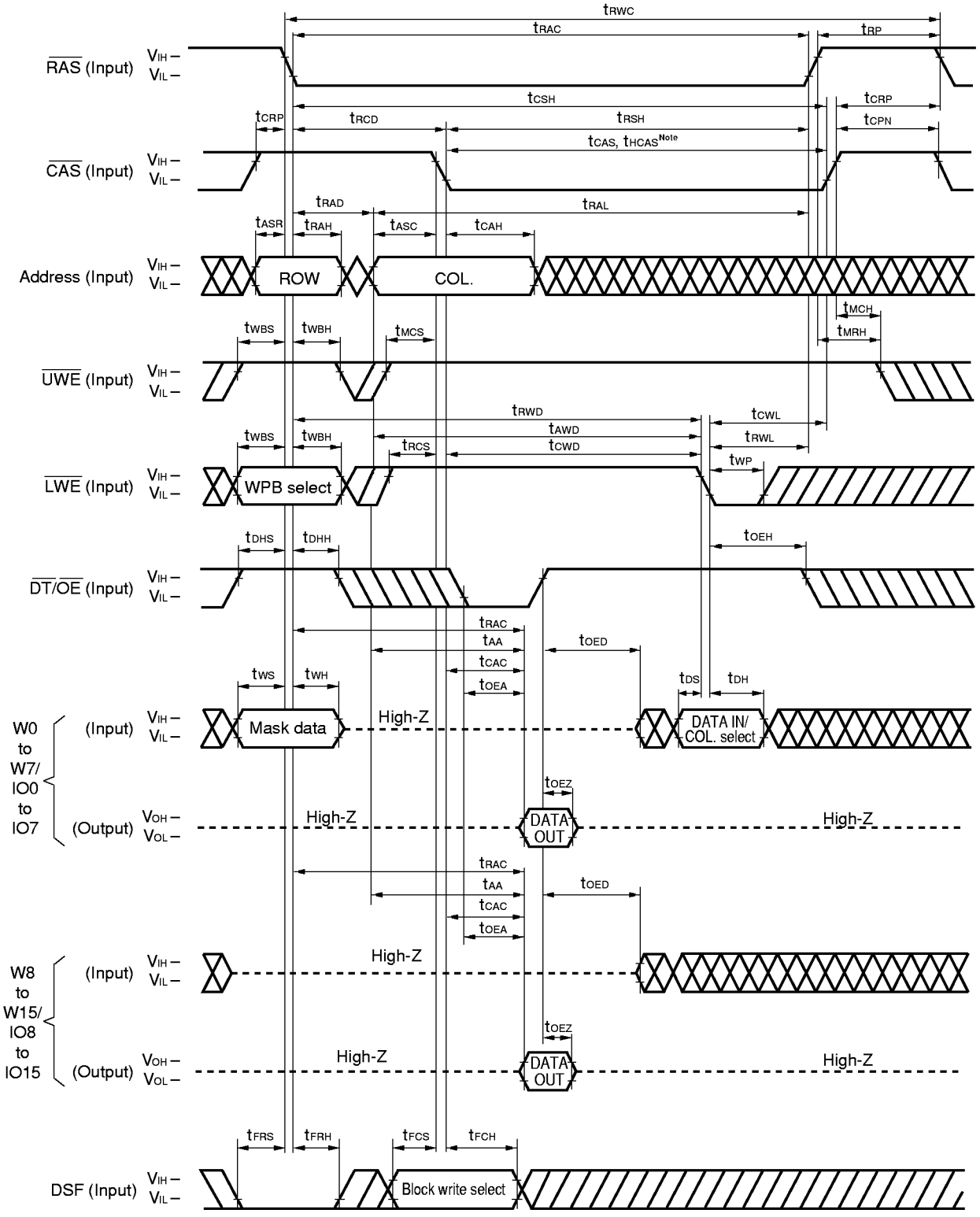
Remarks 1. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

2. WPB : Write-per-bit

3. When block write cycle is selected, input the column selection data to DATA IN.

4. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Read Modify Lower Byte Write Cycle/Read Modify Lower Byte Block Write Cycle



Note t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

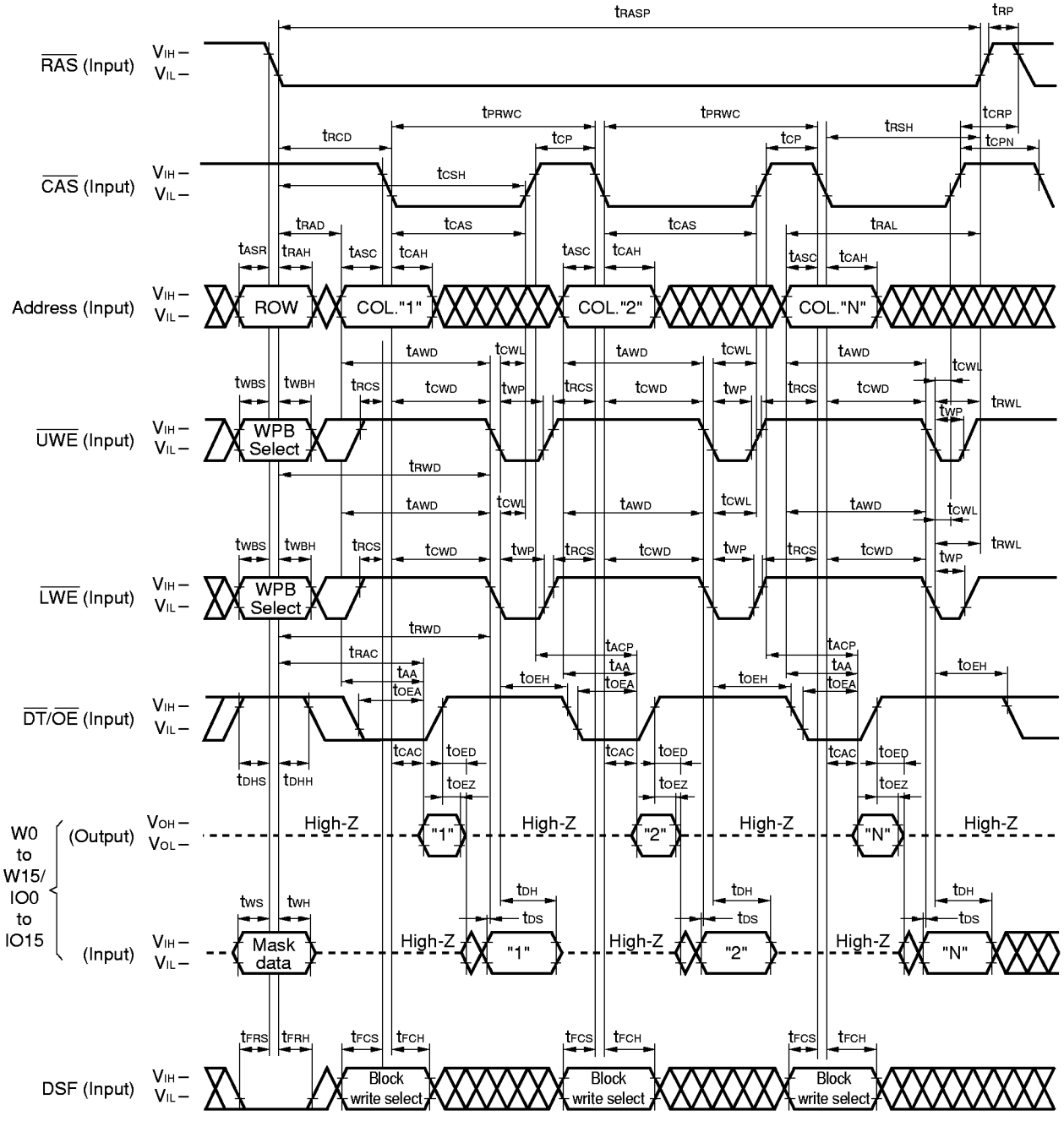
Remarks 1. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

2. WPB : Write-per-bit

3. When block write cycle is selected, input the column selection data to DATA IN.

4. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Fast Page Mode Read Modify Write Cycle (μPD482444)/
Fast Page Mode Read Modify Block Write Cycle (μPD482444)



Remarks 1. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

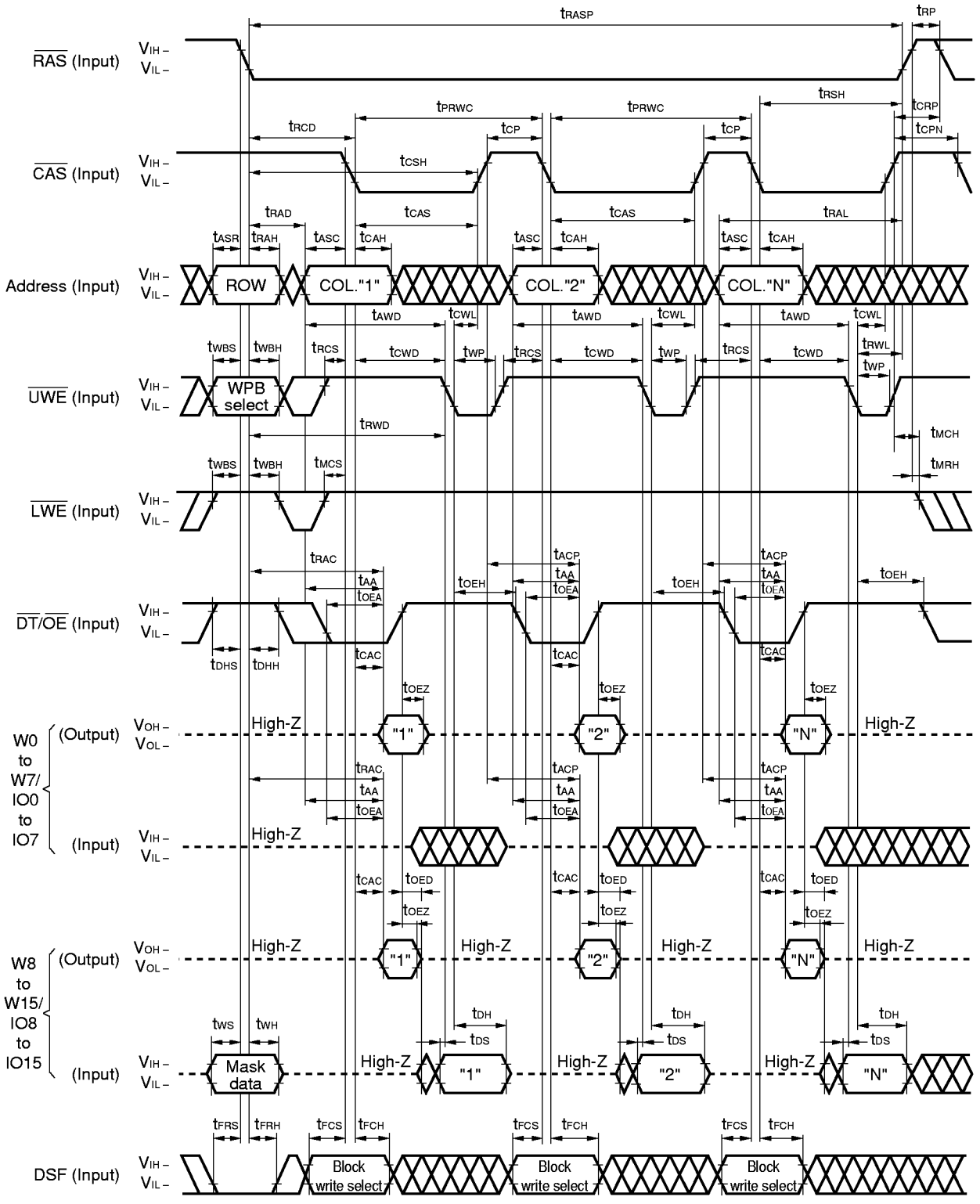
2. WPB : Write-per-bit

3. When block write cycle is selected, input the column selection data to DATA IN.

4. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

[MEMO]

Fast Page Mode Read Modify Upper Byte Write Cycle (μPD482444)/
Fast Page Mode Read Modify Upper Byte Block Write Cycle (μPD482444)



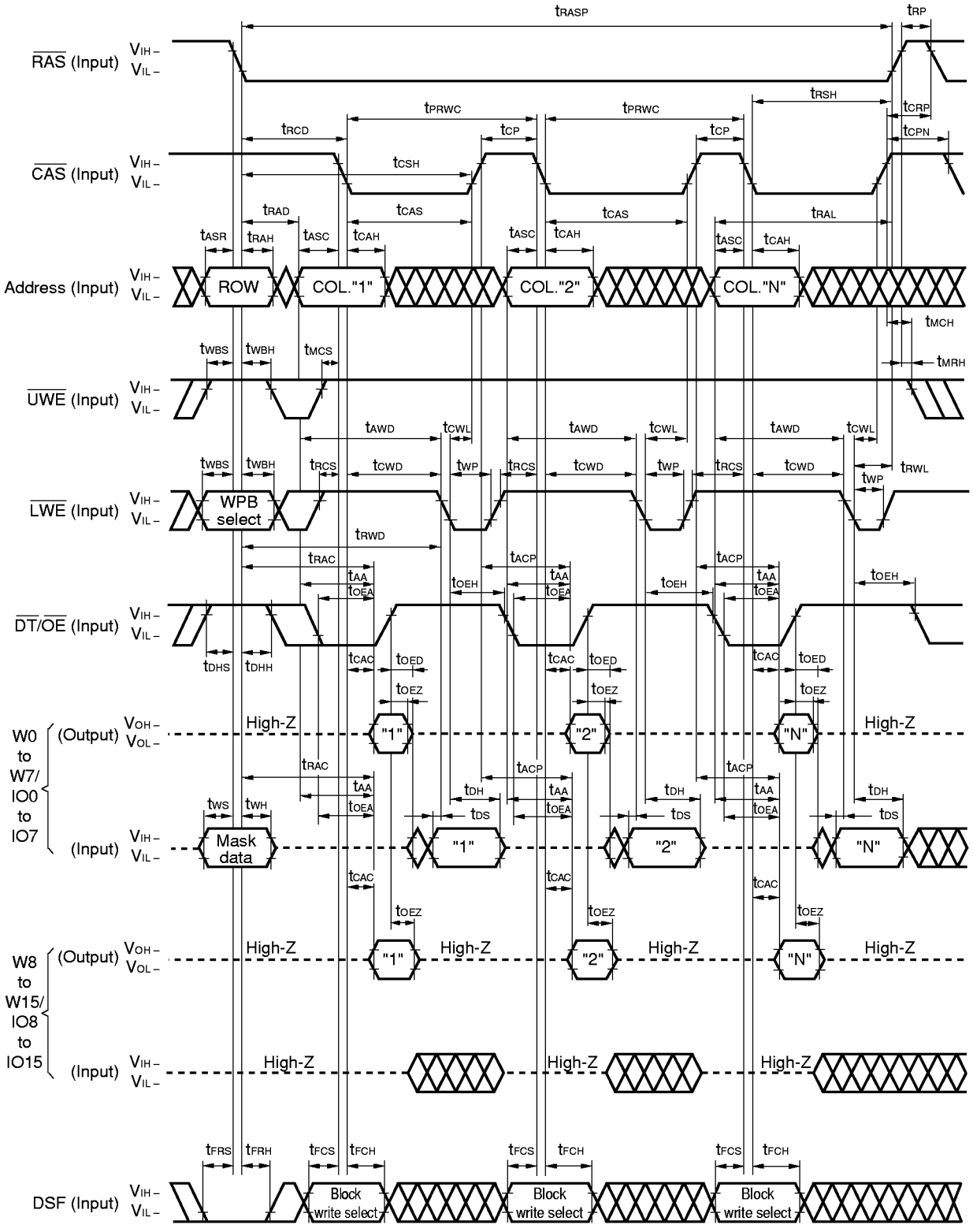
Remarks 1. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

2. WPB : Write-per-bit

3. When block write cycle is selected, input the column selection data to DATA IN.

4. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Fast Page Mode Read Modify Lower Byte Write Cycle (μPD482444)/
Fast Page Mode Read Modify Lower Byte Block Write Cycle (μPD482444)



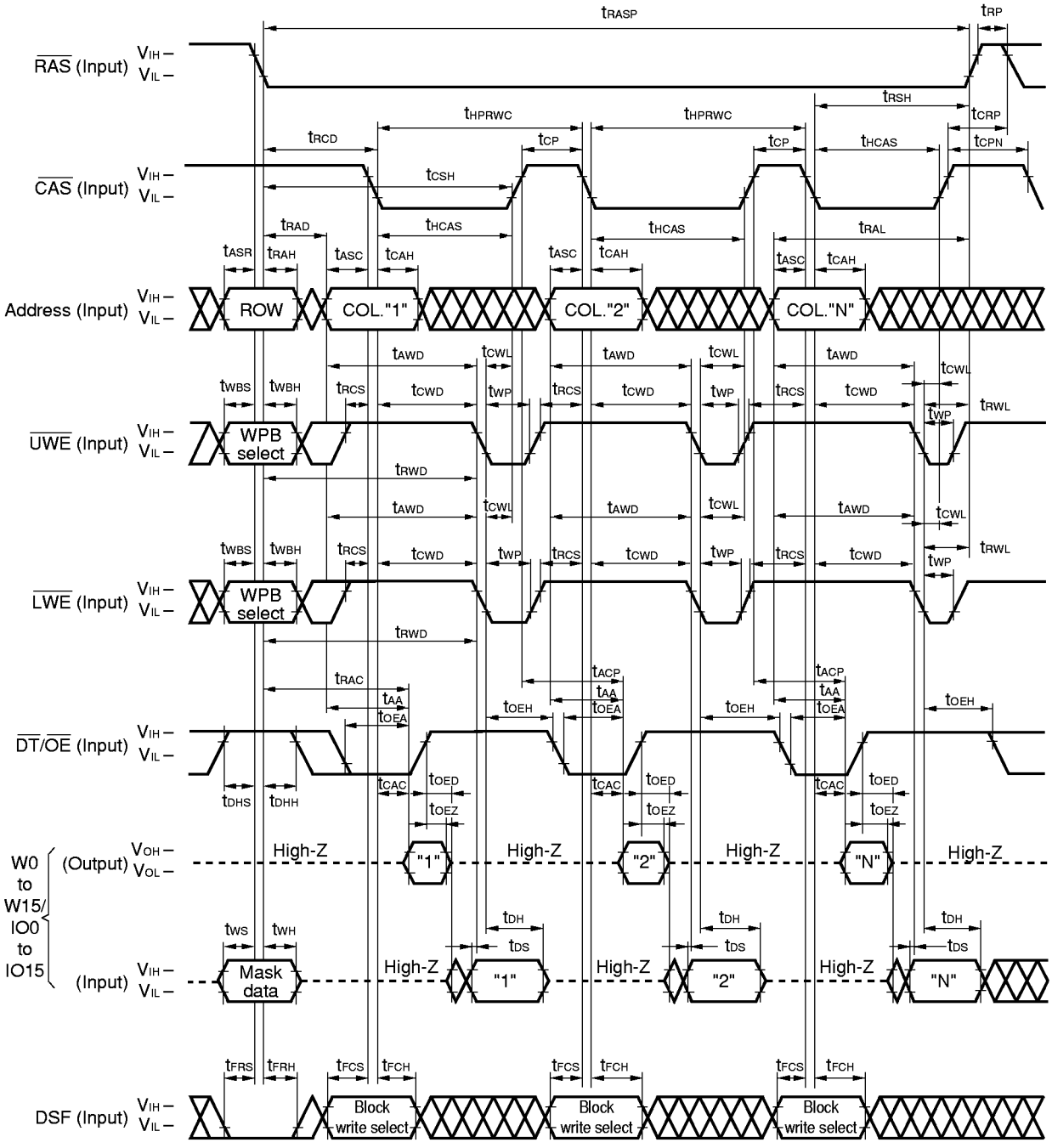
Remarks 1. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

2. WPB : Write-per-bit

3. When block write cycle is selected, input the column selection data to DATA IN.

4. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Hyper Page Mode Read Modify Write Cycle (Extended data output: μPD482445, 482445L)/
Hyper Page Mode Read Modify Block Write Cycle (Extended data output: μPD482445, 482445L)



Remarks 1. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

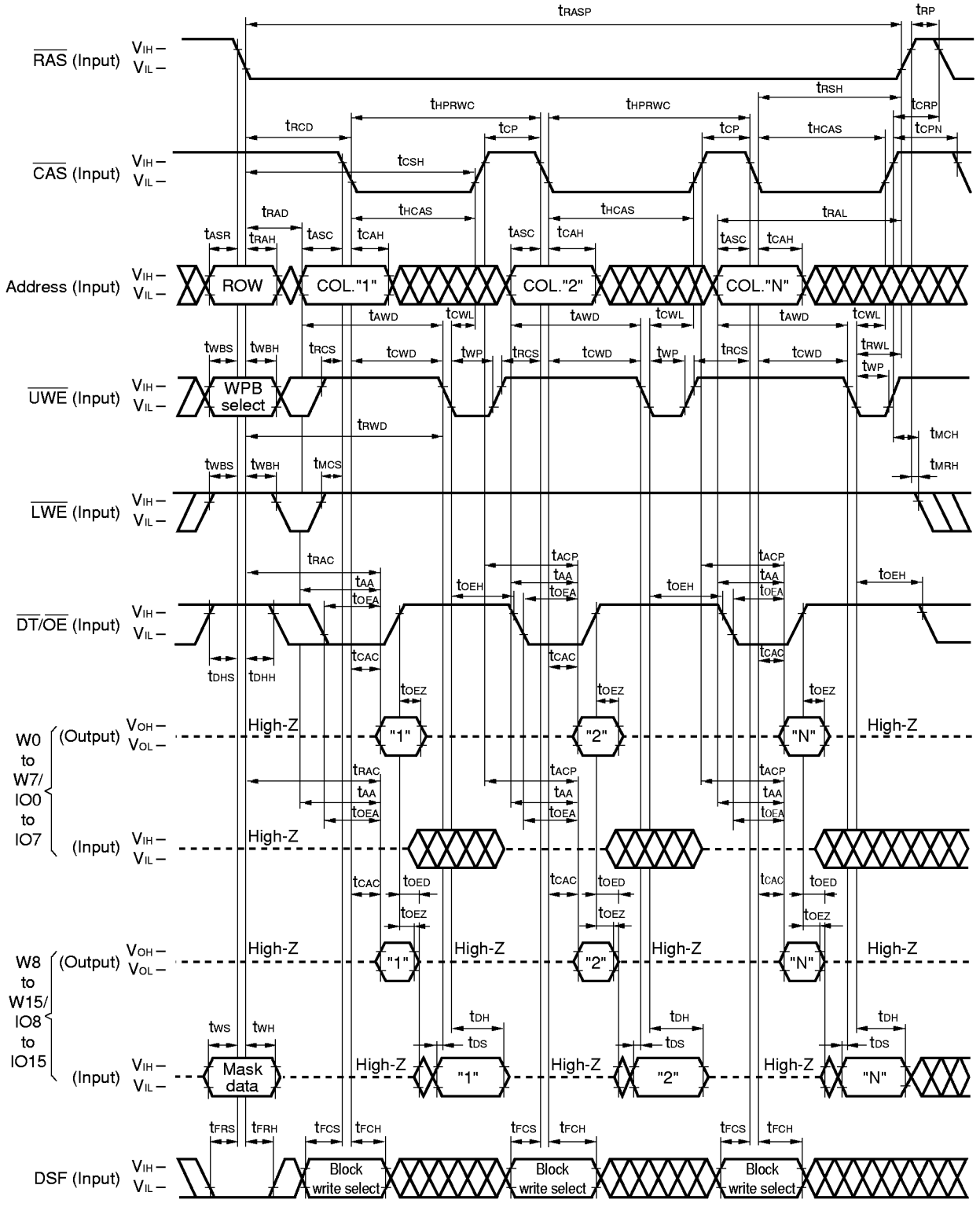
2. WPB : Write-per-bit

3. When block write cycle is selected, input the column selection data to DATA IN.

4. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

[MEMO]

Hyper Page Mode Read Modify Upper Byte Write Cycle (Extended data output: μPD482445, 482445L)/
Hyper Page Mode Read Modify Upper Byte Block Write Cycle (Extended data output: μPD482445, 482445L)



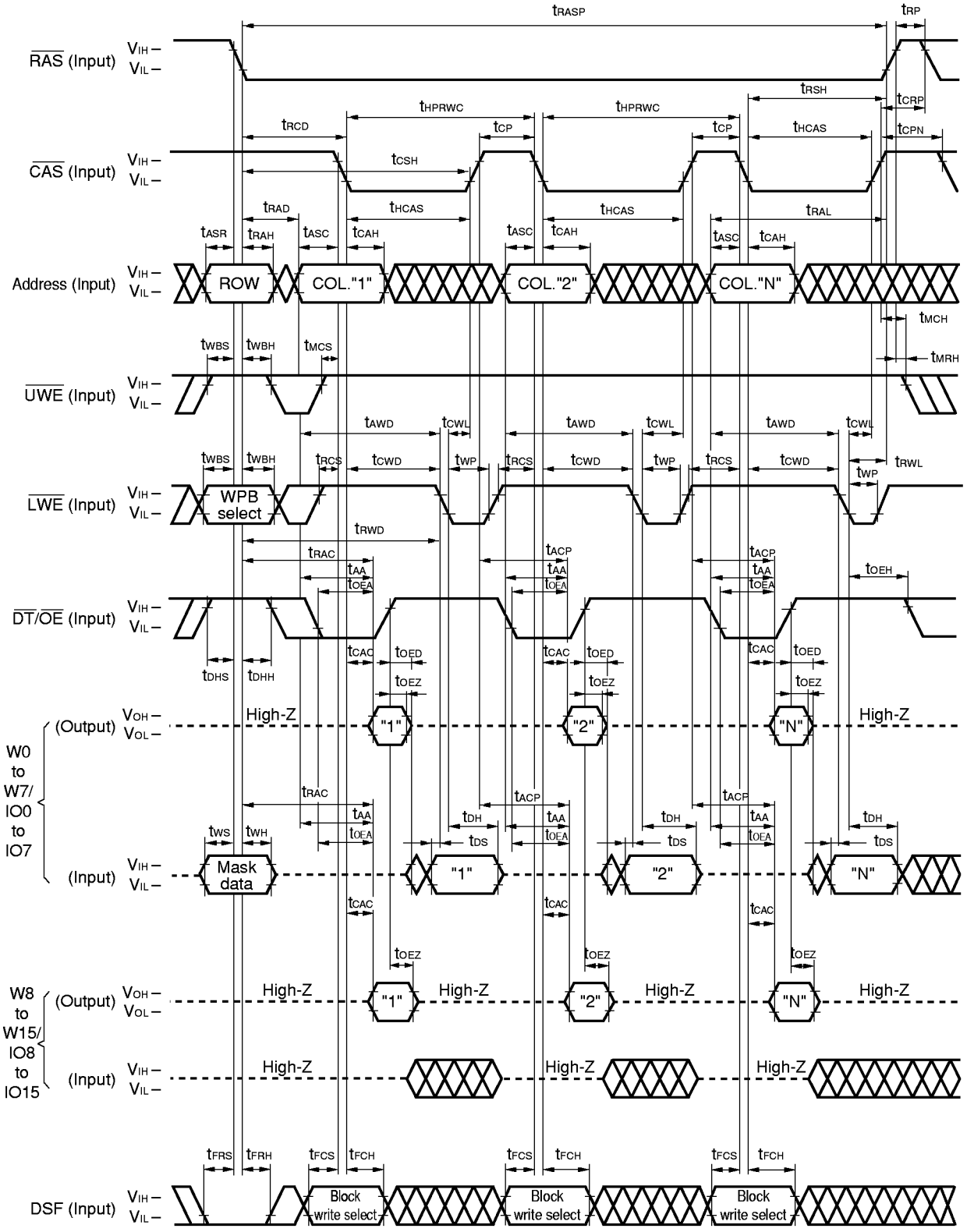
Remarks 1. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

2. WPB : Write-per-bit

3. When block write cycle is selected, input the column selection data to DATA IN.

4. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Hyper Page Mode Read Modify Lower Byte Write Cycle (Extended data output: μPD482445, 482445L)/
Hyper Page Mode Read Modify Lower Byte Block Write Cycle (Extended data output: μPD482445, 482445L)



Remarks 1. When DSF is high level : Block write cycle
When DSF is low level : Write cycle

2. WPB : Write-per-bit

3. When block write cycle is selected, input the column selection data to DATA IN.

4. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

[Refresh cycle]

Parameter	Symbol	μPD482444-60 μPD482445-60		μPD482444-70 μPD482445-70 μPD482445L-A70		Unit	Conditions
		MIN.	MAX.	MIN.	MAX.		
Refresh period	t_{REF}		8		8	ms	
$\overline{RAS}$ high to $\overline{CAS}$ low precharge time	t_{RPC}	10		10		ns	
$\overline{CAS}$ setup time (for $\overline{CAS}$ before $\overline{RAS}$ refresh cycle)	t_{CSR}	5		5		ns	
$\overline{CAS}$ hold time (for $\overline{CAS}$ before $\overline{RAS}$ refresh cycle)	t_{CHR}	10		10		ns	
$\overline{OE}$ to $\overline{RAS}$ inactive setup time	t_{OES}	0		0		ns	
SC setup time from $\overline{RAS}$	t_{SRS}	10		10		ns	**Notes 1, 2, 3**
SC hold time from $\overline{RAS}$	t_{SRH}	10		10		ns	**Note 1**

Notes 1. The t_{SRS} and t_{SRH} in the hidden refresh cycle, $\overline{CAS}$ before $\overline{RAS}$ refresh cycle (STOP register set cycle and optional reset cycle) are specified to guarantee the serial port operations until the transfer cycle is executed after the STOP register value is changed. When the STOP register value is not to be changed, or when the binary boundary jump function is not used (when the TAP register is empty), t_{SRS} and t_{SRH} will not be specified.

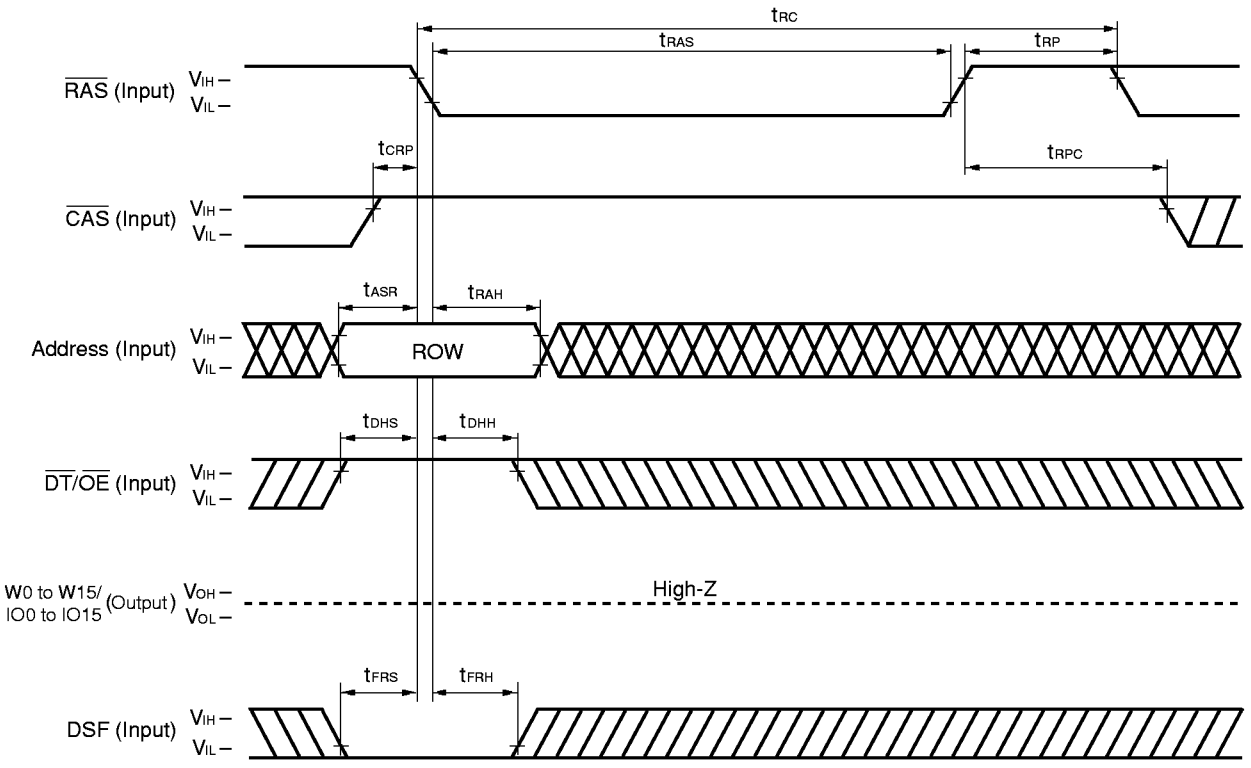
2. t_{SSC} (split read data transfer cycle) and t_{SRS} (split write data transfer cycle) are specified at the rising edge of SC which reads/writes the address of the jump source in the binary boundary jump function. t_{SDHR} (split read data transfer cycle and split write data transfer cycle) is specified at the rising edge of SC which reads/writes the address of the jump destination in the binary boundary jump function. The rising edge of these SCs cannot be input in periods (1) and (2).

(1) Split read data transfer cycle: Period from the rising edge of the SC specifying t_{SSC} to that of the SC specifying t_{SDHR} (Refer to **Note 2 at the Split Read/Write Data Transfer Cycle Timing Chart**.)

(2) Split write data transfer cycle: Period from the rising edge of the SC specifying t_{SRS} to that of the SC specifying t_{SDHR} (Refer to **Note 2 at the Split Read/Write Data Transfer Cycle Timing Chart**.)

3. Limitations of split read/write data transfer cycle during serial write operations. When split read/write data transfer is performed while serial write is executed for the column specified by the STOP register, serial write operations cannot be guaranteed.

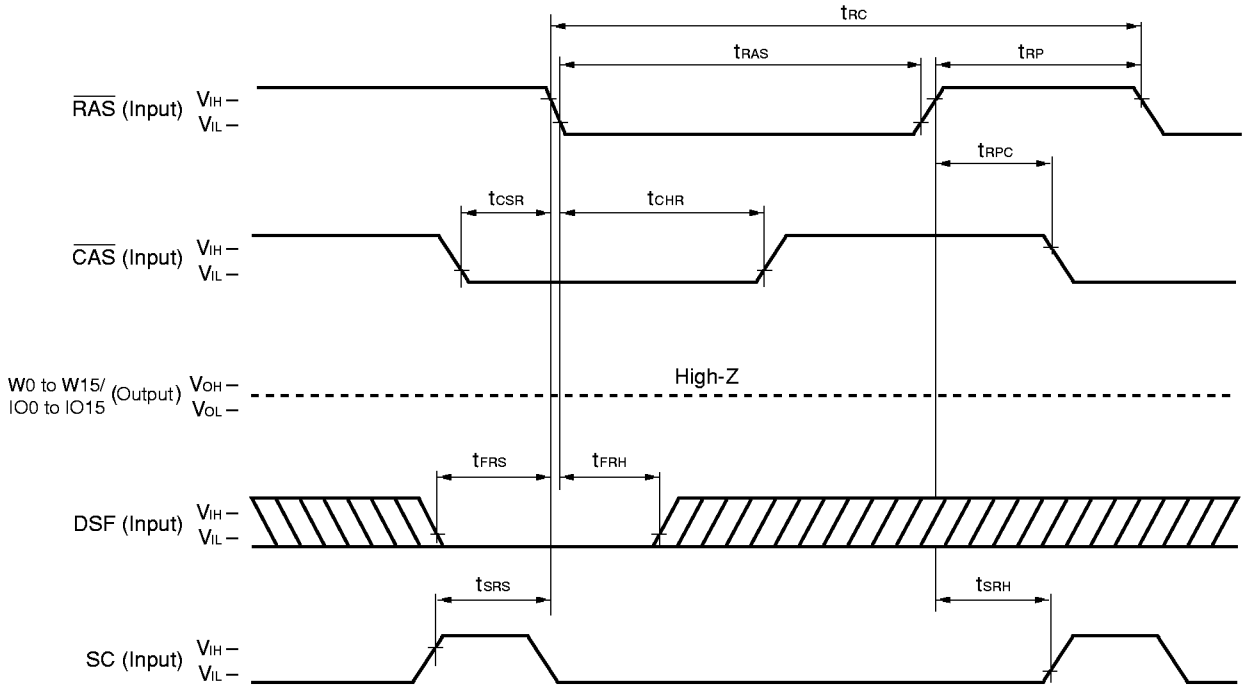
$\overline{\text{RAS}}$ Only Refresh Cycle



Remarks 1. $\overline{\text{UWE}}$, $\overline{\text{LWE}}$: Don't care

2. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{\text{SE}}$, SIO pins in this cycle.

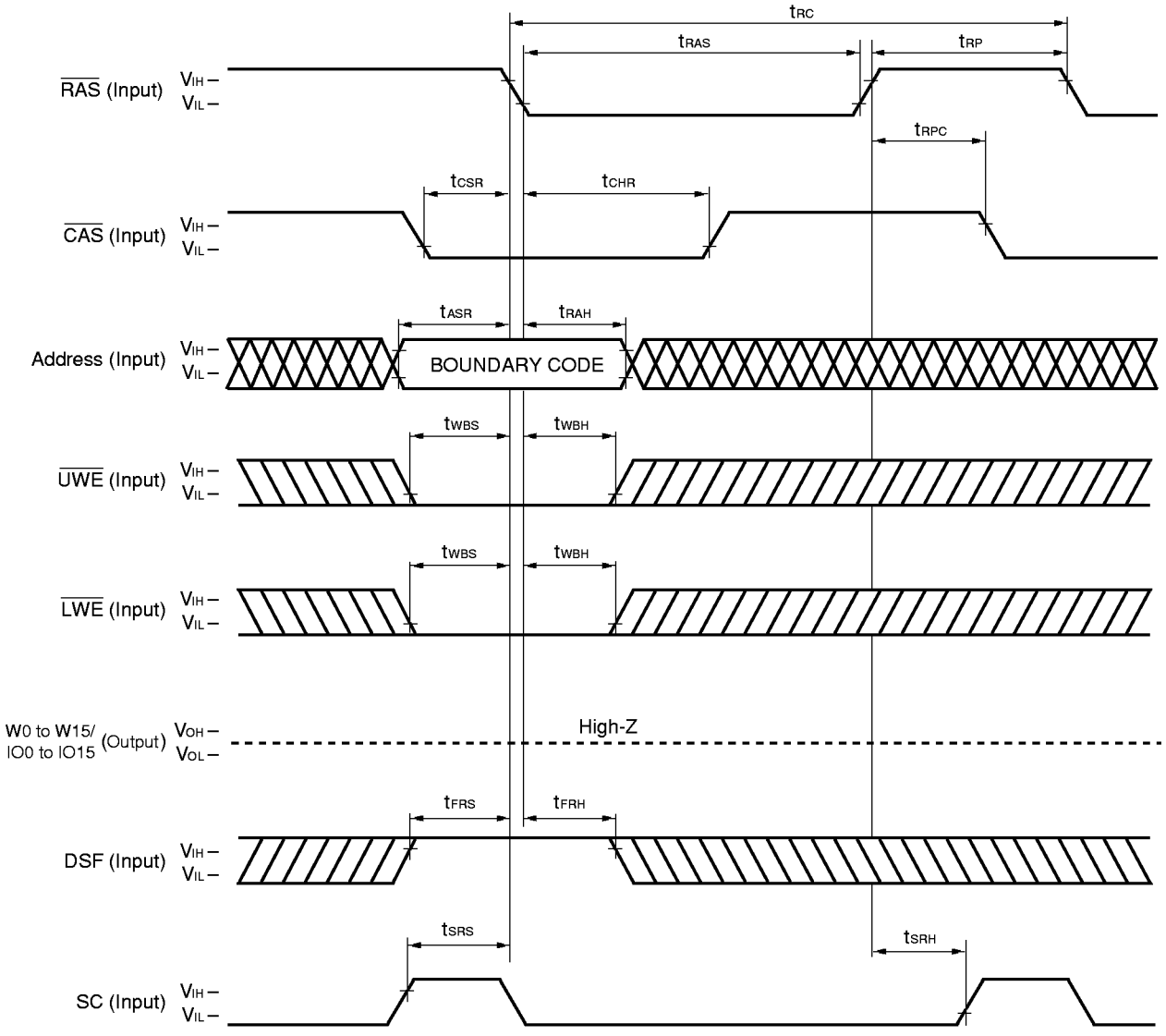
$\overline{CAS}$ Before $\overline{RAS}$ Refresh Cycle (Optional Reset)



Remarks 1. A0 to A8, $\overline{UWE}$, $\overline{LWE}$, $\overline{DT}/\overline{OE}$: Don't care

2. Because the serial access port operates independently of the random access port, there is no need to control the $\overline{SE}$, SIO pins in this cycle.

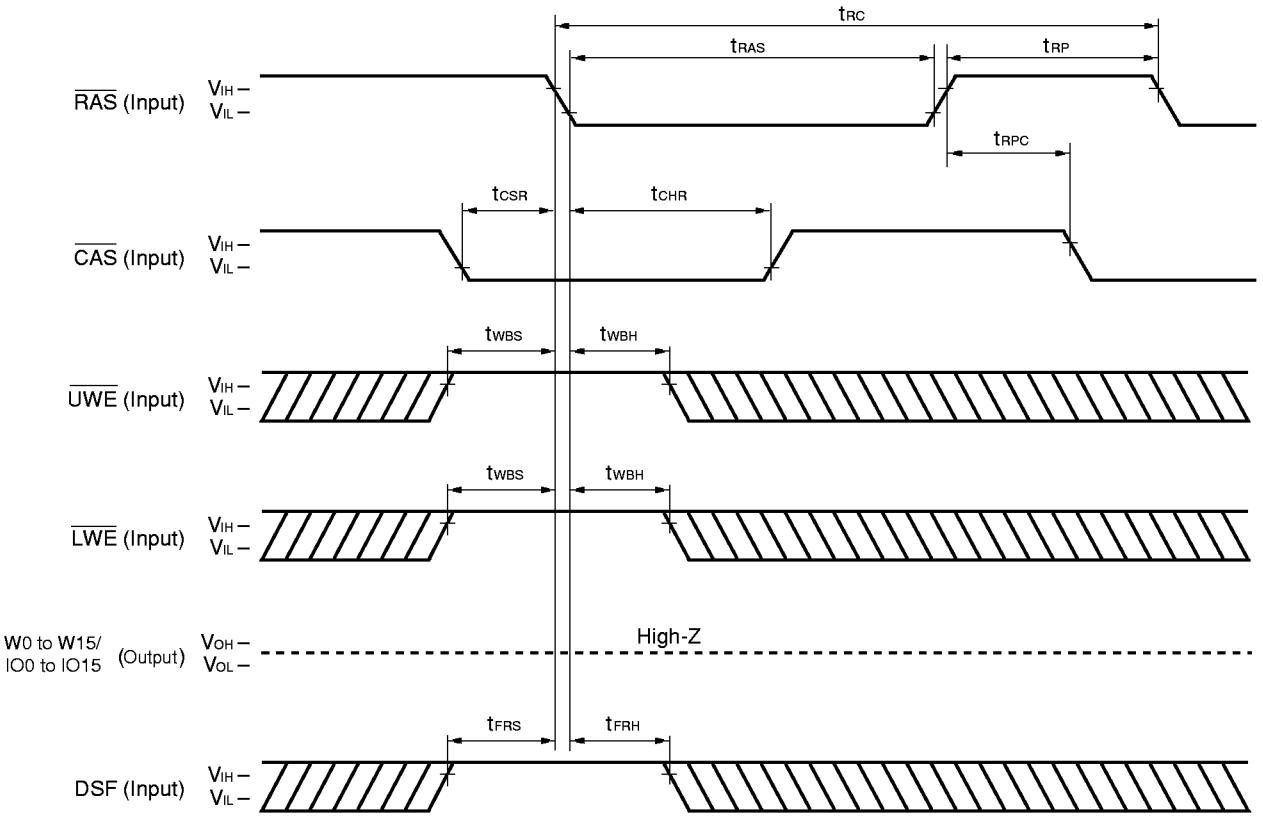
$\overline{CAS}$ Before $\overline{RAS}$ Refresh Cycle (STOP Register Set)



Remarks 1. $\overline{DT}/\overline{OE}$: Don't care

2. Because the serial access port operates independently of the random access port, there is no need to control the $\overline{SE}$, SIO pins in this cycle.

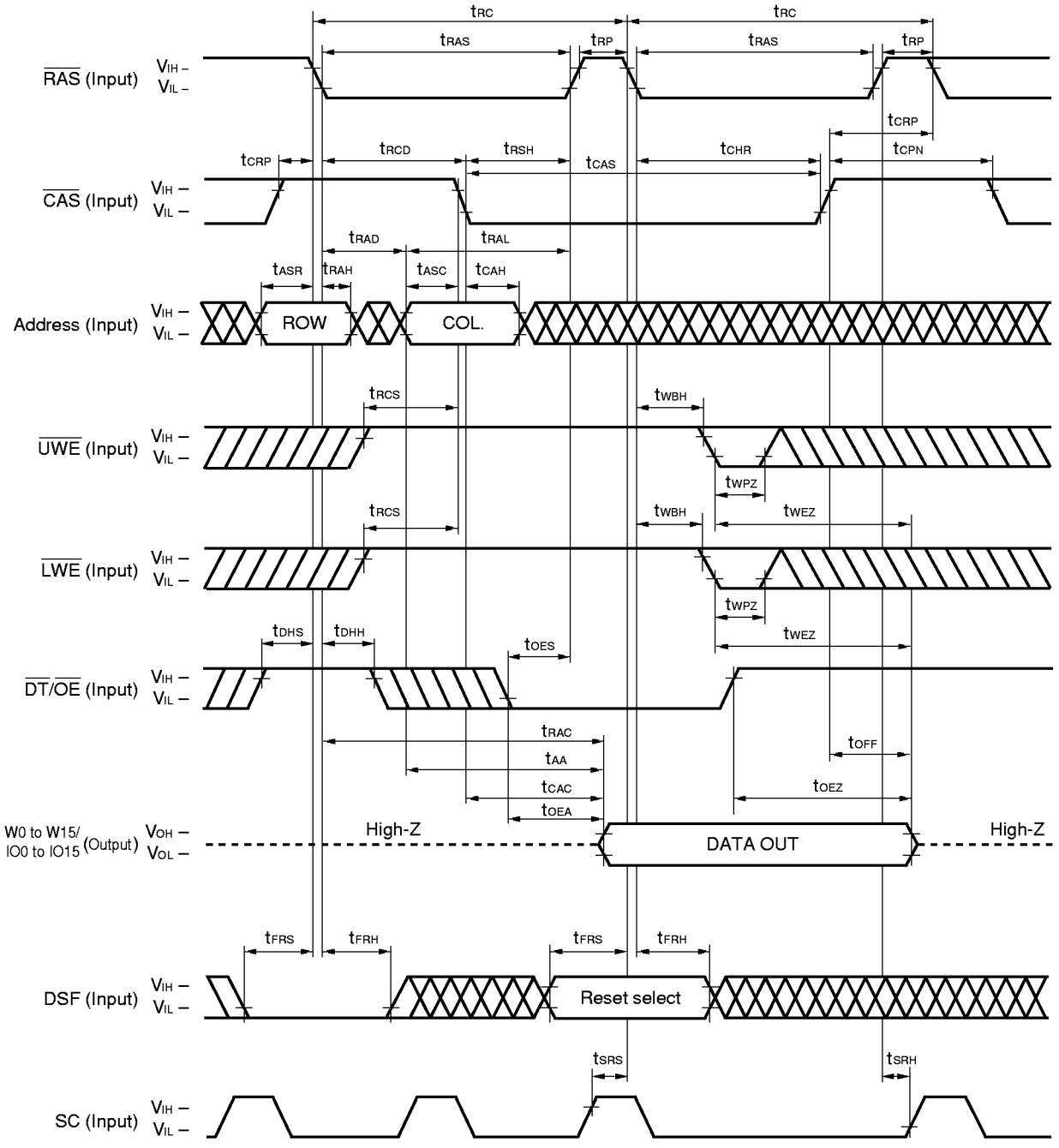
$\overline{CAS}$ Before $\overline{RAS}$ Refresh Cycle (No Reset)



Remarks 1. A0 to A8, $\overline{DT}/\overline{OE}$: Don't care

2. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

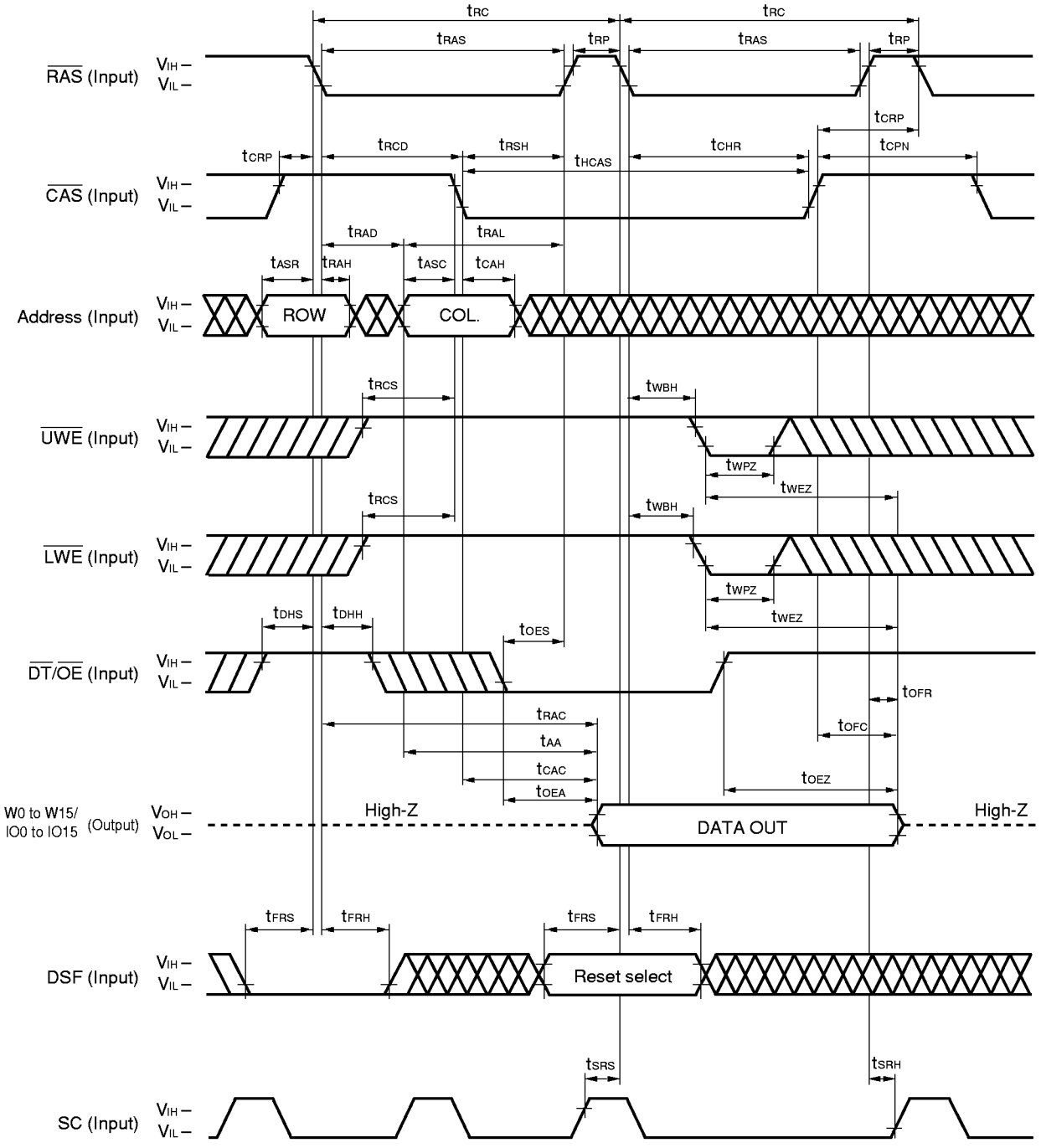
Hidden Refresh Cycle (μPD482444)



Remarks 1. When DSF is high level : Reset select = No Reset
When DSF is low level : Reset select = Optional Reset

2. Because the serial access port operates independently of the random access port, there is no need to control the $\overline{SE}$, SIO pins in this cycle.

Hidden Refresh Cycle (Extended data output: μPD482445, 482445L)



Remarks 1. When DSF is high level : Reset select = No Reset
When DSF is low level : Reset select = Optional Reset

2. Because the serial access port operates independently of the random access port, there is no need to control the $\overline{SE}$, SIO pins in this cycle.

[Register set cycle]

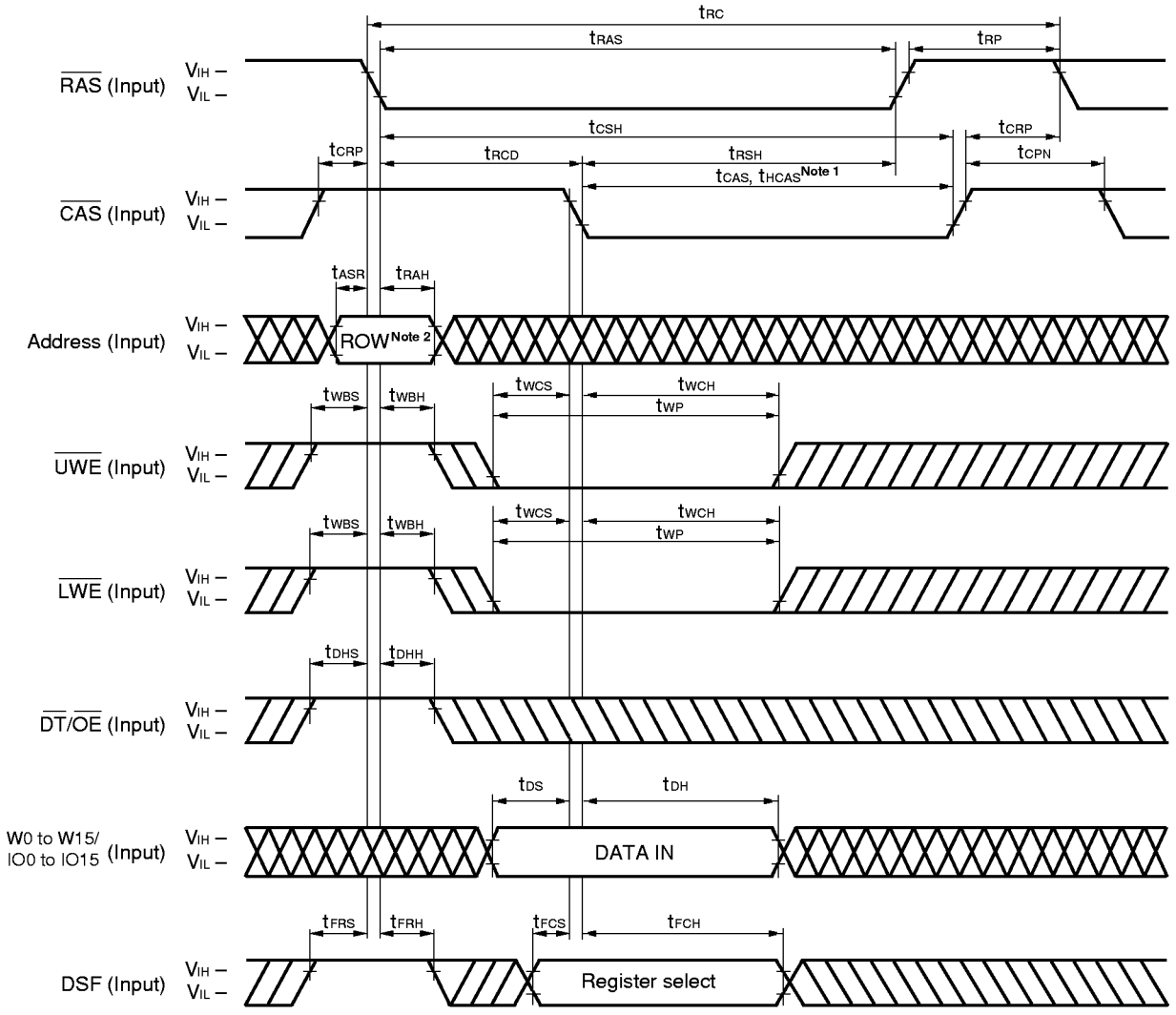
Parameter	Symbol	μPD482444-60 μPD482445-60		μPD482444-70 μPD482445-70 μPD482445L-A70		Unit	Condition
		MIN.	MAX.	MIN.	MAX.		
$\overline{RAS}$ high to $\overline{CAS}$ low precharge time	t_{RPC}	10		10		ns	
Write command setup time	t_{WCS}	0		0		ns	**Note**
Write command hold time	t_{WCH}	12		12		ns	

Note $t_{WCS} \geq t_{WCS}$ (MIN.) is the condition for early write cycle to be set. D_{OUT} becomes high impedance during the cycle.

$t_{RWD} \geq t_{RWD}$ (MIN.), $t_{CWD} \geq t_{CWD}$ (MIN.), $t_{AWD} \geq t_{AWD}$ (MIN.), are conditions for read modify write cycle to be set. The data of the selected address is output to D_{OUT}.

If any of the above conditions are not met, pin W/IO will become undefined.

Register Set Cycle (Early Write)



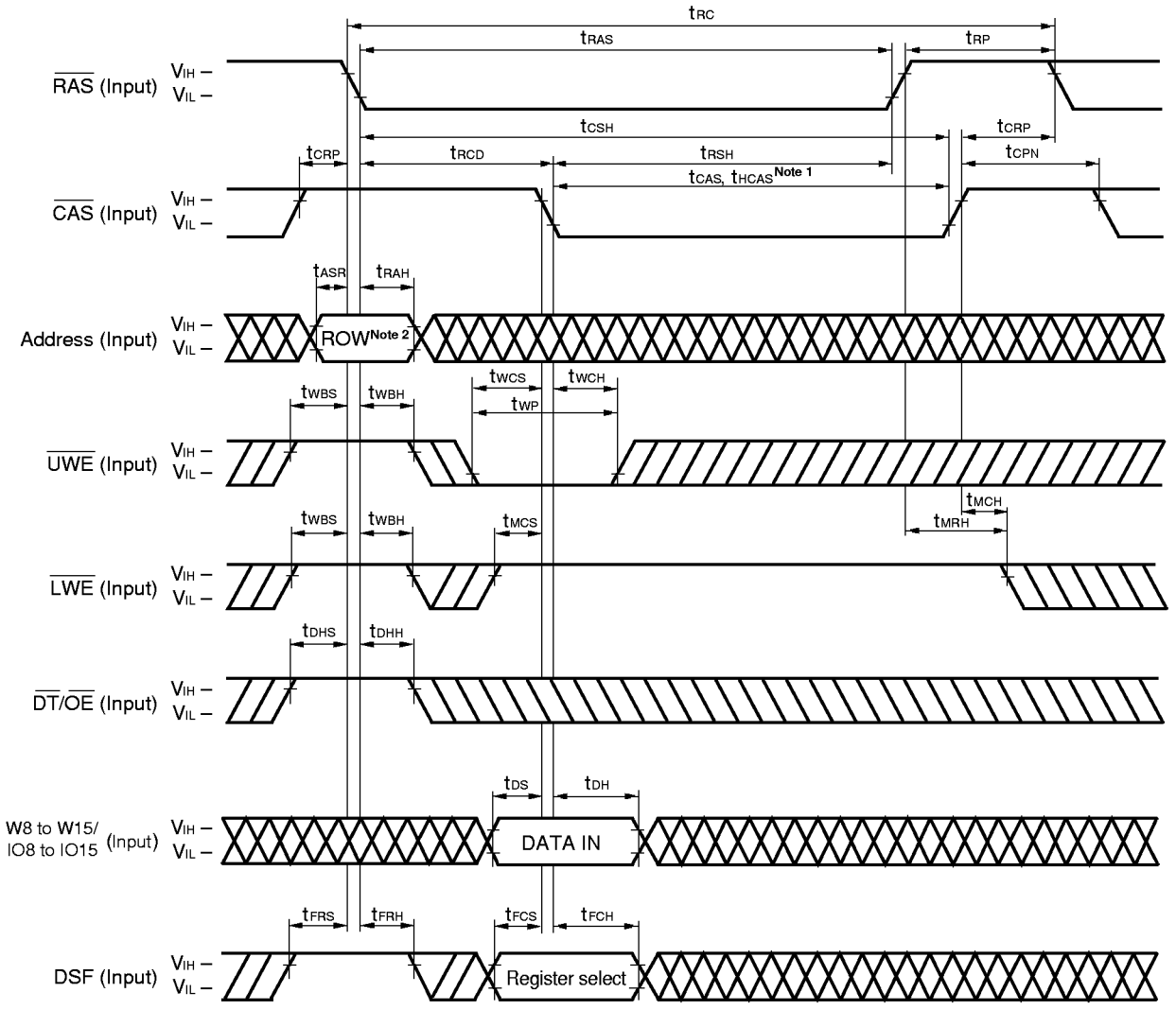
Notes 1. t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

2. Refresh address ($\overline{RAS}$ only refresh)

Remarks 1. When DSF is high level : Register select = Color Register Select
When DSF is low level : Register select = Write Mask Register Select

2. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Register Set Cycle (Upper Byte Early Write)



Notes 1. t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

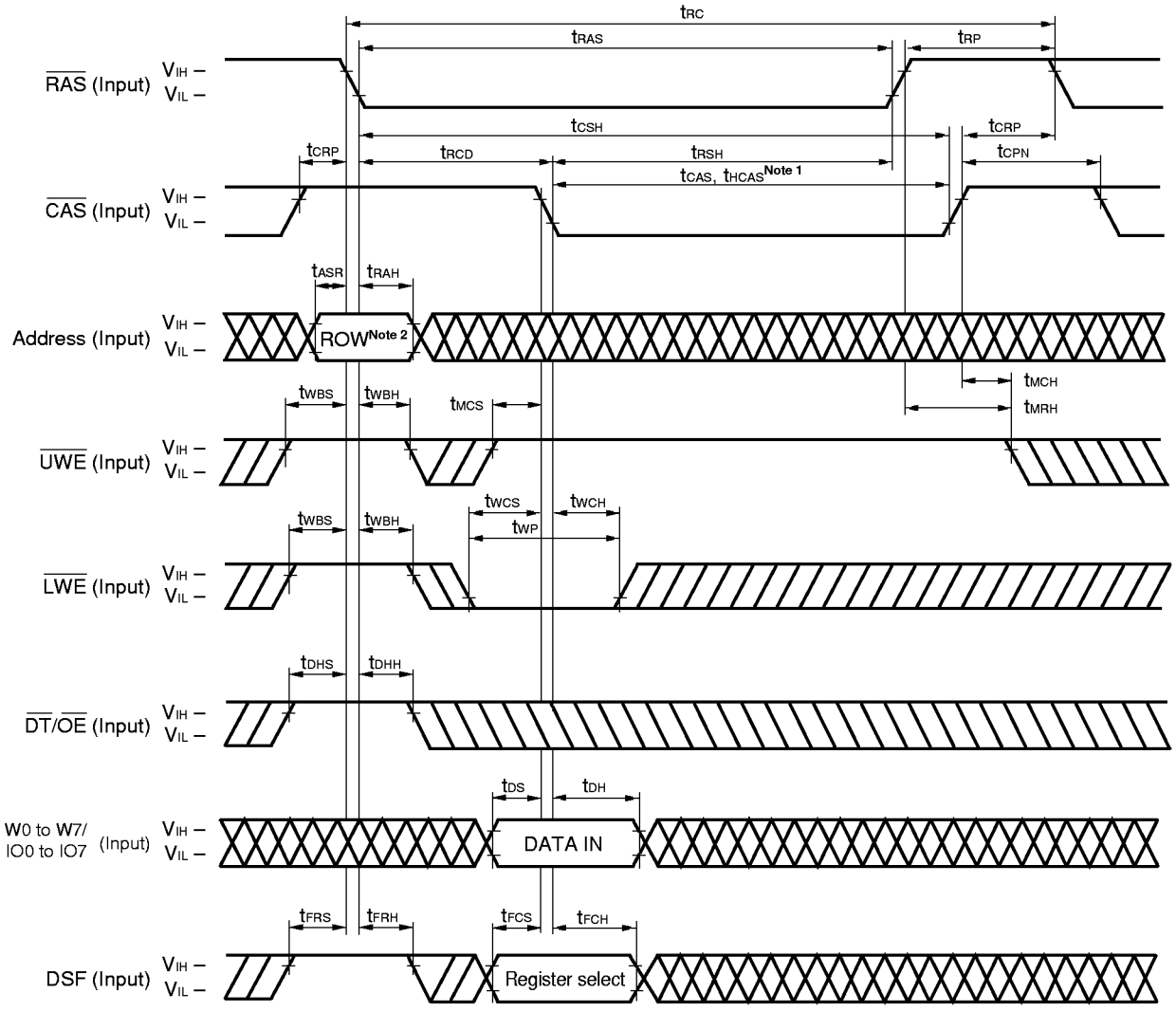
2. Refresh address ($\overline{RAS}$ only refresh)

Remarks 1. W0 to W7/IO0 to IO7 : Don't care

2. When DSF is high level : Register select = Color Register Select
When DSF is low level : Register select = Write Mask Register Select

3. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Register Set Cycle (Lower Byte Early Write)



Notes 1. t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

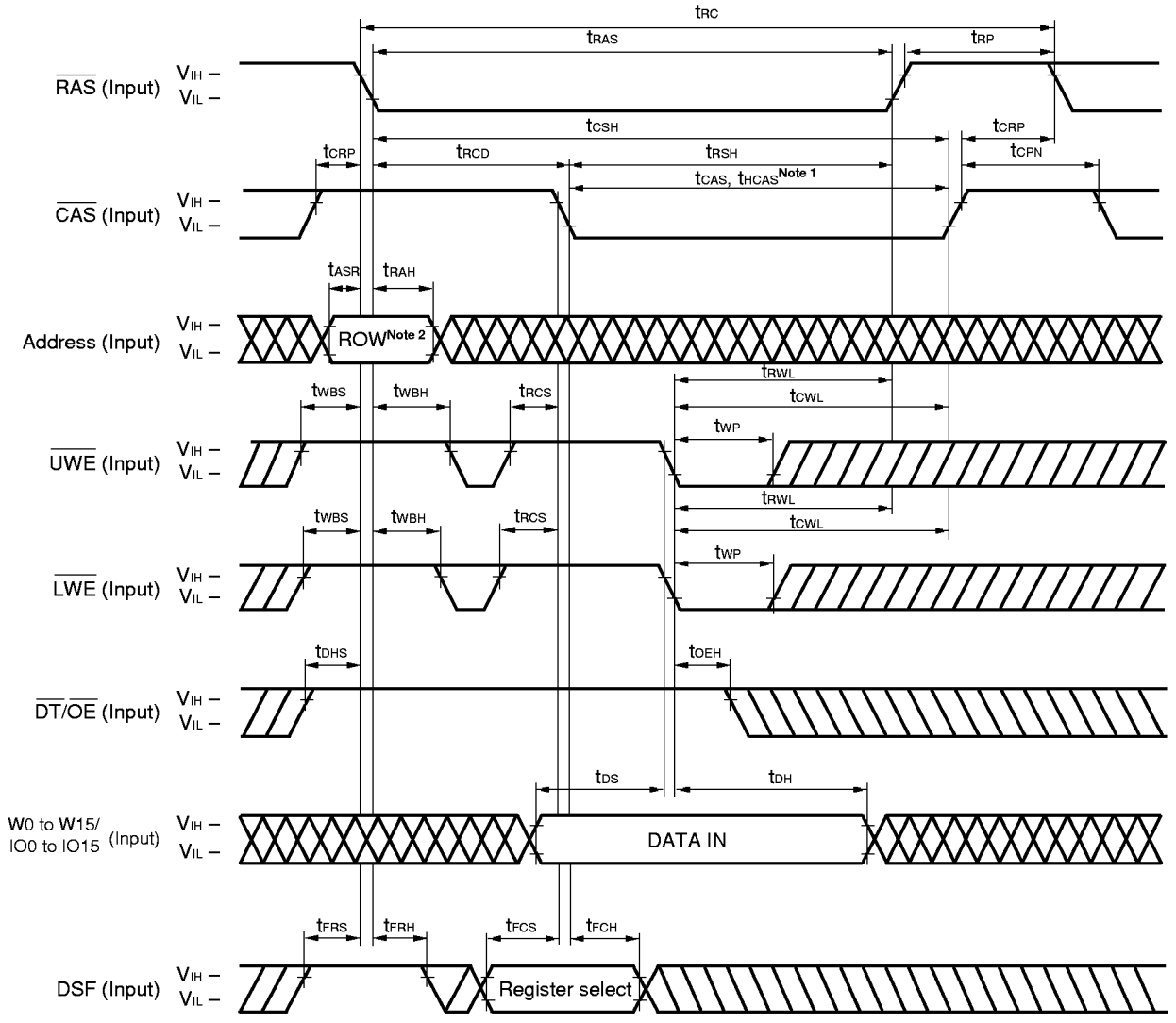
2. Refresh address ($\overline{RAS}$ only refresh)

Remarks 1. W8 to W15/IO8 to IO15 : Don't care

2. When DSF is high level : Register select = Color Register Select
When DSF is low level : Register select = Write Mask Register Select

3. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Register Set Cycle (Late Write)



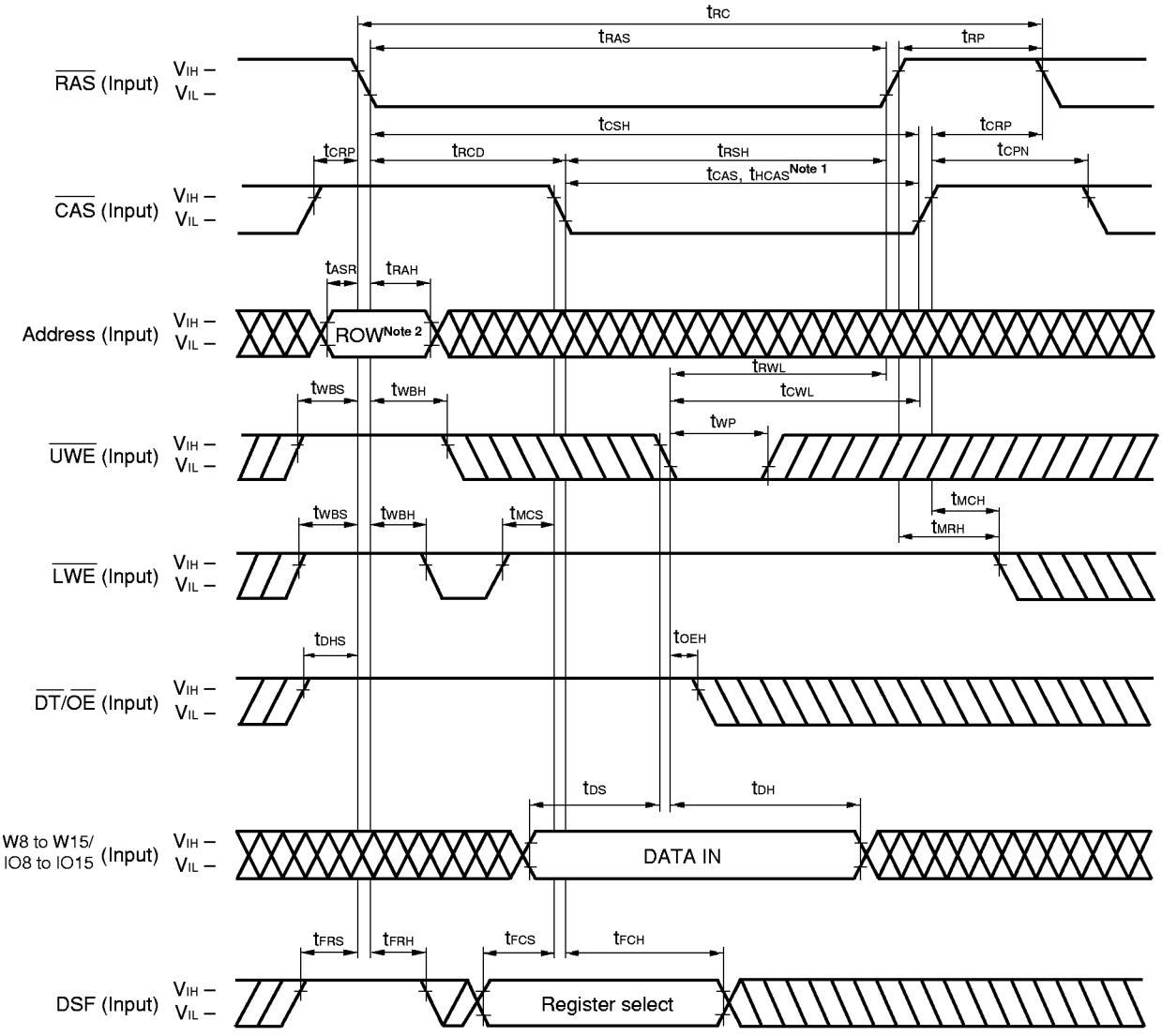
Notes 1. t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

2. Refresh address ($\overline{RAS}$ only refresh)

Remarks 1. When DSF is high level : Register select = Color Register Select
When DSF is low level : Register select = Write Mask Register Select

2. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Register Set Cycle (Upper Byte Late Write)



Notes 1. t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

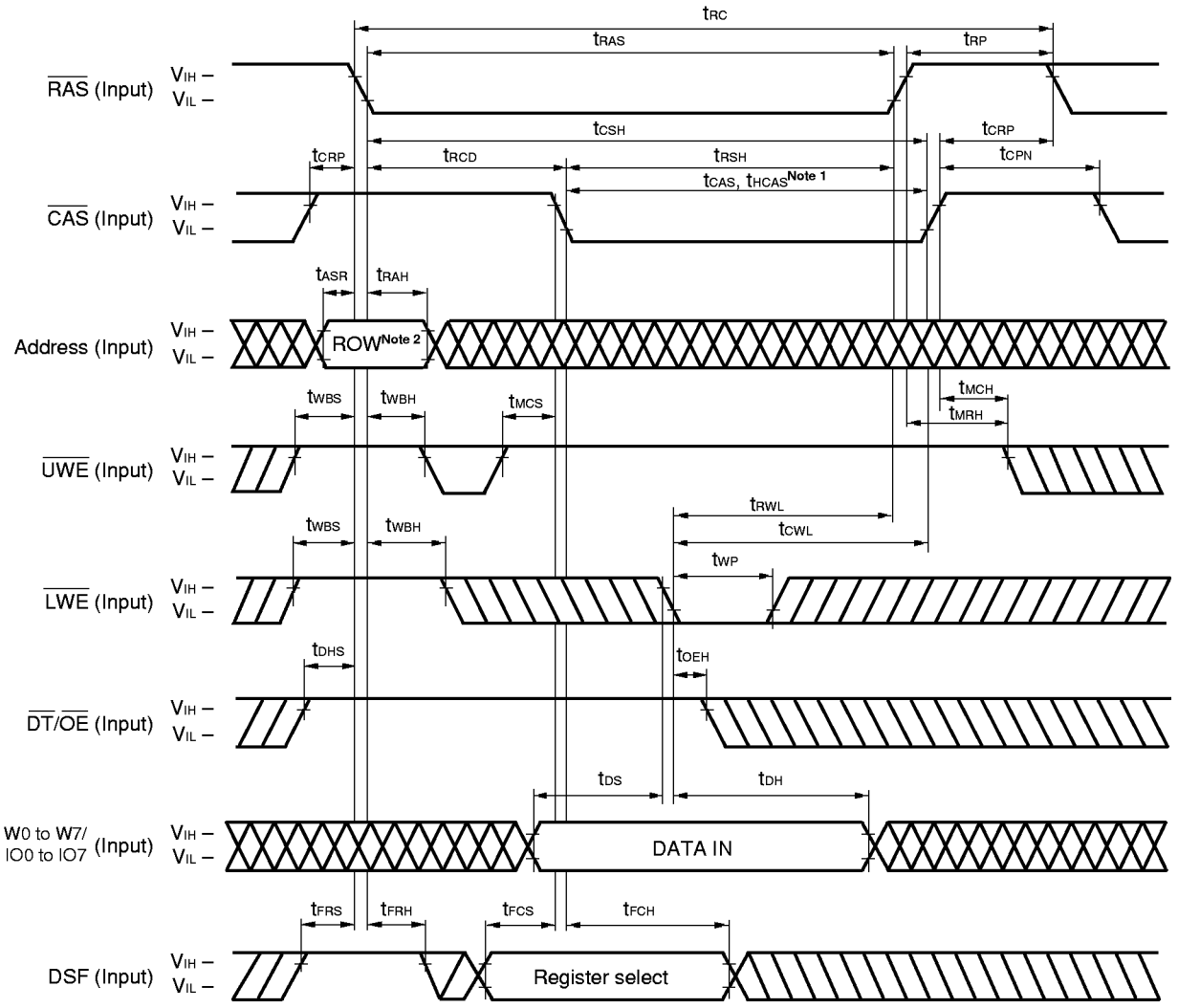
2. Refresh address ($\overline{RAS}$ only refresh)

Remarks 1. W0 to W7/IO0 to IO7 : Don't care

2. When DSF is high level : Register select = Color Register Select
When DSF is low level : Register select = Write Mask Register Select

3. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

Register Set Cycle (Lower Byte Late Write)



Notes 1. t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

2. Refresh address ($\overline{RAS}$ only refresh)

Remarks 1. W8 to W15/IO8 to IO15 : Don't care

2. When DSF is high level : Register select = Color Register Select
When DSF is low level : Register select = Write Mask Register Select

3. Because the serial access port operates independently of the random access port, there is no need to control the SC, $\overline{SE}$, SIO pins in this cycle.

[Data transfer cycle]

Parameter	Symbol	μPD482444-60 μPD482445-60		μPD482444-70 μPD482445-70 μPD482445L-A70		Unit	Conditions
		MIN.	MAX.	MIN.	MAX.		
Serial clock cycle time	t_{SCC}	20		22		ns	
Serial output access time from SC	t_{SCA}		15		17	ns	
Propagation delay time from SC to QSF	t_{PD}	0	20	0	20	ns	
Propagation delay time from $\overline{RAS}$ to QSF	t_{RQD}	0	80	0	95	ns	
Propagation delay time from $\overline{CAS}$ to QSF	t_{CQD}	0	60	0	65	ns	
Propagation delay time from $\overline{DT}/\overline{OE}$ to QSF	t_{DQD}	0	30	0	30	ns	
Propagation delay time from $\overline{RAS}$ high to QSF	t_{DQR}	0	40	0	40	ns	
Serial input enable time from $\overline{RAS}$	t_{SZH}	40		40		ns	
SC precharge time	t_{SCL}	5		5		ns	
SC pulse width	t_{SCH}	5		5		ns	
$\overline{DT}$ high pulse width	t_{DTP}	20		20		ns	
$\overline{DT}$ low setup time	t_{DLS}	0		0		ns	
Serial output hold time after SC high	t_{SOH}	3		5		ns	
Serial data in setup time	t_{SIS}	0		0		ns	
Serial data in hold time	t_{SIH}	10		10		ns	
SC setup time from $\overline{RAS}$	t_{SRS}	10		10		ns	**Notes 1, 2, 3**
$\overline{DT}$ low hold time after $\overline{RAS}$ low	t_{RDH}	55		60		ns	**Note 4**
$\overline{DT}$ low hold time after $\overline{RAS}$ low	t_{RDHS}	15		15		ns	**Note 4**
$\overline{DT}$ low hold time after $\overline{CAS}$ low	t_{CDH}	20		20		ns	**Note 4**
$\overline{DT}$ low hold time after address	t_{ADD}	25		25		ns	**Note 4**
SC low hold time after $\overline{DT}$ high	t_{SDH}	60		60		ns	**Note 4**
SC low hold time after $\overline{DT}$ high	t_{SDHR}	60		60		ns	**Notes 2, 4**
SC high to $\overline{CAS}$ low	t_{SSC}	10		10		ns	**Notes 2, 3, 4**
SC high to $\overline{DT}$ high	t_{SDD}	0		0		ns	**Note 4**
$\overline{DT}$ high to $\overline{RAS}$ high delay time	t_{DTR}	0		0		ns	**Note 4**
Serial input disable time from SC	t_{SIZ}	0		0		ns	
Serial output disable time from $\overline{RAS}$	t_{SRZ}	0		0		ns	

Notes 1. The t_{SRS} and t_{SRH} in the hidden refresh cycle, $\overline{CAS}$ before $\overline{RAS}$ refresh cycle (STOP register set cycle and optional reset cycle) are specified to guarantee the serial port operations until the transfer cycle is executed after the STOP register value is changed. When the STOP register value is not to be changed, or when the binary boundary jump function is not used (when the TAP register is empty), t_{SRS} and t_{SRH} will not be specified.

2. t_{SSC} (split read data transfer cycle) and t_{SRS} (split write data transfer cycle) are specified at the rising edge of SC which reads/writes the address of the jump source in the binary boundary jump function. t_{SDHR} (split read data transfer cycle and split write data transfer cycle) is specified at the rising edge of SC which reads/writes the address of the jump destination in the binary boundary jump function. The rising edge of these SCs cannot be input in periods (1) and (2).

(1) Split read data transfer cycle: Period from the rising edge of the SC specifying t_{SSC} to that of the SC specifying t_{SDHR} (Refer to **Note 2 at the Split Read/Write Data Transfer Cycle Timing Chart**.)

(2) Split write data transfer cycle: Period from the rising edge of the SC specifying t_{SRS} to that of the SC specifying t_{SDHR} (Refer to **Note 2 at the Split Read/Write Data Transfer Cycle Timing Chart**.)

3. Limitations of split read/write data transfer cycle during serial write operations. When split read/write data transfer is performed while serial write is executed for the column specified by the STOP register, serial write operations cannot be guaranteed.

4. One of the following specifications will be valid depending on the type of read data transfer method used.

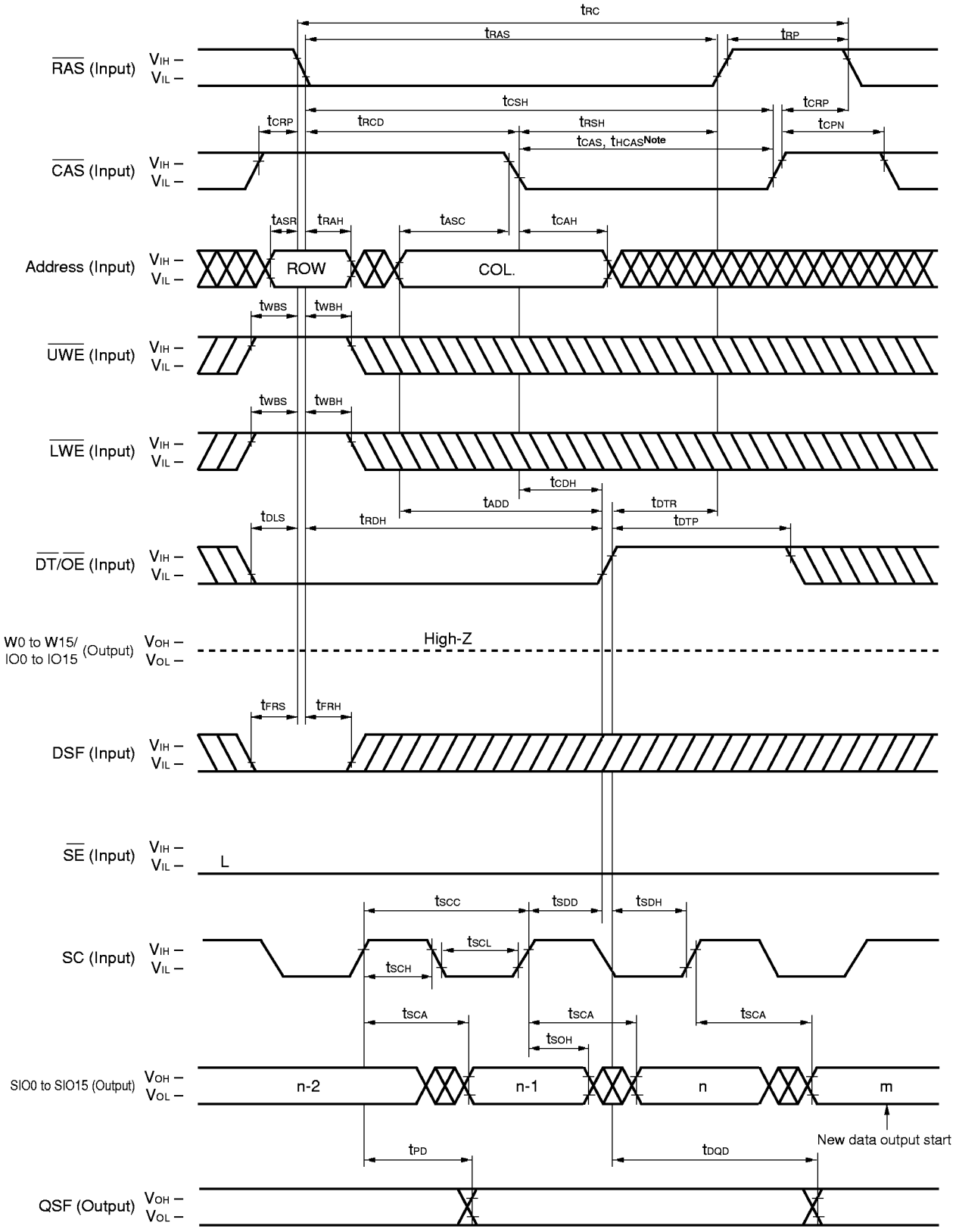
(1) $\overline{DT}/\overline{OE}$ edge control: Satisfy the following specifications.

- For $\overline{DT}/\overline{OE}$ edge inputs : t_{RDH}, t_{CDH}, t_{ADD}, t_{DTR}
- For SC inputs : t_{SDD}, t_{SDH}

(2) Self control: Satisfy the following specification.

- For $\overline{DT}/\overline{OE}$ edge inputs : t_{RDHS}
- For SC inputs : t_{SSC}, t_{SDHR}

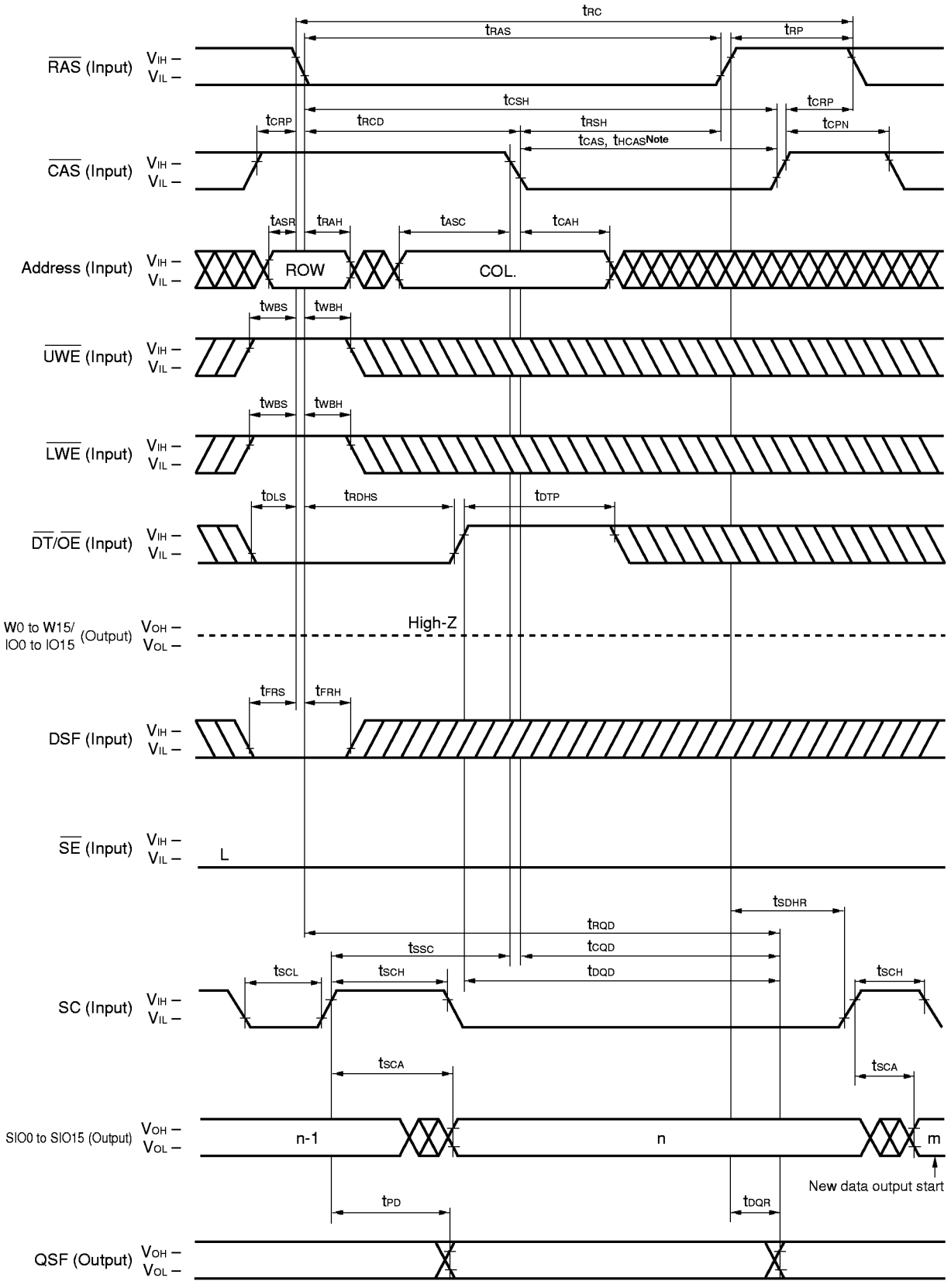
Read Data Transfer Cycle (SC Active)



Note t_{CAS} for the μPD482444

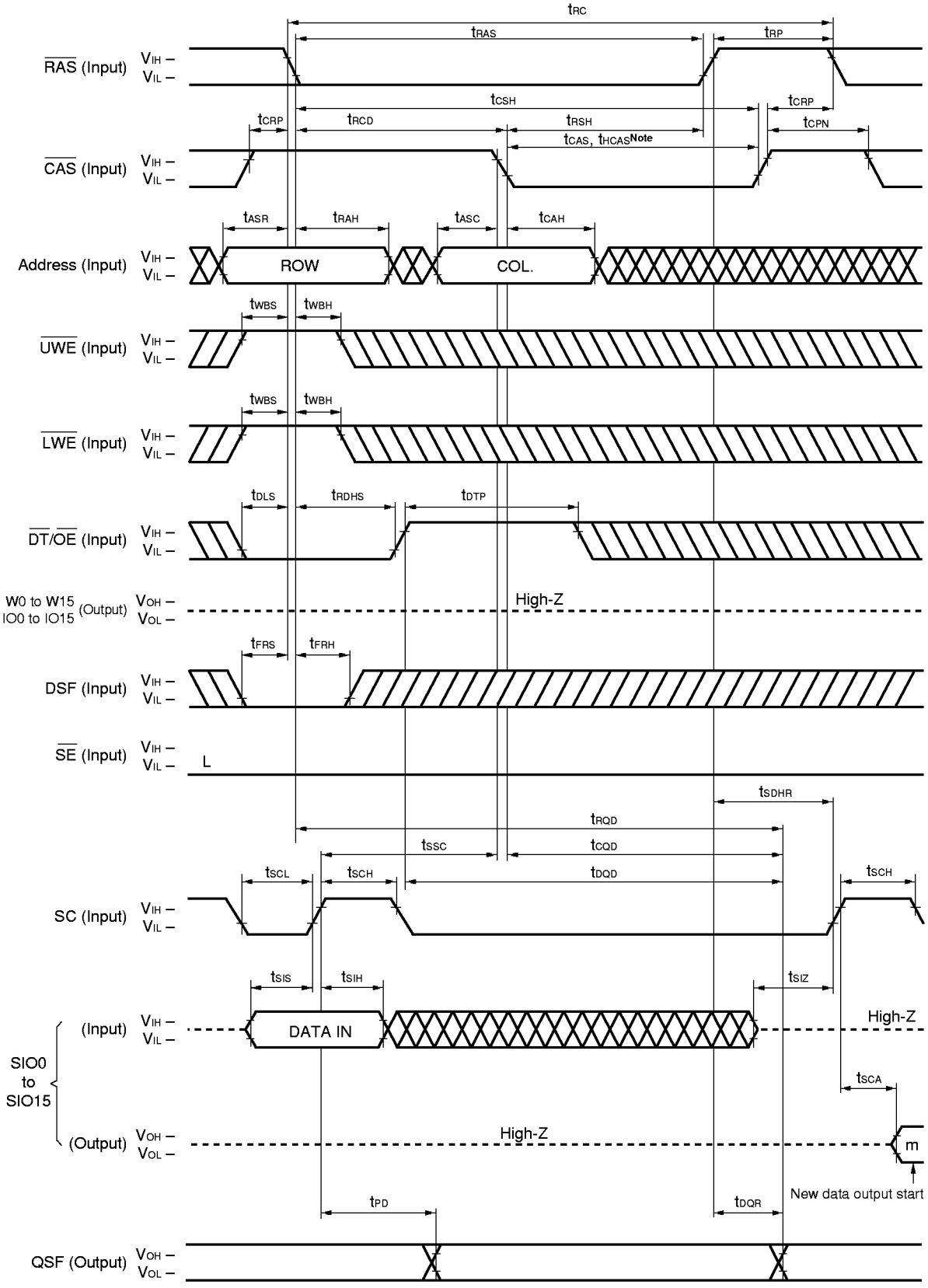
t_{HCAS} for the μPD482445, 482445L

Read Data Transfer Cycle (SC Inactive)



Note t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

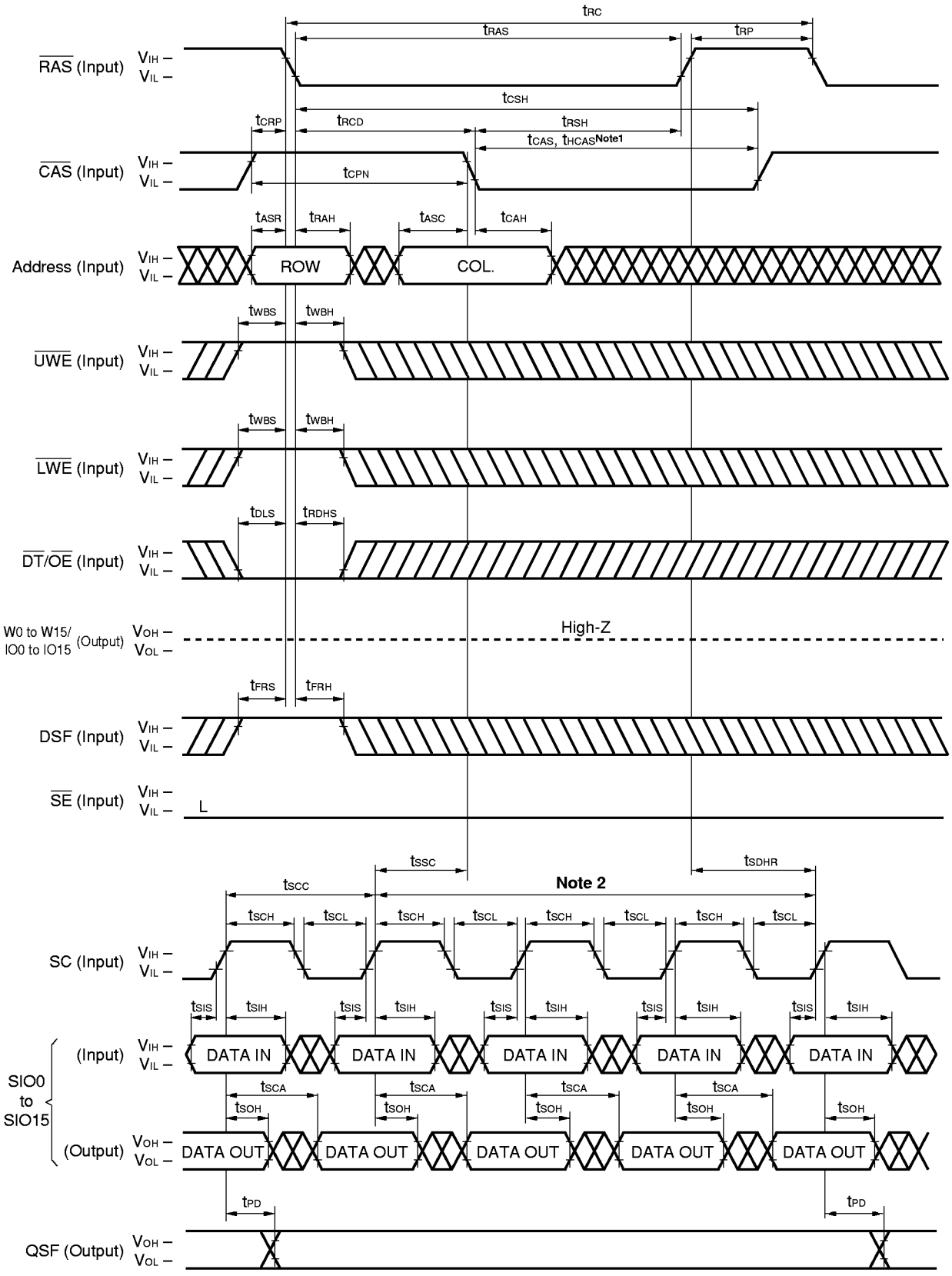
Read Data Transfer Cycle (Serial Write → Serial Read Switching)



Note t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

[MEMO]

Split Read Data Transfer Cycle

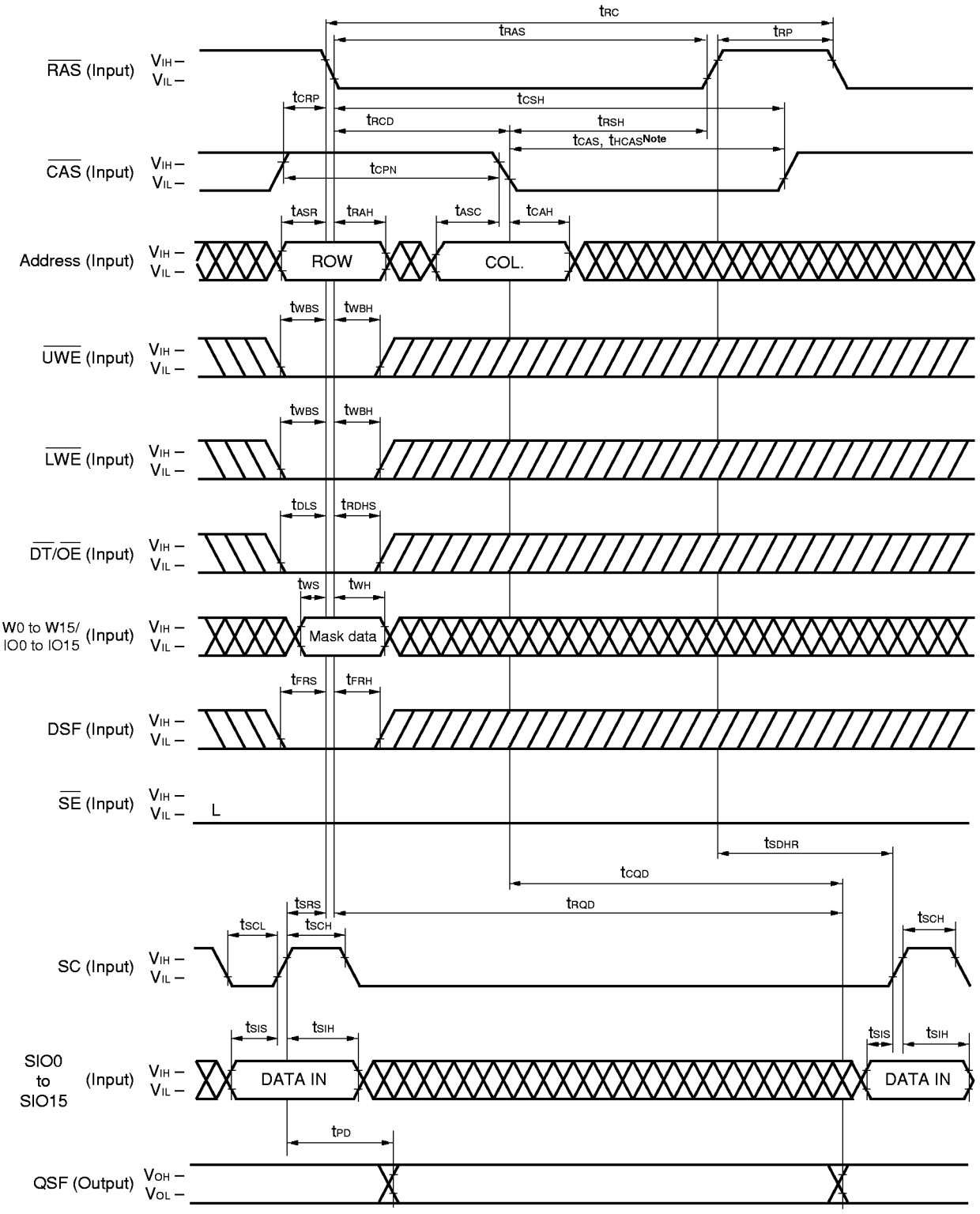


Notes 1. t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

2. Do not perform the following two serial read/write during this period.

- Serial read/write of jump source address set to the STOP register of the data register which does not perform the data transfer cycle.
- Serial read/write of last address of data register (Address 255 or 511)

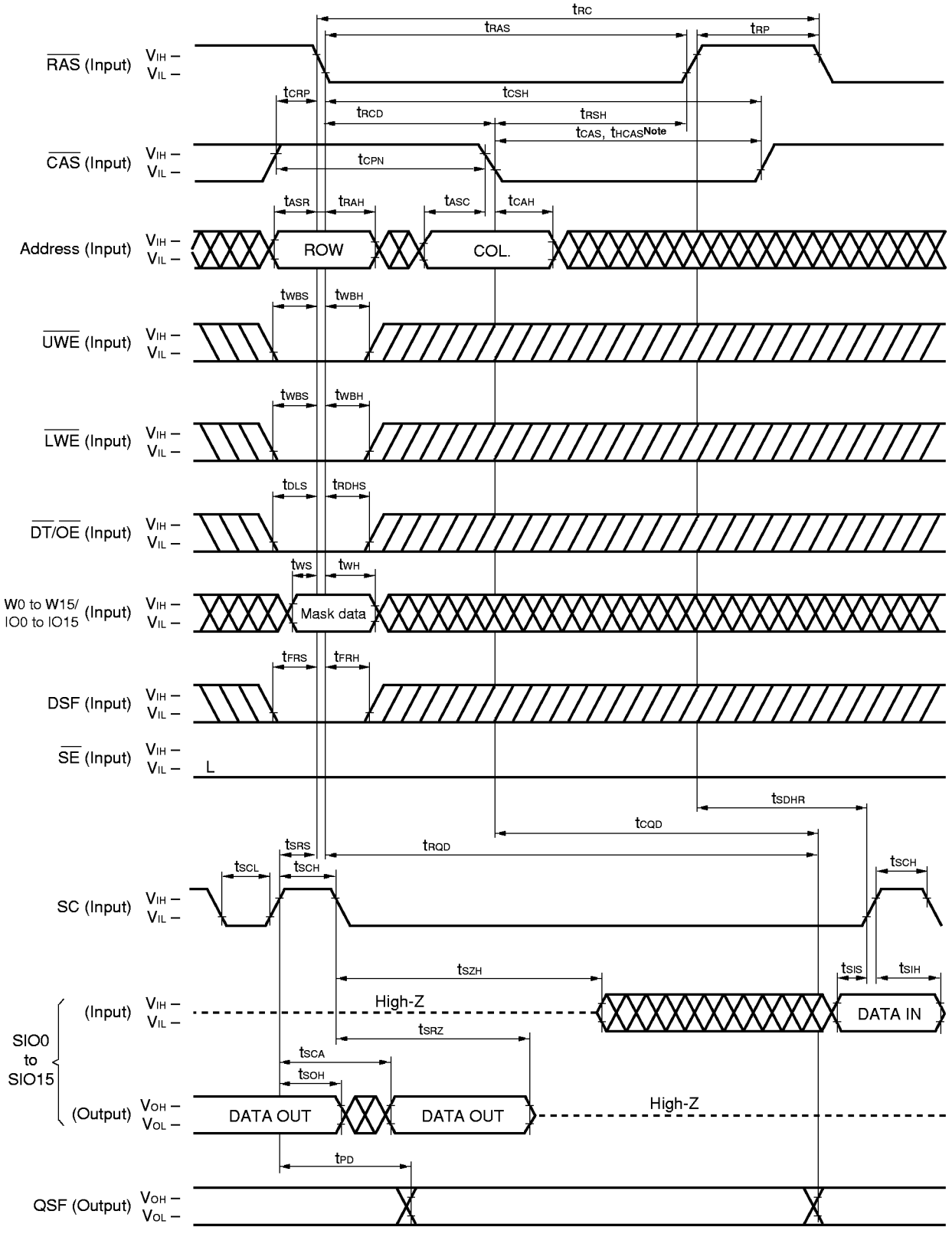
Write Data Transfer Cycle



Note t_{CAS} for the μPD482444

t_{HCAS} for the μPD482445, 482445L

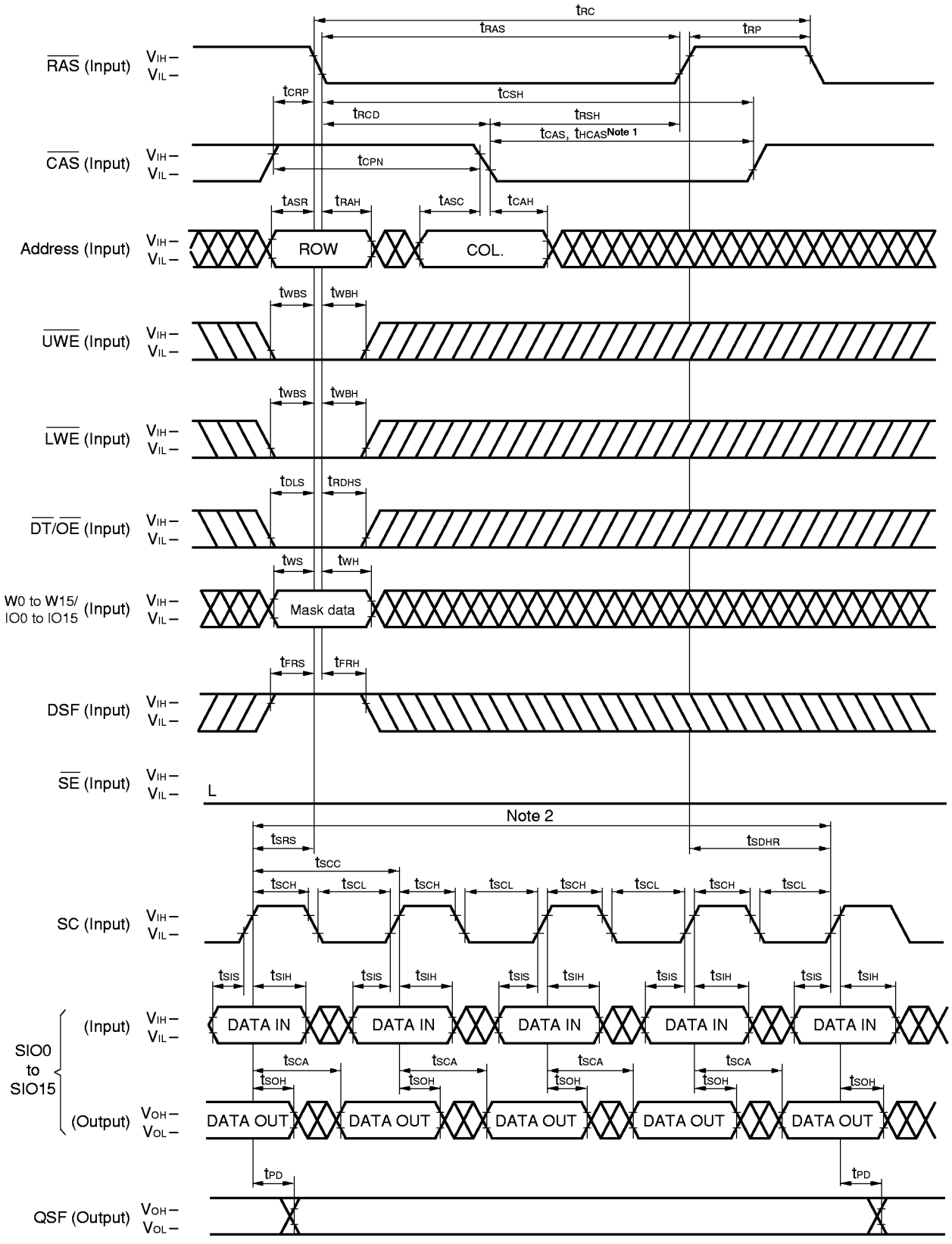
Write Data Transfer Cycle (Serial Read → Serial Write Switching)



Note t_{CAS} for the μPD482444

t_{HCAS} for the μPD482445, 482445L

Split Write Data Transfer Cycle



Notes 1. t_{CAS} for the μPD482444
t_{HCAS} for the μPD482445, 482445L

2. Do not perform the following two serial read/write during this period.

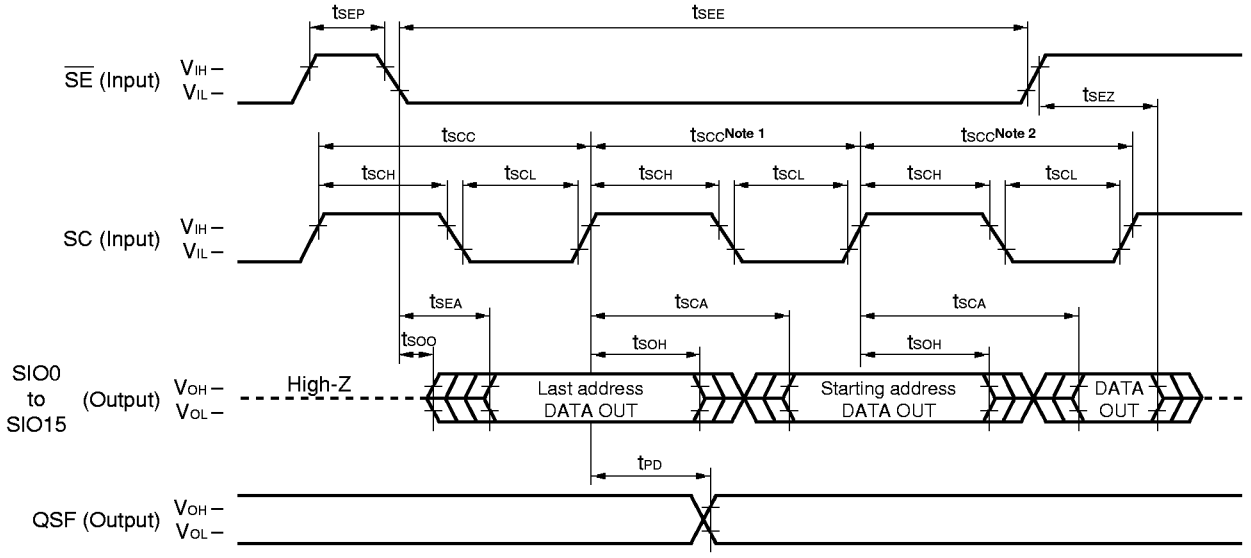
- Serial read/write of jump source address set to the STOP register of the data register which does not perform the data transfer cycle.
- Serial read/write of last address of data register (Address 255 or 511)

[Serial read, write cycle]

Parameter	Symbol	μPD482444-60 μPD482445-60		μPD482444-70 μPD482445-70 μPD482445L-A70		Unit	Condition
		MIN.	MAX.	MIN.	MAX.		
Serial clock cycle time	t_{SCC}	20		22		ns	
Serial output access time from $\overline{SE}$	t_{SEA}		15		17	ns	
Serial output access time from SC	t_{SCA}		15		17	ns	
Propagation delay time from SC to QSF	t_{PD}	0	20	0	20	ns	
SC precharge time	t_{SCL}	5		5		ns	
$\overline{SE}$ precharge time	t_{SEP}	5		5		ns	
SC pulse width	t_{SCH}	5		5		ns	
$\overline{SE}$ pulse width	t_{SEE}	5		5		ns	
$\overline{SE}$ setup time	t_{SES}	0		0		ns	
$\overline{SE}$ hold time from SC	t_{SEH}	10		10		ns	
Serial data in setup time	t_{SIS}	0		0		ns	
Serial data in hold time	t_{SIH}	10		10		ns	
Serial output hold time after SC high	t_{SOH}	3		5		ns	
Output disable time from $\overline{SE}$ high	t_{SEZ}	0	15	0	15	ns	**Note**
$\overline{SE}$ low to serial output setup delay time	t_{SOO}	3		5		ns	

Note t_{SEZ}, t_{OEZ}, t_{WEZ}, t_{OFF}, t_{OFR}, and t_{OFC} define the time when the output achieves the condition of high impedance and is not referenced to V_{OH} or V_{OL}.

Serial Read Cycle

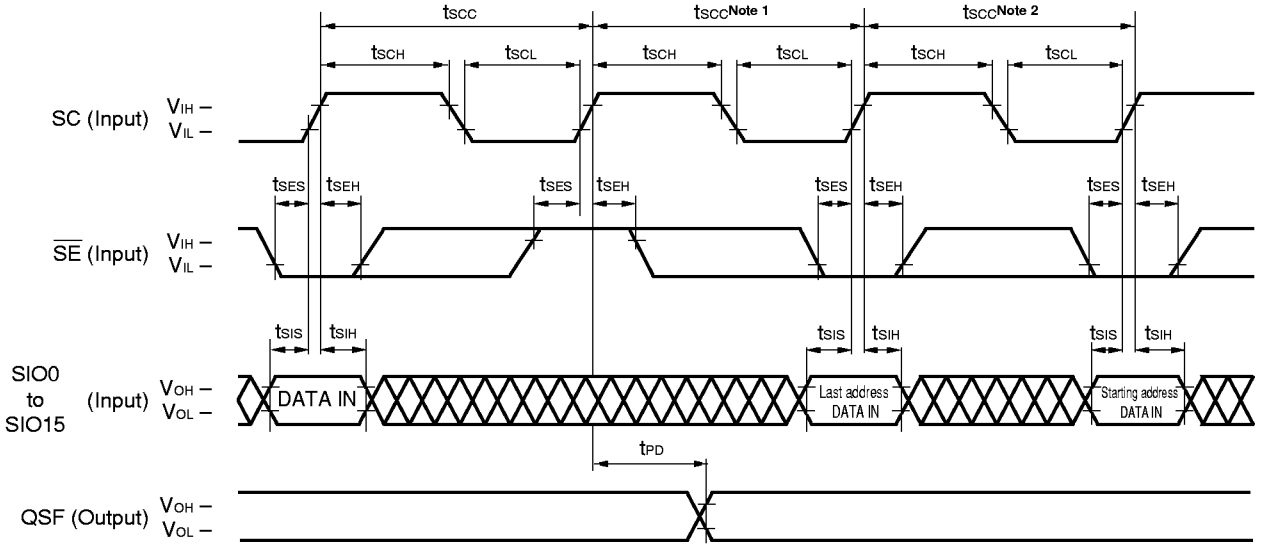


Notes 1. Last address of data register (Address 255 or 511)

2. Starting address of data register newly read (address is specified in the data transfer cycle).

Remark Because the random access port operates independently of the serial access port, there is no need to control the $\overline{RAS}$, $\overline{CAS}$, Address, $\overline{UWE}$, $\overline{LWE}$, $\overline{DT}/\overline{OE}$, WI/O, DSF pins in this cycle.

Serial Write Cycle



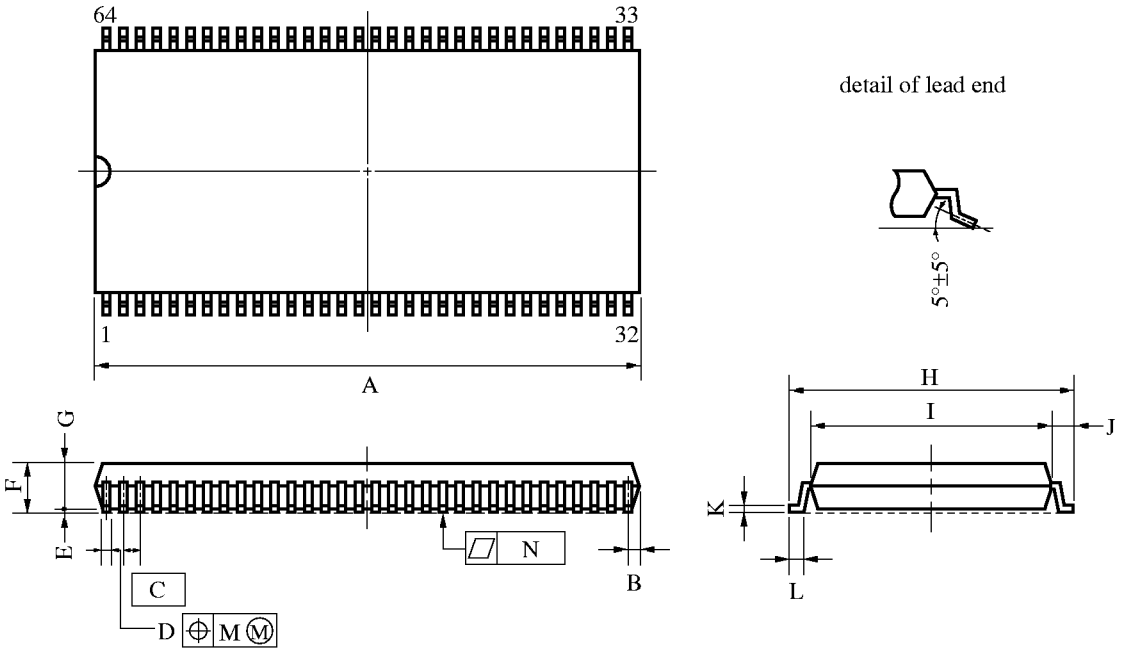
Notes 1. Last address of data register (Address 255 or 511)

2. Starting address of data register newly read (address is specified in the data transfer cycle).

Remark Because the random access port operates independently of the serial access port, there is no need to control the $\overline{RAS}$, $\overline{CAS}$, Address, $\overline{UWE}$, $\overline{LWE}$, $\overline{DT}/\overline{OE}$, WI/O, DSF pins in this cycle.

5. Package Drawings

64 PIN PLASTIC SHRINK SOP (525 mil)



P64GW-80-525A-1

NOTE

Each lead centerline is located within 0.10 mm (0.004 inch) of its true position (T.P.) at maximum material condition.

ITEM	MILLIMETERS	INCHES
A	26.30 MAX.	1.036 MAX.
B	0.75 MAX.	0.030 MAX.
C	0.8 (T.P.)	0.031 (T.P.)
D	0.35±0.05	$0.014^{+0.002}_{-0.003}$
E	0.15±0.05	0.006±0.002
F	2.3 MAX.	0.091 MAX.
G	2.0	0.079
H	13.8±0.3	$0.543^{+0.013}_{-0.012}$
I	11.8±0.1	$0.465^{+0.004}_{-0.005}$
J	1.0±0.2	$0.039^{+0.009}_{-0.008}$
K	$0.20^{+0.10}_{-0.05}$	$0.008^{+0.004}_{-0.002}$
L	0.5±0.2	$0.020^{+0.008}_{-0.009}$
M	0.10	0.004
N	0.10	0.004

[MEMO]

6. Recommended Soldering Conditions

Please consult with our sales offices for soldering conditions of the μPD482444, 482445 and 482445L.

Types of Surface Mount Device

μPD482444GW : 64-Pin Plastic Shrink SOP (525 mil)
μPD482445GW : 64-Pin Plastic Shrink SOP (525 mil)
μPD482445LGW-A : 64-Pin Plastic Shrink SOP (525 mil)

NOTES FOR CMOS DEVICES

① PRECAUTION AGAINST ESD FOR SEMICONDUCTORS

Note: Strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it once, when it has occurred. Environmental control must be adequate. When it is dry, humidifier should be used. It is recommended to avoid using insulators that easily build static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work bench and floor should be grounded. The operator should be grounded using wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with semiconductor devices on it.

② HANDLING OF UNUSED INPUT PINS FOR CMOS

Note: No connection for CMOS device inputs can be cause of malfunction. If no connection is provided to the input pins, it is possible that an internal input level may be generated due to noise, etc., hence causing malfunction. CMOS device behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using a pull-up or pull-down circuitry. Each unused pin should be connected to V_{DD} or GND with a resistor, if it is considered to have a possibility of being an output pin. All handling related to the unused pins must be judged device by device and related specifications governing the devices.

③ STATUS BEFORE INITIALIZATION OF MOS DEVICES

Note: Power-on does not necessarily define initial status of MOS device. Production process of MOS does not define the initial operation status of the device. Immediately after the power source is turned ON, the devices with reset function have not yet been initialized. Hence, power-on does not guarantee out-pin levels, I/O settings or contents of registers. Device is not initialized until the reset signal is received. Reset operation must be executed immediately after power-on for devices having reset function.

[MEMO]