



## CY2305 and CY2309 as PCI and SDRAM Buffers

### Introduction to Cypress Zero Delay Buffers

#### What is a Zero Delay Buffer?

A zero delay buffer is a device that can fan out 1 clock signal into multiple clock signals with zero delay and very low skew between the outputs. This device is well suited as a buffer for PCI or SDRAM due to its zero input to output delay and very low output to output skew.

A simplified diagram of the CY2308 zero delay buffer is shown in *Figure 1*. The CY2308 is built using a PLL that uses a reference input and a feedback input. The feedback loop is closed by driving the feedback input (FBK) from one of the outputs. The phase detector in the PLL adjusts the output frequency of the VCO so that the two inputs have no phase difference. Since an output is one of the inputs to the PLL, zero phase difference is maintained from REF to the output driving FBK. Now if all outputs are uniformly loaded, zero phase difference will be maintained from REF to all outputs. This is a simple zero delay buffer. Introducing additional devices (e.g., dividers) between the output and FBK can give rise to some innovative applications for the PLL, and for further information on these refer to the Cypress Application Note "CY2308 Zero Delay Buffer". Since many buffering applications require only a simple closure of the feedback loop, Cypress has designed zero delay buffers with Internal Feedback Loops: the CY2305 and CY2309.

#### What are the CY2305 and CY2309?

Cypress has designed zero delay buffers especially suited for use with PCI or SDRAM buffering. The CY2305 and CY2309 have been designed with the feedback path integrated for simpler system design. A simplified block diagram of the CY2309 zero delay buffer is shown *Figure 2*. This zero delay

buffer uses a input/output pad on CLKOUT so that the feedback signal can be sensed directly from the output itself.

#### Drive Capability

The CY2305 and CY2309 have high drive outputs designed to meet the JEDEC SDRAM specifications of 30 pF capacitance on each DIMM clock input.

Since the typical CMOS input is 7 pF and the CY2305/09 are designed to drive up to 30 pF; this means that up to 4 CMOS inputs can be driven from a single output of a CY2305/09. However the output loading on the CY2305/09 must be equal on all outputs to maintain zero delay from the input.

#### Power Down

The CY2305 and CY2309 have a unique power-down mode: if the input reference is stopped, the part automatically enters a shutdown state, shutting down the PLL and three-stating the outputs. When the part is in shutdown mode it draws less than 50  $\mu$ A, and can come out of shutdown mode with the PLL locked in less than 1 ms. This power down mode can also be entered by three-stating the input reference driver and allowing the internal pull-down to pull the input LOW (the input does not have to go LOW, it only has to stop).

#### 5 Volt to 3.3 Volt Level Shifting

The CY2305 and CY2309 can act as a 5-volt to 3.3-volt level shifter. The reference input pad is 5-volt signal-compatible. Since many system components still operate at 5 volts, this feature provides the capability to generate multiple 3.3-volt clocks from a single 5-volt reference clock. This 5-volt signal-compatibility is only available on the reference pad; the other input pads on the CY2309 are not 5-volt compatible.

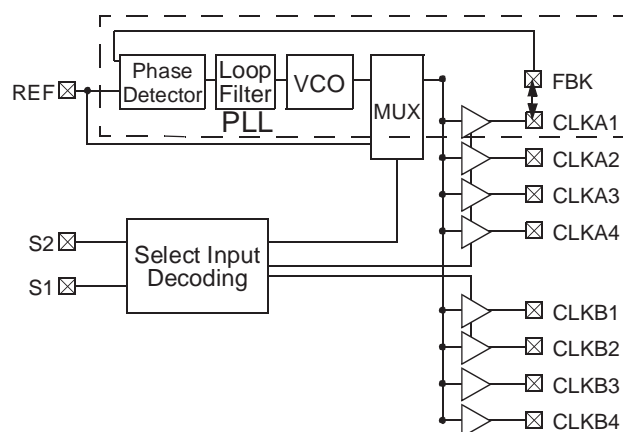


Figure 1. Simplified Block Diagram of CY2308

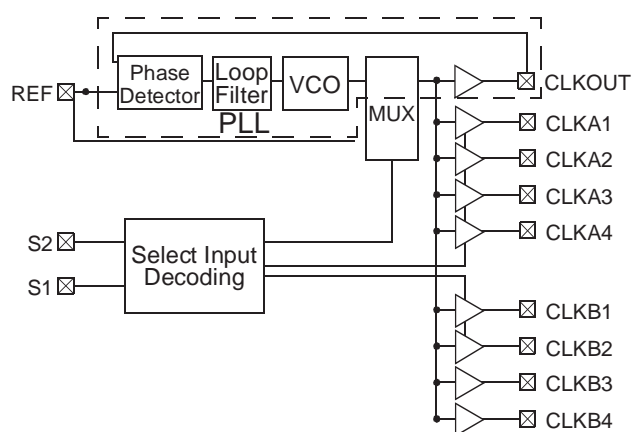


Figure 2. Simplified Block Diagram of CY2309

### Lead or Lag Adjustments

To adjust the lead or lag of the outputs on the CY2305 or CY2309, one must understand the relationships between REF and CLKOUT, and the relationship between CLKOUT and the other outputs. To understand the relationship, first we need to understand a few properties of the CY2305 and CY2309 Phase Locked Loops. The PLL senses the phase of the CLKOUT pin at a threshold of  $V_{dd}/2$  and compares it to the REF pin at the same  $V_{dd}/2$  threshold. All the outputs start their transition at the same time (including CLKOUT). Changing the load on an output changes its rise time and therefore how long it takes the output to get to the  $V_{dd}/2$  threshold. Using these properties to our advantage, we can then adjust the time when the outputs reach the  $V_{dd}/2$  threshold relative to when the REF input reaches the  $V_{dd}/2$  threshold. The CLKOUT output however cannot be adjusted: it will always have

zero delay from the REF input at  $V_{dd}/2$ . The outputs can be advanced by loading the CLKOUT output more heavily than the other outputs or can be delayed by loading CLKOUT more lightly than the other outputs. *Figure 3* shows how many ps the outputs are moved vs. the difference in the loading between CLKOUT and the other outputs. As a rough guideline, the adjustment is 50 ps/pF of loading difference. Note: the zero delay buffer will always adjust itself to keep the  $V_{dd}/2$  point of the output at zero delay from the  $V_{dd}/2$  point of the reference. If the application requires the outputs of the zero delay buffer to have zero delay from another output of the reference clock chip, the output of the clock chip that is driving the zero delay buffer must be loaded the same as the other outputs of the clock chip or the outputs of the zero delay buffer will be advanced/delayed with reference to those other outputs.

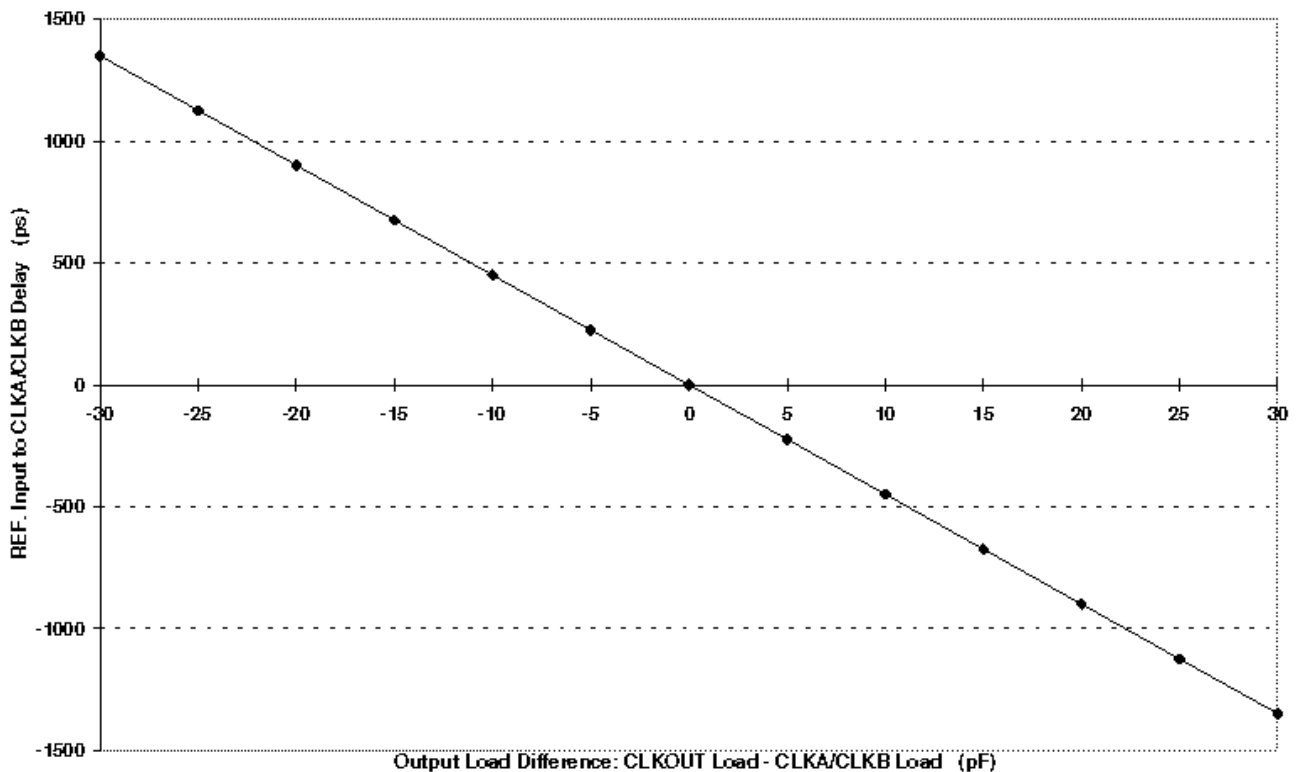


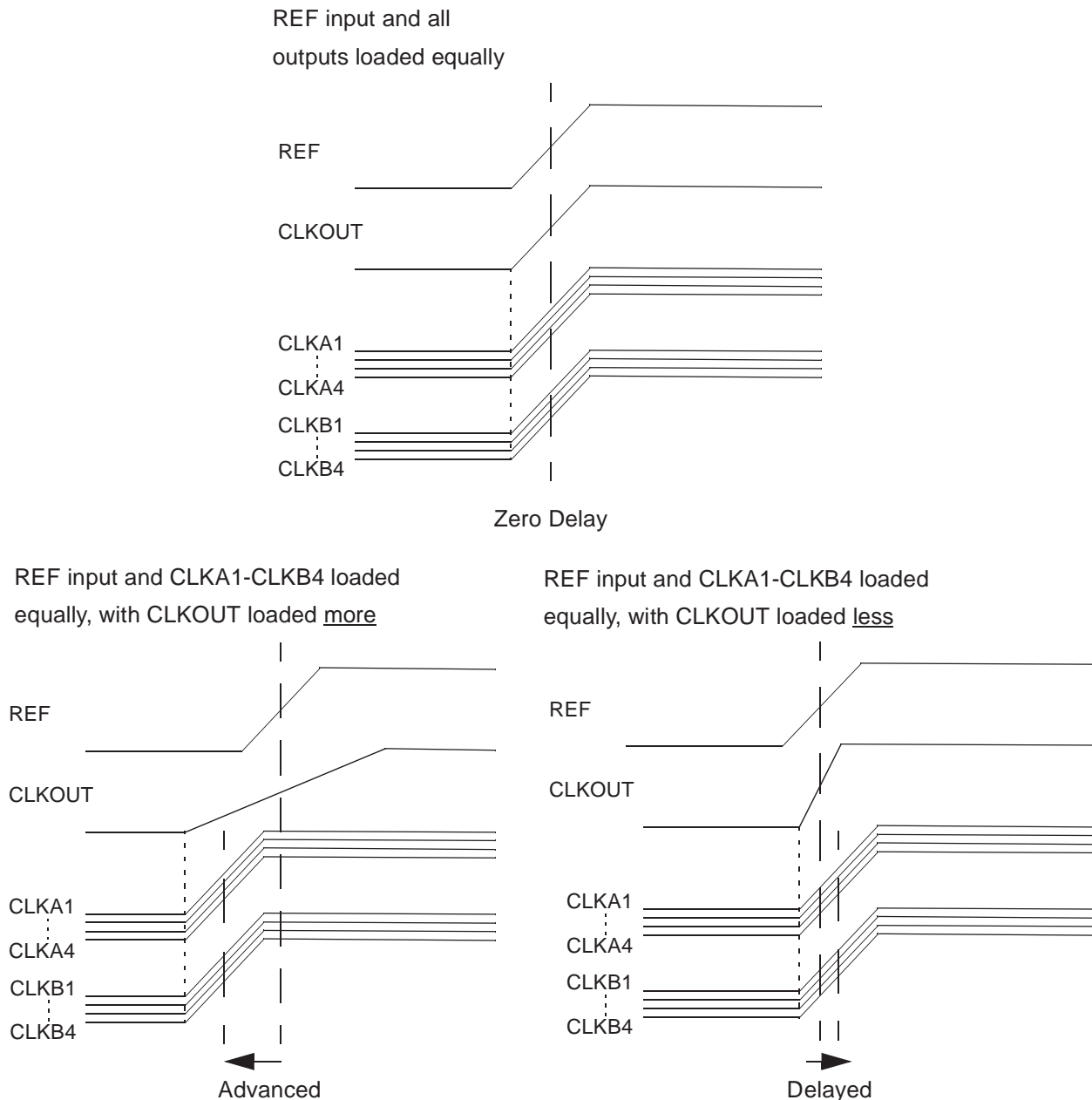
Figure 3. Lead Lag Adjustments

### Output To Output Skew

The skew between CLKOUT and the other outputs is not dynamically adjusted by the loop. All MUST have the same load on them to achieve zero output to output skew. If the other outputs are less loaded than CLKOUT, they will lead it; and if the other outputs are more loaded, they will lag the CLKOUT. The relationship that exists between the CLKOUT and the

rest of the outputs is that they all start the rising edge at the same time, but different loads will cause them to have different rise times and different times crossing the measurement thresholds. Since CLKOUT is the only output that is monitored, it will be the output that has the zero delay from the reference and the other clocks will be relative to CLKOUT and their loading differences.

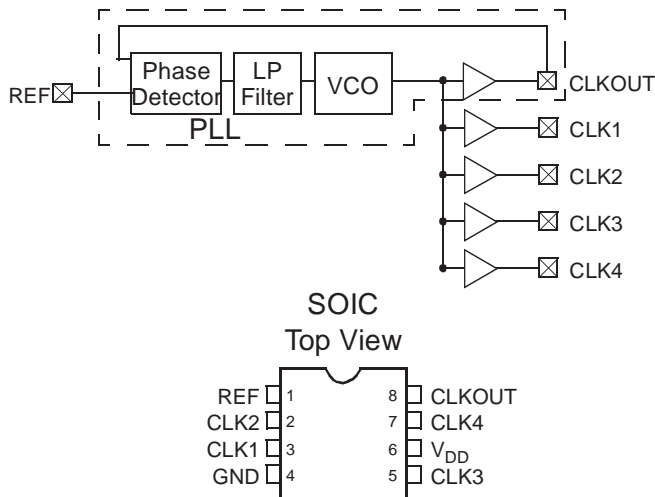
### Zero Delay Buffer Timing diagrams with different loading configurations.



## Product Information

### The CY2305 Zero Delay Buffer

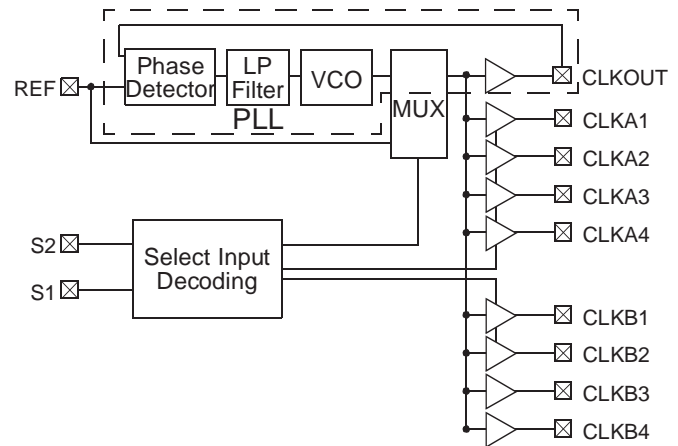
The CY2305 is a 3.3-volt, five output zero delay buffer in an 8-pin 150-mil SOIC package. This part is intended for buffering one clock into five clocks for PCI buffering or four clocks for use with 1 SDRAM module. The CY2305 is the simplest and easiest to use part in the Cypress zero delay buffer family. For a discussion of the special features of the CY2305 see the special features section of this application note, or for the complete specifications on the CY2305 please refer to the CY2305/CY2309 data sheet.



### The CY2309 Zero Delay Buffer

The CY2309 is a 3.3-volt, nine output zero delay buffer in a 16-pin 150-mil SOIC package. This part is intended for buffering one clock into 9 clocks for PCI buffering or eight clocks for use with 2 SDRAM modules. For the complete specifications please refer to the CY2305/CY2309 data sheet.

The CY2309 has several options for shutting down the output banks or completely shutting down the part to conserve power. As shown in the table below, the inputs S1 and S2 control which output banks are driven and the state of the PLL. You will notice that the CLKOUT output is always driven. This is because the PLL must have the CLKOUT pin running in order to maintain phase lock. The CY2309 will also go into a power down state if the input reference stops as described in the "Special Features of the Cypress Zero Delay Buffers" section.



### Select Input Decoding for CY2309

S2	S1	CLOCK A1–A4	CLOCK B1–B4	CLKOUT <sup>[1]</sup>	Output Source	PLL Shutdown
0	0	Three-State	Three-State	Driven	PLL	N
0	1	Driven	Three-State	Driven	PLL	N
1	0	Driven	Driven	Driven	Reference	Y
1	1	Driven	Driven	Driven	PLL	N

#### Note:

1. This output is driven and has an internal feedback for the PLL. The load on this output can be adjusted to change the delay between the reference and the CLKA/CLKB outputs.

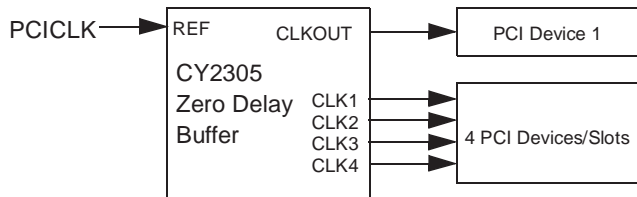
## Applications

### 5 and 9 PCI Device/Slot Zero Delay Buffer Solution

The CY2305 and CY2309 are an excellent clocking solution for a system that requires more PCI clocks than the currently popular clock chips provide. The CY2305 comes in a tiny 150-mil 8-pin SOIC package and the CY2309 comes in a small 150-mil 16-pin SOIC package. The CY2305 and CY2309 are priced very aggressively for the high volume PC market. There are two solutions for implementing a PCI zero delay buffer with the Cypress zero delay buffers: a 5 device/slot and a 9 device/slot buffer.

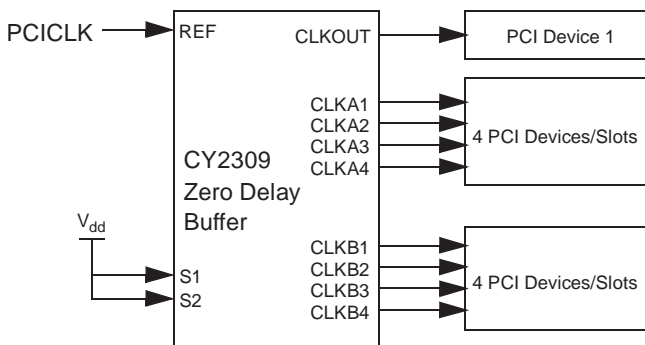
*The 5 Device/Slot Solution:*

- PCI/Slot 1 (CLKOUT) must always be loaded.
- If PCI Slots represent different loads, they will have earlier or later clocks (See Lead or Lag Adjustments section of "Special Features of Cypress Zero Delay Buffers".



*The 9 Device/Slot Solution:*

- PCI/Slot 1 (CLKOUT) must always be loaded.
- Select lines can be used to shut down output banks, see CY2309 data sheet.

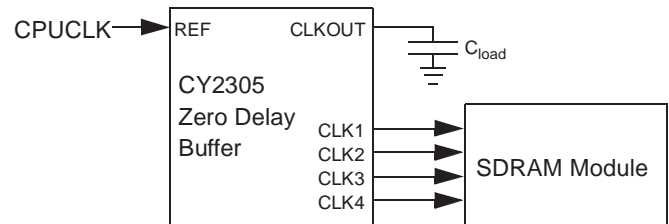


### 1 SDRAM DIMM Zero Delay Buffer Solution

The CY2305 is an excellent clocking solution for a system using 1 SDRAM DIMM. The CY2305 comes in a very small 150-mil 8-pin SOIC package and is priced very aggressively for the high volume PC market. There are two solutions for implementing 1 SDRAM DIMM support with the CY2305: the first is the adjustable delay solution, and the second is the self adjusting delay solution.

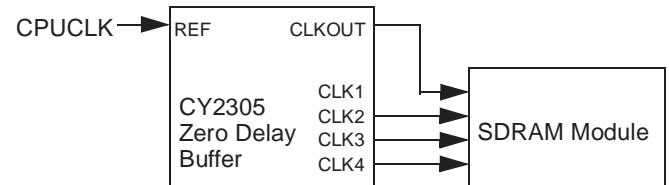
*The Adjustable Delay Solution:*

- $C_{load}$  must be equal to SDRAM module loading for zero delay.
- To make the SDRAM inputs lead or lag the reference input see the Lead or Lag Adjustments section of "Special Features of the Cypress Zero Delay Buffers".



*The Self Adjusting Solution:*

- This solution will automatically compensate for different SDRAM input loads.
- CLKOUT must drive CK0 on the SDRAM module so that CLKOUT is always fully loaded (pin 42 on the SDRAM module).

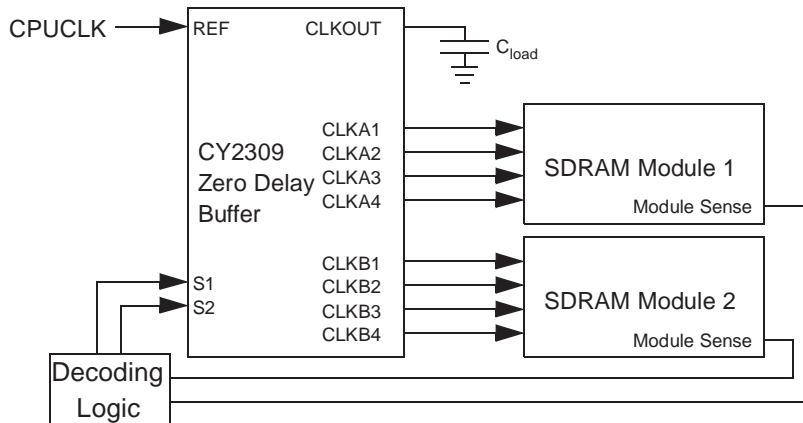


## 2 SDRAM DIMM Zero Delay Buffer Solution

The CY2309 is an excellent clocking solution for a system using 2 SDRAM DIMMs. The CY2309 comes in a small 150-mil 16-pin SOIC package and is priced very aggressively for the high volume PC market. There are two solutions for implementing 2 SDRAM DIMMs support with the CY2309: the first is the adjustable delay solution, and the second is the self adjusting delay solution.

### The Adjustable Delay Solution:

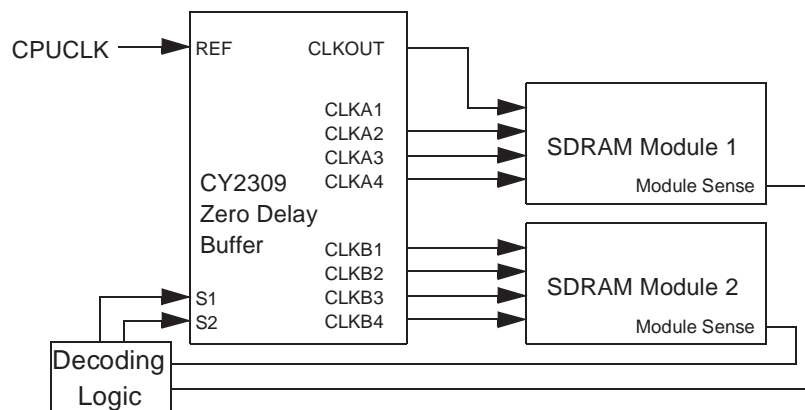
- $C_{load}$  must be equal to SDRAM module loading for zero delay.
- To make the SDRAM inputs lead or lag the reference input see the Lead or Lag Adjustments section of "Special Features of the Cypress Zero Delay Buffers".
- Clocks are three-stated when that SDRAM module is not present.
- If only 1 SDRAM module is installed it must be module 1.



### The Self Adjusting Solution:

- This solution will automatically compensate for different SDRAM input loads (only on module 1).
- CLKOUT must drive CK0 on the SDRAM module 1 so that CLKOUT is always fully loaded (pin 42 on the SDRAM module).

- If only one SDRAM module is installed it must be module 1.
- CLKA and CLKB clocks are three-stated when their respective SDRAM module is not present, but CLKOUT will continue to run.

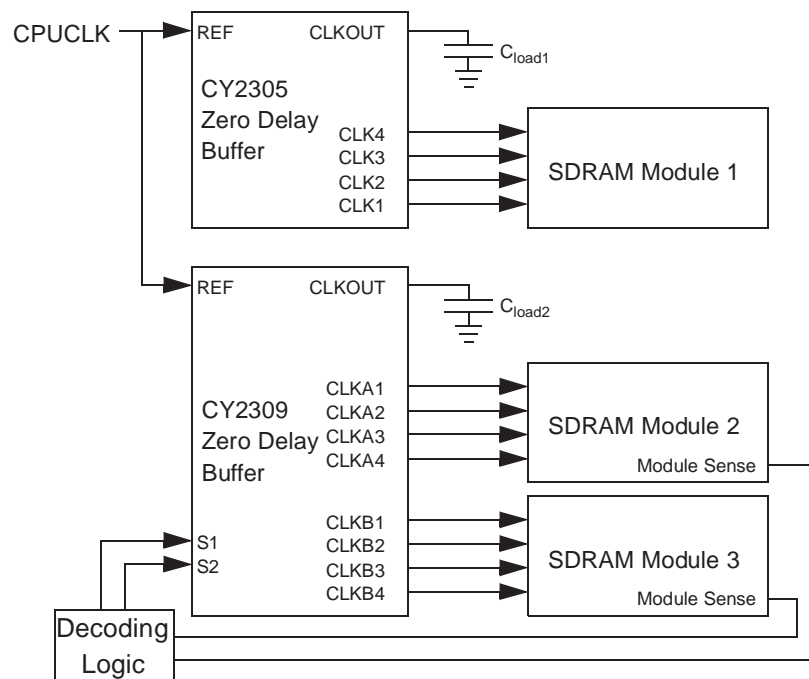


### 3 SDRAM DIMM Zero Delay Buffer Solution

The CY2305 and CY2309 are excellent clocking solutions for a system using 3 SDRAM DIMMs. The CY2305 comes in a small 150-mil 8-pin SOIC package and the CY2309 comes in a small 150-mil 16-pin SOIC. Both buffers are priced very aggressively for the high volume PC market. There are two solutions for implementing 3 SDRAM DIMMs support with the CY2305 and CY2309: the first is the adjustable delay solution, and the second is the self adjusting delay solution.

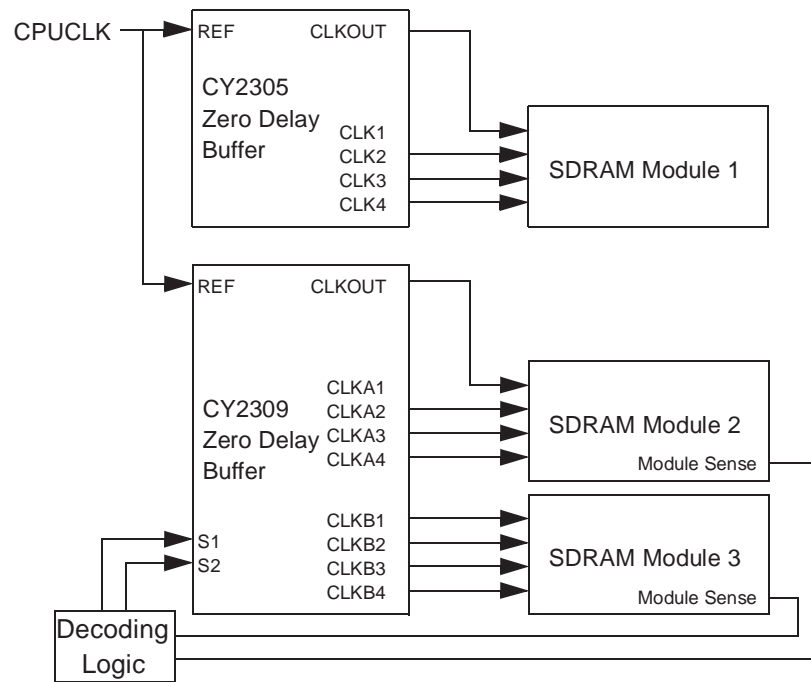
#### *The Adjustable Delay Solution:*

- $C_{load1}$  and  $C_{load2}$  must be equal to SDRAM module loading for zero delay.
- To make the SDRAM inputs lead or lag the reference input see the Lead or Lag Adjustments section of "Special Features of the Cypress Zero Delay Buffers".
- SDRAM modules must be installed in order (module 1 first and module 3 last).
- Module 2 and 3 clocks are three-stated when those SDRAM modules are not present, but CLKOUT will continue to run.
- Module 1 clocks can only be three-stated by three-stating CPUCLK which will also three-state modules 2 and 3.



*The Self Adjusting Solution:*

- This solution will automatically compensate for different SDRAM input loads (only on Module 1 and Module 2).
- CLKOUT must drive CK0 on the SDRAM module 1 and module 2 so that CLKOUT is always fully loaded (pin 42 on the SDRAM module).
- SDRAM modules must be installed in order (module 1 first and module 3 last).
- Module 2 and 3 clocks are three-stated when those SDRAM modules are not present, but CLKOUT will continue to run.
- Module 1 clocks can only be three-stated by three-stating CPUCLK which will also three-state modules 2 and 3.



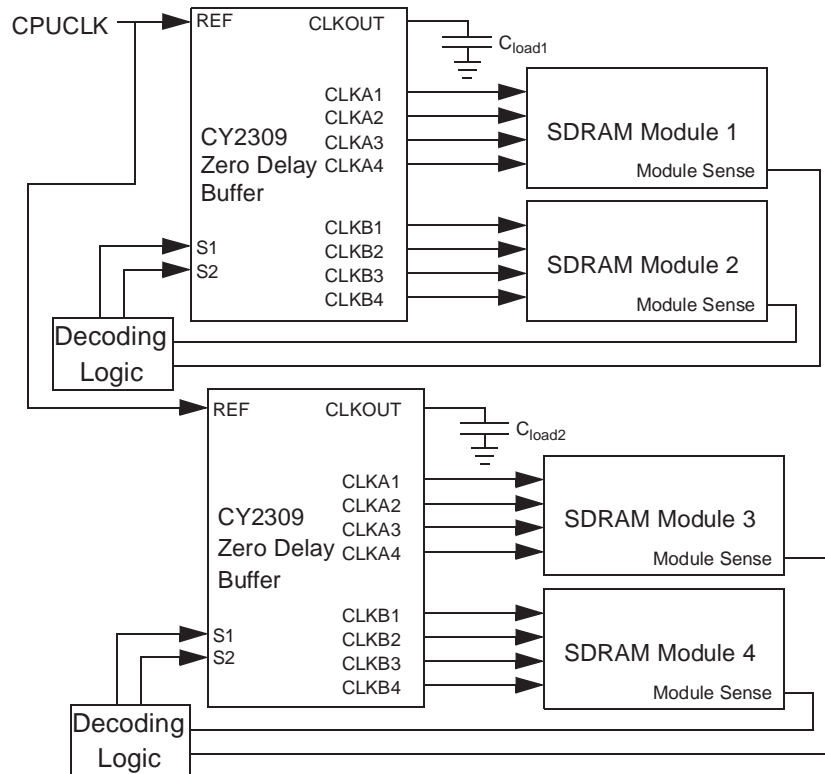


#### 4 SDRAM DIMM Zero Delay Buffer Solution

Two CY2309s are an excellent clocking solution for a system using 4 SDRAM DIMMs. The CY2309 comes in a small 150-mil 16-pin SOIC package and is priced very aggressively for the high volume PC market. There are two solutions for implementing 4 SDRAM DIMMs support with the CY2309: the first is the adjustable delay solution, and the second is the self adjusting delay solution.

#### *The Adjustable Delay Solution:*

- $C_{load1}$  and  $C_{load2}$  must be equal to SDRAM module loading for zero delay.
- To make the SDRAM inputs lead or lag the reference input see the Lead or Lag Adjustments section of "Special Features of the Cypress Zero Delay Buffers".
- Clocks are three-stated when that SDRAM module is not present.
- SDRAM modules must be installed in order (module 1 first and module 4 last).



*The Self Adjusting Solution:*

- This solution will automatically compensate for different SDRAM input loads (only on Module 1 and Module 3).
- CLKOUT must drive CK0 on the SDRAM module 1 and module 3 so that CLKOUT is always fully loaded (pin 42 on the SDRAM module).
- SDRAM modules must be installed in order (module 1 first and module 4 last).
- Clocks are three-stated when that SDRAM module is not present, but CLKOUT will continue to run.

