LSI/CSI

LS7166

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24-BIT QUADRATURE COUNTER

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FEATURES:

- Programmable modes are: Up/Down, Binary, BCD, 24 Hour Clock, Divide-by-N, x1 or x2 or x4 Quadrature and Single-Cycle.
- DC to 25MHz Count Frequency.
- 8-Bit I/O Bus for uP Communication and Control.
- 24-Bit comparator for pre-set count comparison.
- Readable status register.
- Input/Output TTL and CMOS compatible.
- 3V to 5.5V operation (V_{DD} - V_{SS}).
- LS7166 (DIP); LS7166-S (SOIC); LS7166-TS24 (24-Pin TSSOP) **- See Figure 1 -**

GENERAL DESCRIPTION:

The LS7166 is a CMOS, 24-bit counter that can be programmed to operate in several different modes. The operating mode is set up by writing control words into internal control registers (see Figure 8). There are three 6-bit and one 2-bit control registers for setting up the circuit functional characteristics. In addition to the control registers, there is a 5-bit output status register (OSR) that indicates the current counter status. The IC communicates with external circuits through an 8-bit three state I/O bus. Control and data words are written into the LS7166 through the bus. In addition to the I/O bus, there are a number of discrete inputs and outputs to facilitate instantaneous hardware based control functions and instantaneous status indication.

REGISTER DESCRIPTION:

Internal hardware registers are accessible through the I/O bus (D0 - D7) for READ or WRITE when $\overline{CS}$ = 0. The C/$\overline{D}$ input selects between the control registers (C/$\overline{D}$ = 1) and the data registers (C/$\overline{D}$ = 0) during a READ or WRITE operation. (See Table 1)

PIN ASSIGNMENTS - Top View

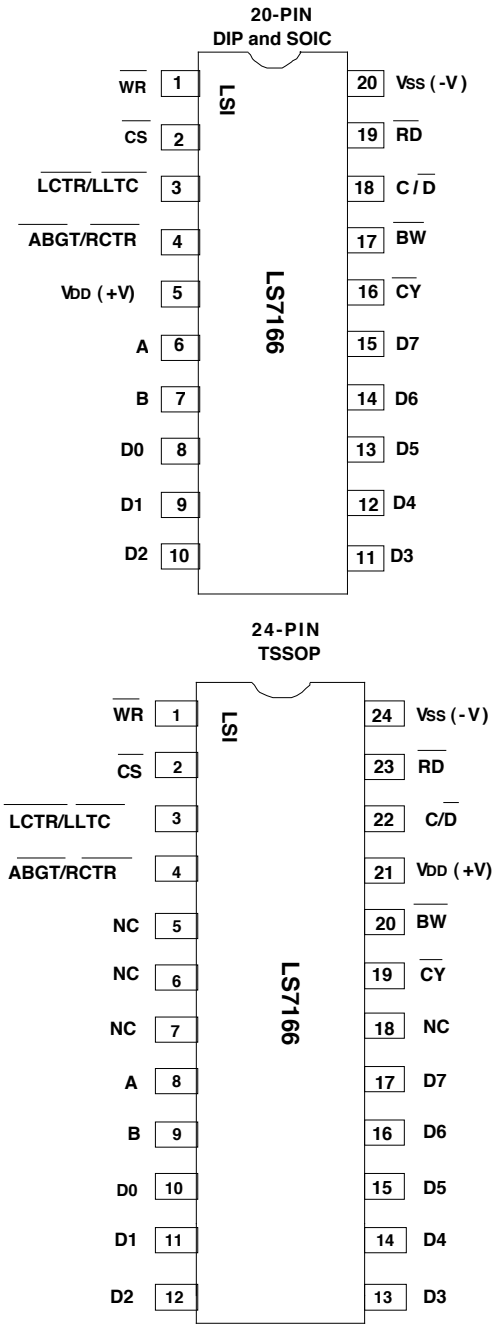
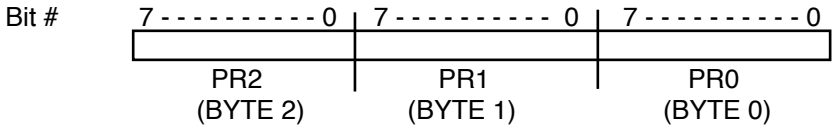


FIGURE 1

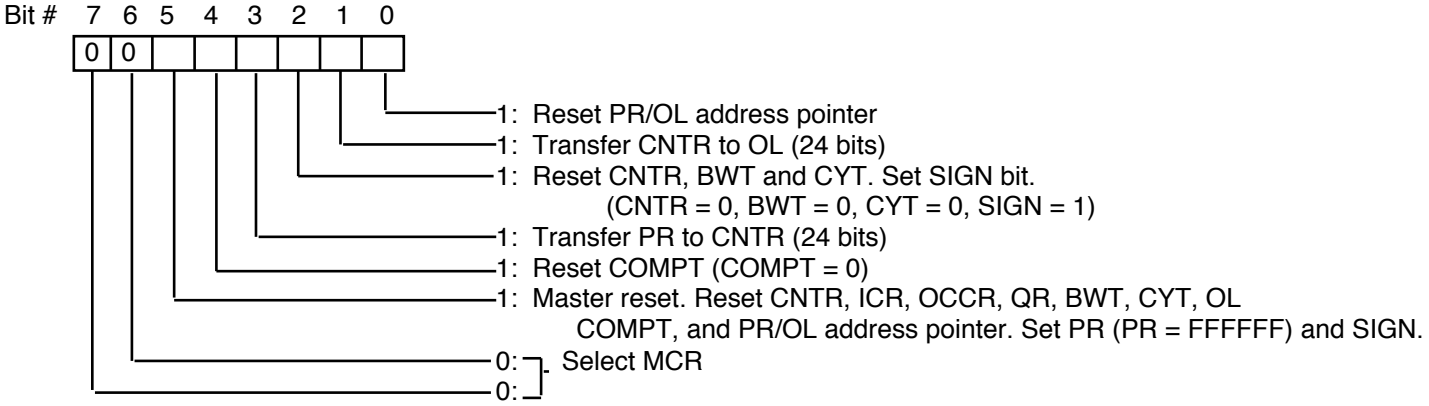
PR (Preset register). The PR is the input port for the CNTR. The CNTR is loaded with a 24 bit data via the PR. The data is first written into the PR in 3 WRITE cycle sequence of Byte 0 (PR0), Byte 1 (PR1) and Byte 2 (PR2).
The address pointer for PR0/PR1/PR2 is automatically incremented with each write cycle.
Accessed by: WRITE when C/$\overline{D}$ = 0, $\overline{CS}$ = 0.



Standard Sequence for Loading PR and Reading CNTR:

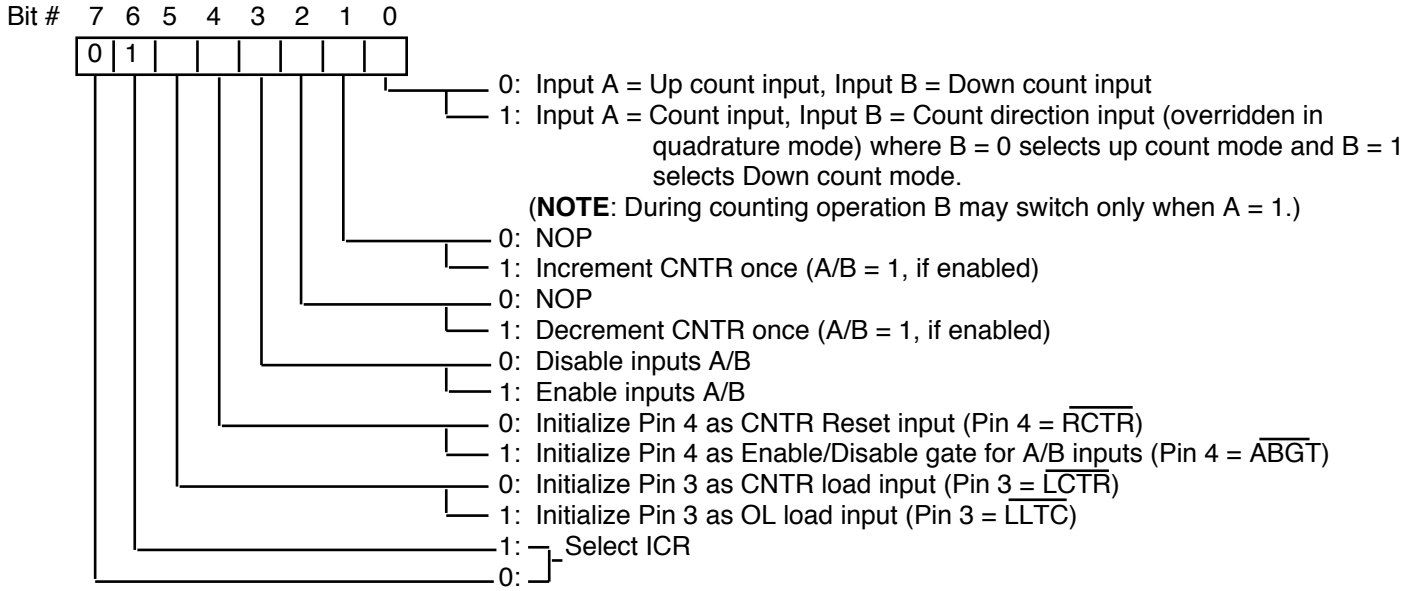
```
1 ⟶MCR      ; Reset PR address pointer
WRITE PR    ; Load Byte 0 and into PR0 increment address
WRITE PR    ; Load Byte 1 and into PR1 increment address
WRITE PR    ; Load Byte 2 and into PR3 increment address
8 ⟶ MCR     ;  Transfer PR to CNTR
```

MCR (Master Control Register). Performs register reset and load operations. Writing a "non-zero" word to MCR does not require a follow-up write of an "all-zero" word to terminate a designated operation.
Accessed by: WRITE when C/$\overline{D}$ = 1, $\overline{CS}$ = 0.



NOTE: Control functions may be combined.

ICR (Input Control Register). Initializes counter input operating modes.
Accessed by: WRITE when C/$\overline{D}$ = 1, $\overline{CS}$ = 0.



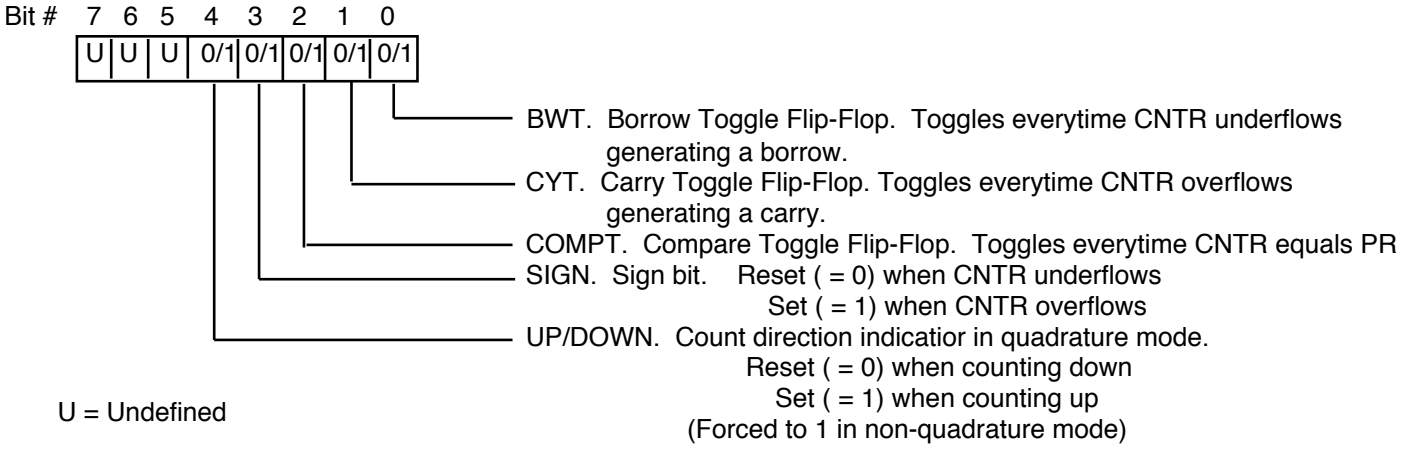
NOTE: Control functions may be combined.

TABLE 1 - Register Addressing Modes

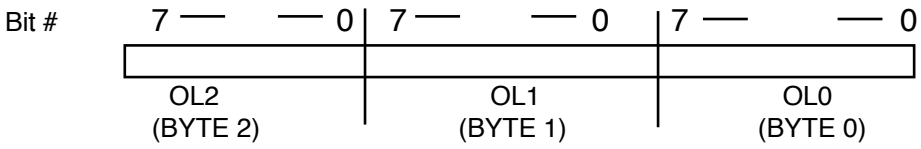
D7	D6	C/$\overline{D}$	$\overline{RD}$	$\overline{WR}$	$\overline{CS}$	COMMENT
X	X	X	X	X	1	Disable Chip for READ/WRITE
0	0	1	1	⌐⌊⌐	0	Write to Master Control Register (MCR)
0	1	1	1	⌐⌊⌐	0	Write to input control register (ICR)
1	0	1	1	⌐⌊⌐	0	Write to output/counter control register (OCCR)
1	1	1	1	⌐⌊⌐	0	Write to quadrature register (QR)
X	X	0	1	⌐⌊⌐	0	Write to preset register (PR) and increment register address counter.
X	X	0	⌐⌊⌐	1	0	Read output latch (OL) and increment register address counter
X	X	1	⌐⌊⌐	1	0	Read output status register (OSR).

X = Don't Care

OSR (Output Status Register). Indicates CNTR status: Accessed by**:** READ when C/$\overline{D}$ = 1, $\overline{CS}$ = 0.



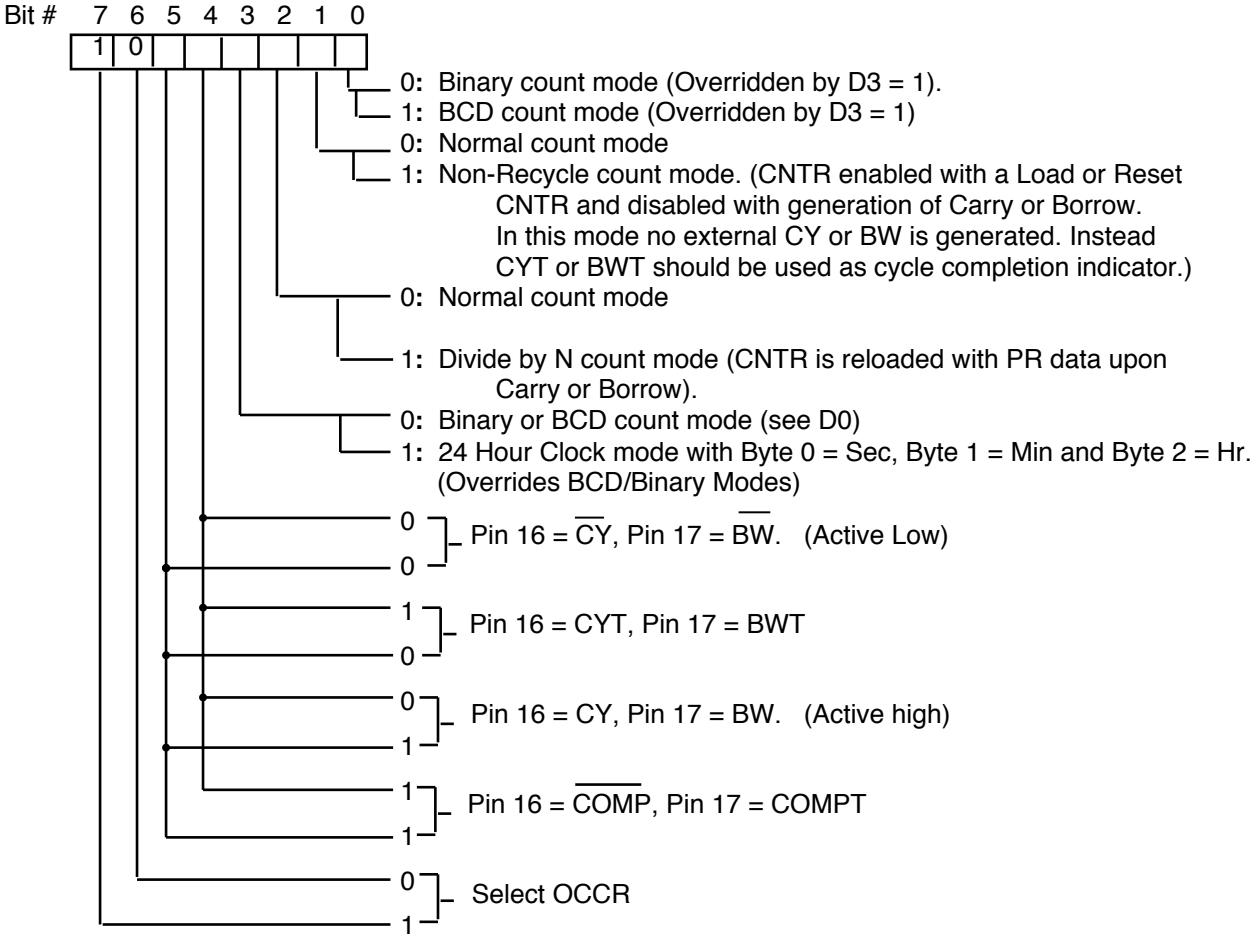
OL(Output latch). The OL is the output port for the CNTR. The 24 bit CNTR Value at any instant can be accessed by performing a CNTR to OL transfer and then reading the OL in 3 READ cycle sequence of Byte 0 (OL0), Byte 1 (OL1) and Byte 2 (OL2). The address pointer for OL0/OL1/OL2 is automatically incremented with each READ cycle. Accessed by**:** READ when C/$\overline{D}$ = 0, $\overline{CS}$ = 0.



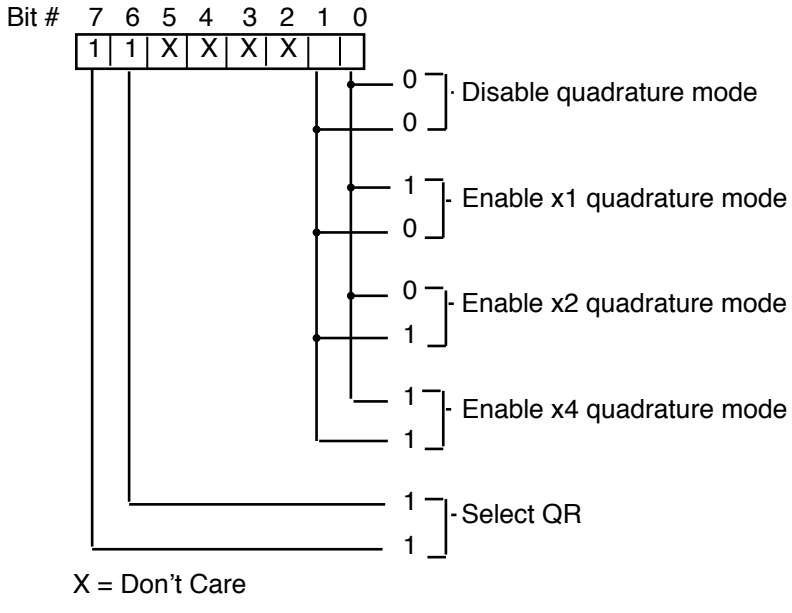
Standard Sequence for Loading and Reading OL**:**

```
3 ⟶ MCR     ;  Reset OL address pointer and Transfer CNTR to OL
READ OL     ;  Read Byte 0 and increment address
READ OL     ;  Read Byte 1 and increment address
READ OL     ;  Read Byte 2 and increment address
```

OCCR (Output Control Register) Initializes CNTR and output operating modes.
Accessed by **:** WRITE when C/$\overline{D}$ = 1, $\overline{CS}$ = 0.



QR (Quadrature Register). Selects quadrature count mode (See Fig. 7)
Accessed by**:** WRITE when C/$\overline{D}$ = 1, $\overline{CS}$ = 0.



I/O DESCRIPTION:
(See REGISTER DESCRIPTION for I/O Prgramming.)

Data-Bus (D0 - D7) (Pin 8 - Pin 15). The 8-line data bus is a three-state I/O bus for interfacing with the system bus.

$\overline{CS}$ (Chip Select Input) (Pin 2). A logical "0" at this input enables the chip for Read and Write.

$\overline{RD}$ (Read Input) (Pin 19). A logical "0" at this input enables the OSR and the OL to be read on the data bus.

$\overline{WR}$ (Write Input) (Pin 1). A logical "0" at this input enables the data bus to be written into the control and data registers.

C/$\overline{D}$ (Control/Data Input) (Pin 18). A logical "1" at this input enables a control word to be written into one of the four control registers or the OSR to be read on the I/O bus. A logical "0" enables a data word to be written into the PR, or the OL to be read on the I/O bus.

A (Pin 6). Input A is a programmable count input capable of functioning in three different modes, such as up count input, down count input and quadrature input. In non-quadrature mode, the counter advances on the rising edge of Input A

B (Pin 7). Input B is also a programmable count input that can be programmed to function either as down count input, or count direction control gate for input A, or quadrature input. In non- quadrature mode, and when programmed as the Down Count input, the counter advances on the rising edge of Input B. When B is programmed as the count direction control gate, B = 0 enables A as the Up Count input and B = 1 enables A as the Down Count input. When programmed as the direction input, B can switch state only when A is high.

$\overline{ABGT}$/$\overline{RCTR}$ (Pin 4). This input can be programmed to function as either inputs A and B enable gate or as external counter reset input. A logical "0" is the active level on this input. In non-quadrature mode, if Pin 4 is programmed as A and B enable gate input, it may switch state only when A is high (if A is clock and B is direction) or when both A and B are high (if A and B are clocks). In quadrature mode, if Pin 4 is programmed as A and B enable gate, it may switch state only when either A or B switches.

$\overline{LCTR}$/$\overline{LLTC}$ (Pin 3**)** This input can be programmed to function as the external load command input for either the CNTR or the OL. When programmed as counter load input, the counter is loaded with the data contained in the PR. When programmed as the OL load input, the OL is loaded with data contained in the CNTR. A logical "0" is the active level on this input.

$\overline{CY}$ (Pin 16) This output can be programmed to serve as one of the following:

A. $\overline{CY}$. Complemented Carry out (active "0").
B. CY. True Carry out (active "1").
C. CYT. Carry Toggle flip-flop out.
D. $\overline{COMP}$. Comparator out (active "0")

$\overline{BW}$ (Pin 17) This output can be programmed to serve as one of the following:

A. $\overline{BW}$. Complemented Borrow out (active "0").
B. BW. True Borrow out (active "1").
C. BWT. Borrow Toggle flip-flop out.
D. COMPT. Comparator Toggle output.

V_{DD} (Pin 5**)** Supply voltage positive terminal.

V_{SS} (Pin 20**)** Supply voltage negative terminal.

Absolute Maximum Ratings:

Parameter	Symbol	Values	Unit
Voltage at any input	V_{IN}	V_{SS} - 0.3 to V_{DD} + 0.3	V
Operating Temperature	T_A	-40 to +125	^oC
Storage Temperature	T_{STG}	-65 to +150	^oC
Supply Voltage	V_{DD} - V_{SS}	+7.0	V

DC Electrical Characteristics. (All voltages referenced to V_{SS}.
T_A = 0˚ to 85˚C, V_{DD} = 3V to 5.5V, fc = 0, unless otherwise specified)

Parameter	Symbol	Min. Value	Max.Value	Unit	Remarks
Supply Voltage	V_{DD}	3.0	5.5	V	-
Supply Current	I_{DD}	-	350	μA	Outputs open
Input Low Voltage	V_{IL}	0	0.8	V	-
Input High Voltage	V_{IH}	2.0	V_{DD}	V	-
Output Low Voltage	V_{OL}	-	0.4	V	4mA Sink, V_{DD} = 5V
Output High Voltage	V_{OH}	2.5	-	V	200μA Source, V_{DD} = 5V
Input Current	-	-	15	nA	Leakage Current
Output Source Current	I_{SRC}	200	-	μA	V_{OH} = 2.5V, V_{DD} = 5V
Output Sink Current	I_{SINK}	4	-	mA	V_{OL} = 0.4V, V_{DD} = 5V
Data Bus Off-State Leakage Current	-	-	15	nA	-

TRANSIENT CHARACTERISTICS (See Timing Diagrams in Fig. 2 thru Fig. 7, V_{DD} = 3V to 5.5V, T_A = 0° to 85°C, unless otherwise specified)

Parameter	Symbol	Min.Value	Max.Value	Unit
Clock A/B "Low"	T_{CL}	18	No Limit	ns
Clock A/B "High"	T_{CH}	22	No Limit	ns
Clock A/B Frequency (See NOTE 1)	fc	0	25	MHz
Clock UP/DN Reversal Delay	T_{UDD}	100	-	ns
LCTR Positive edge to the next A/B positive or negative edge delay	T_{LC}	100	-	ns
Clock A/B to $\overline{CY}$/$\overline{BW}$/$\overline{COMP}$ "low" propagation delay	T_{CBL}	-	65	ns
Clock A/B to $\overline{CY}$/$\overline{BW}$/$\overline{COMP}$ "high" propagation delay	T_{CBH}	-	85	ns
LCTR and $\overline{LLTC}$ pulse width	T_{LCW}	60	-	ns
Clock A/B to CYT, BWT and COMPT "high" propagation delay	T_{TFH}	-	100	ns
Clock A/B to CYT, BWT and COMPT "low" progagation delay	T_{TFL}	-	100	ns
$\overline{WR}$ pulse width	T_{WR}	60	-	ns
$\overline{RD}$ to data out delay (C_L=20pF)	T_R	-	110	ns
$\overline{CS}$, $\overline{RD}$ Terminate to Data-Bus Tri-State	T_{RT}	-	30	ns
Data-Bus set-up time for $\overline{WR}$	T_{DS}	30	-	ns
Data-Bus hold time for $\overline{WR}$	T_{DH}	30	-	ns
$\overline{CS}$ set-up time for $\overline{RD}$	T_{SRS}	0	-	ns
$\overline{CS}$ hold time for $\overline{RD}$	T_{SRH}	0	-	ns
Back to Back $\overline{RD}$ delay	T_{RR}	60	-	ns
$\overline{RD}$ to $\overline{WR}$ delay	-	60	-	ns
C/$\overline{D}$ set-up time for $\overline{RD}$	T_{CRS}	0		
C/$\overline{D}$ hold time for $\overline{RD}$	T_{CRH}	30		
C/$\overline{D}$ set-up time for $\overline{WR}$	T_{CWS}	30	-	ns
C/$\overline{D}$ hold time for $\overline{WR}$	T_{CWH}	30	-	ns
$\overline{CS}$ set-up time for $\overline{WR}$	T_{SWS}	60	-	ns
$\overline{CS}$ hold time for $\overline{WR}$	T_{SWH}	0	-	ns
Back to Back $\overline{WR}$ delay	Tww	60	-	ns
$\overline{WR}$ to $\overline{RD}$ delay	-	60	-	ns
Quadrature Mode:				
Clock A/B Validation delay (See NOTE 1)	T_{CQV}	-	160	ns
A and B phase delay	T_{PH}	208	-	ns
Clock A/B frequency	f_{CQ}	-	1.2	MHz
$\overline{CY}$, $\overline{BW}$, $\overline{COMP}$ pulse width	T_{CBW}	85	200	ns

NOTE 1: In quadrature mode A/B inputs are filtered and required to be stable for at least T_{CQV} length to be valid.

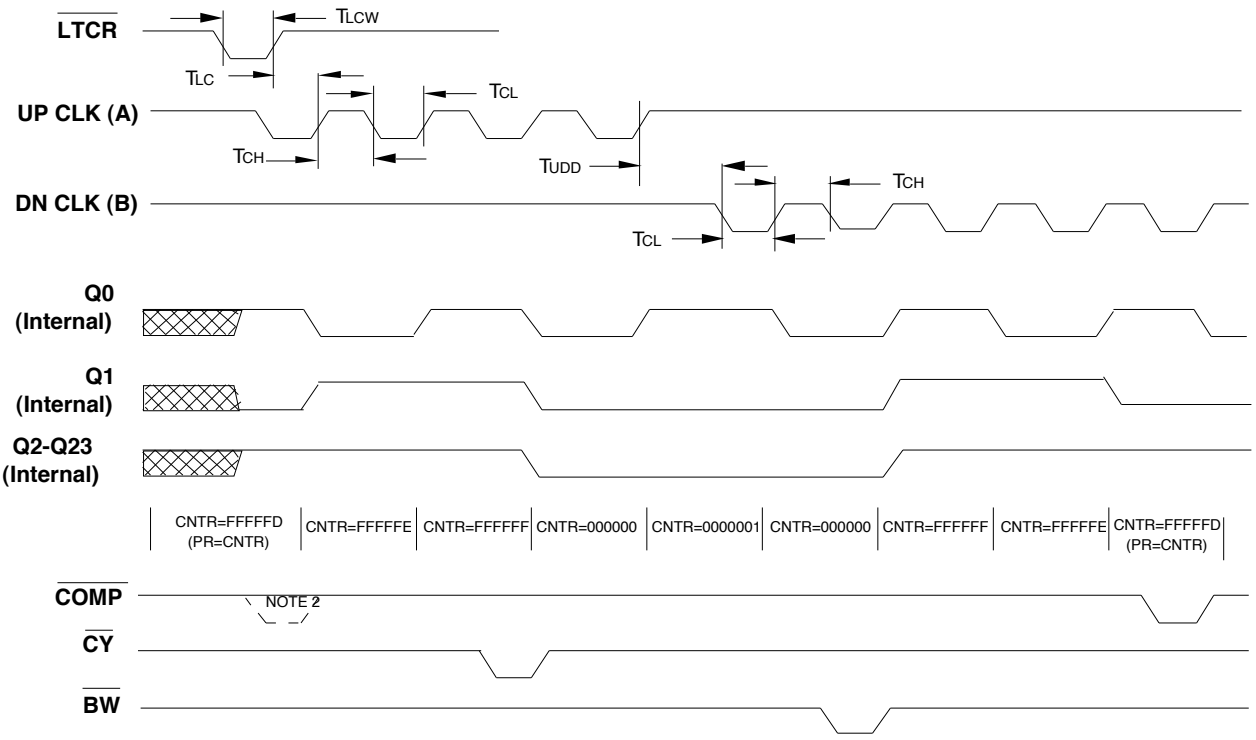


FIGURE 2 . LOAD COUNTER, UP CLOCK, DOWN CLOCK, COMPARE OUT, CARRY, BORROW

NOTE 1: The counter in this example is assumed to be operating in the binary mode.
NOTE 2: No COMP output is generated here, although PR = CNTR. COMP output is disabled with a counter load command and enabled with the rising edge of the next clock, thus eliminating invalid COMP outputs whenever the CNTR is loaded from the PR.
NOTE 3: When UP Clock is active, the DN Clock should be held "HIGH" and vice versa.

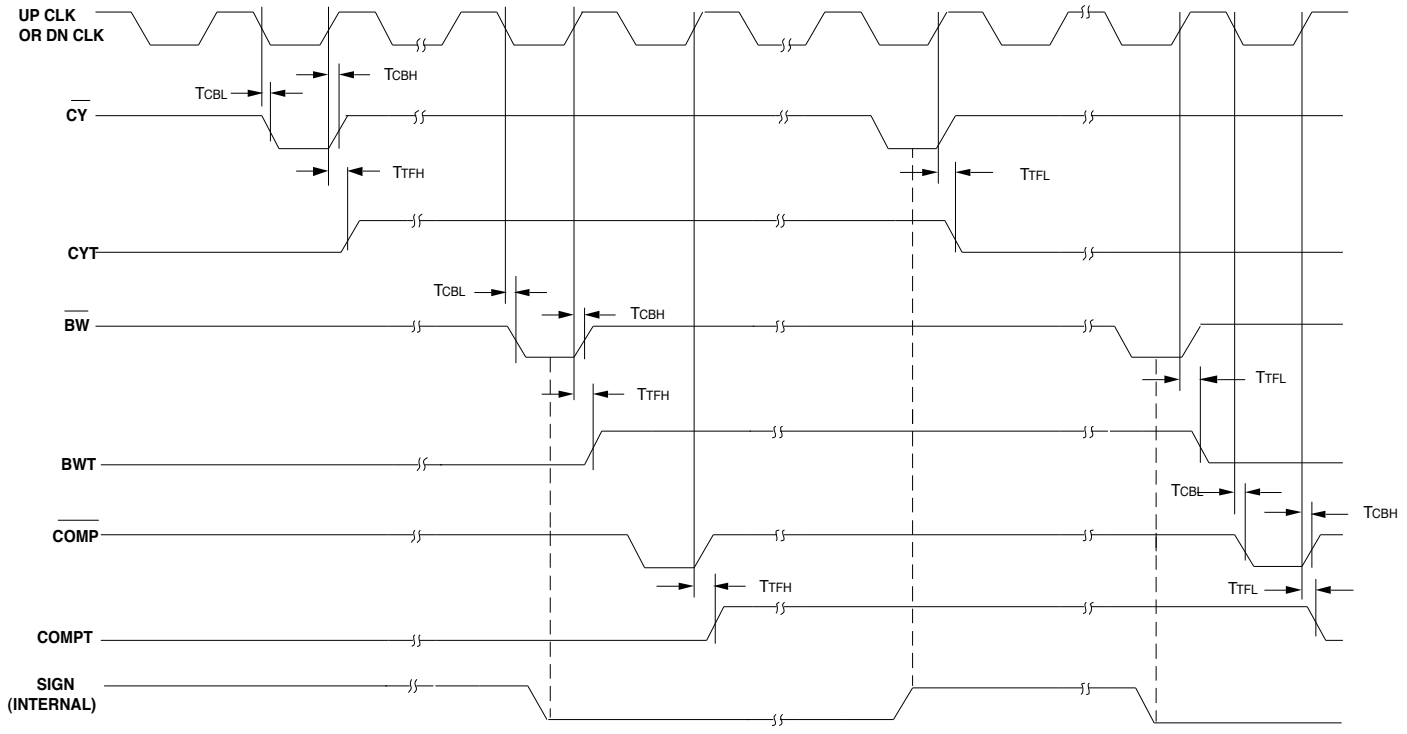


FIGURE 3. CLOCK TO $\overline{CY}$/$\overline{BW}$ OUTPUT PROPAGATION DELAYS

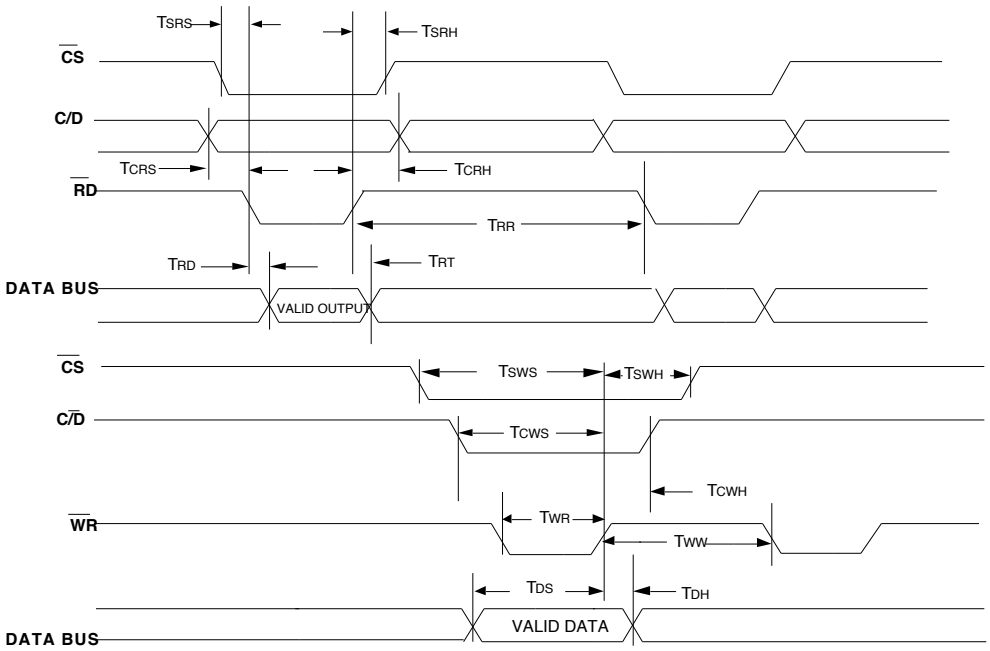
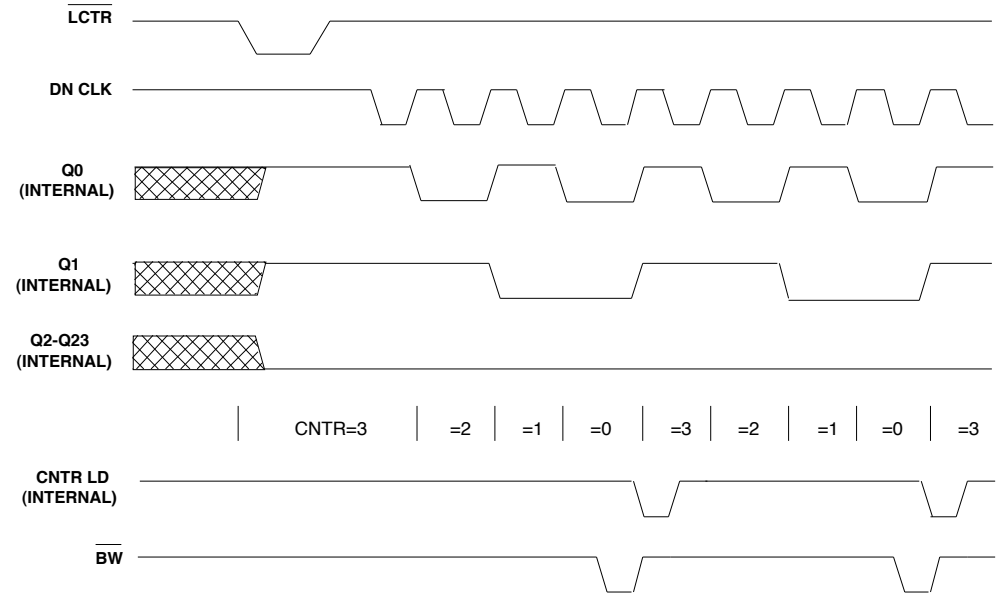


FIGURE 4. READ/WRITE CYCLES



NOTE: EXAMPLE OF DIVIDE BY 4 IN DOWN COUNT MODE

FIGURE 5. DIVIDE BY N MODE

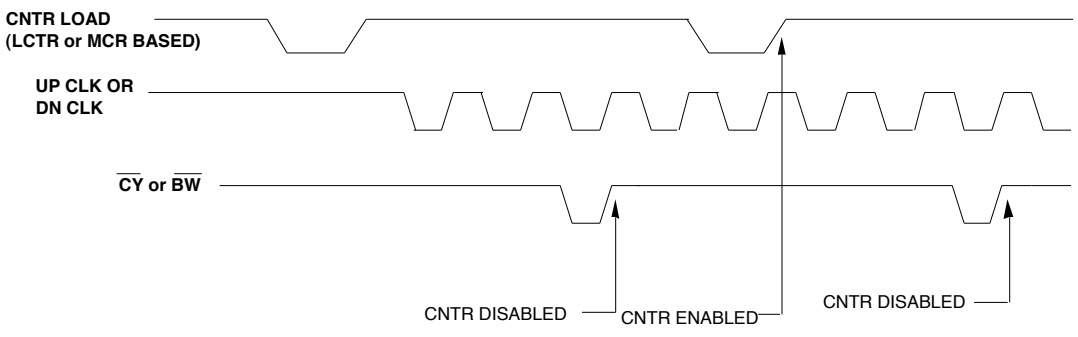


FIGURE 6 . CYCLE ONCE MODE

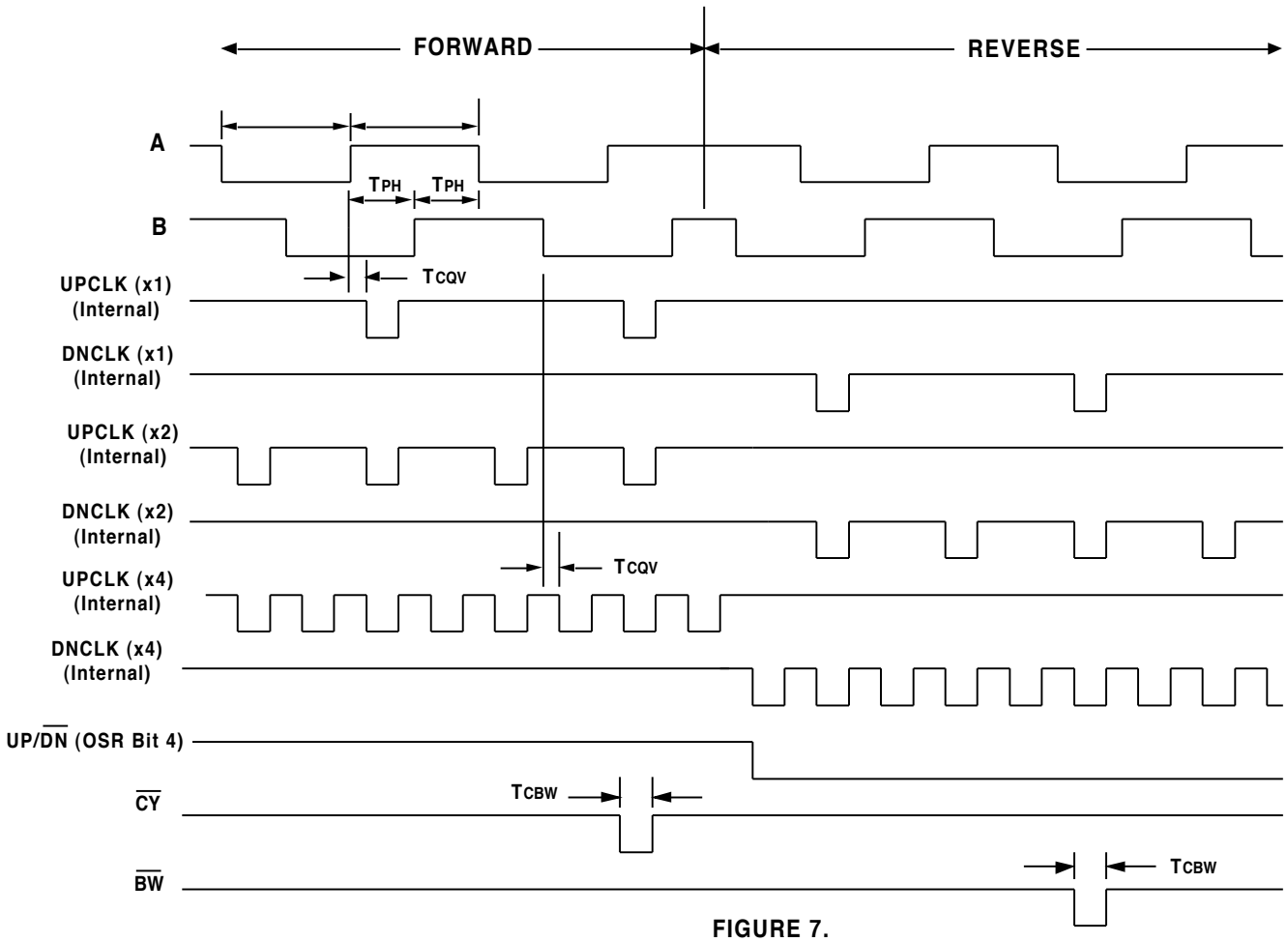


FIGURE 7.
QUADRATURE MODE INTERNAL CLOCKS

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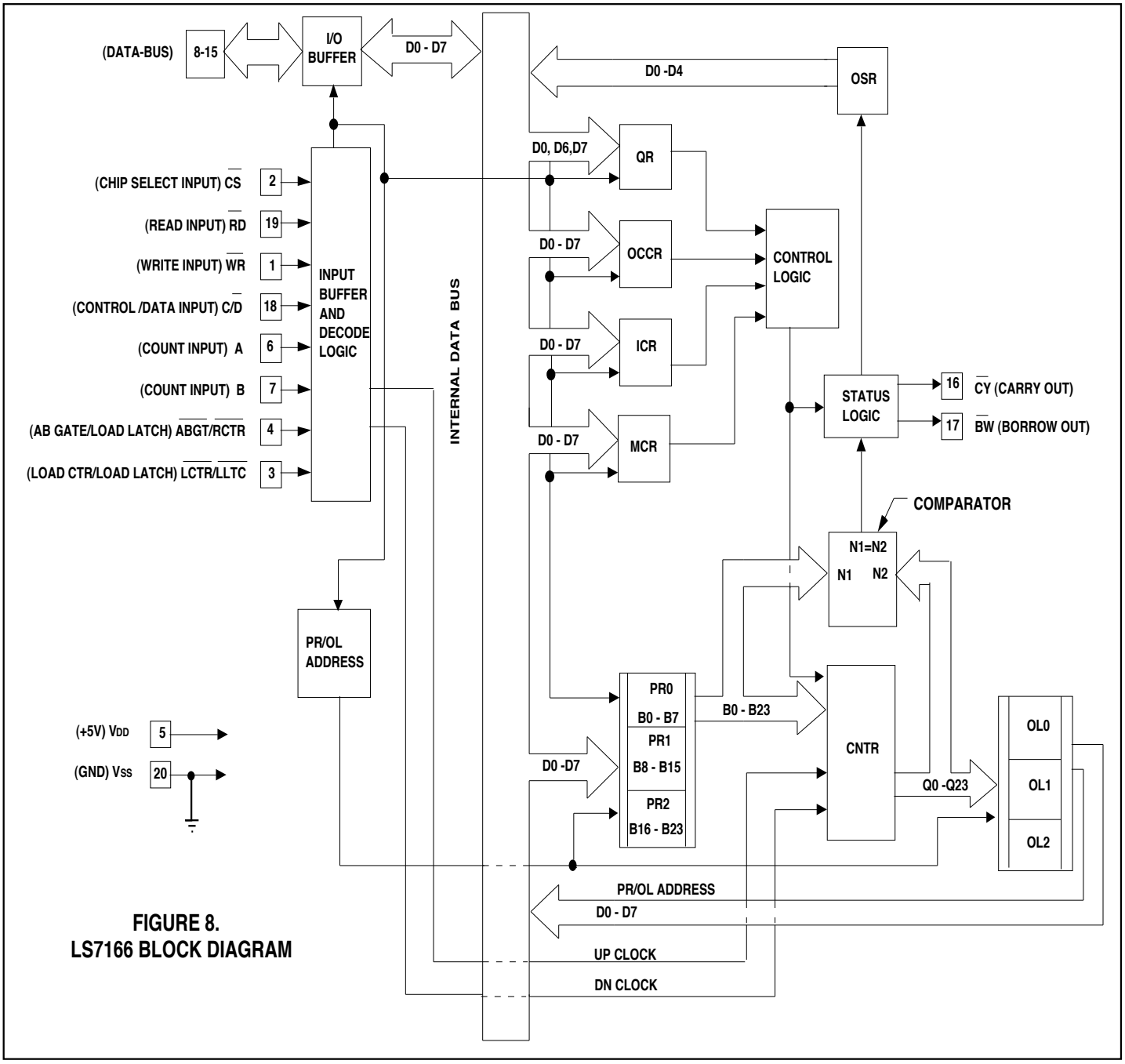

FIGURE 8.
LS7166 BLOCK DIAGRAM

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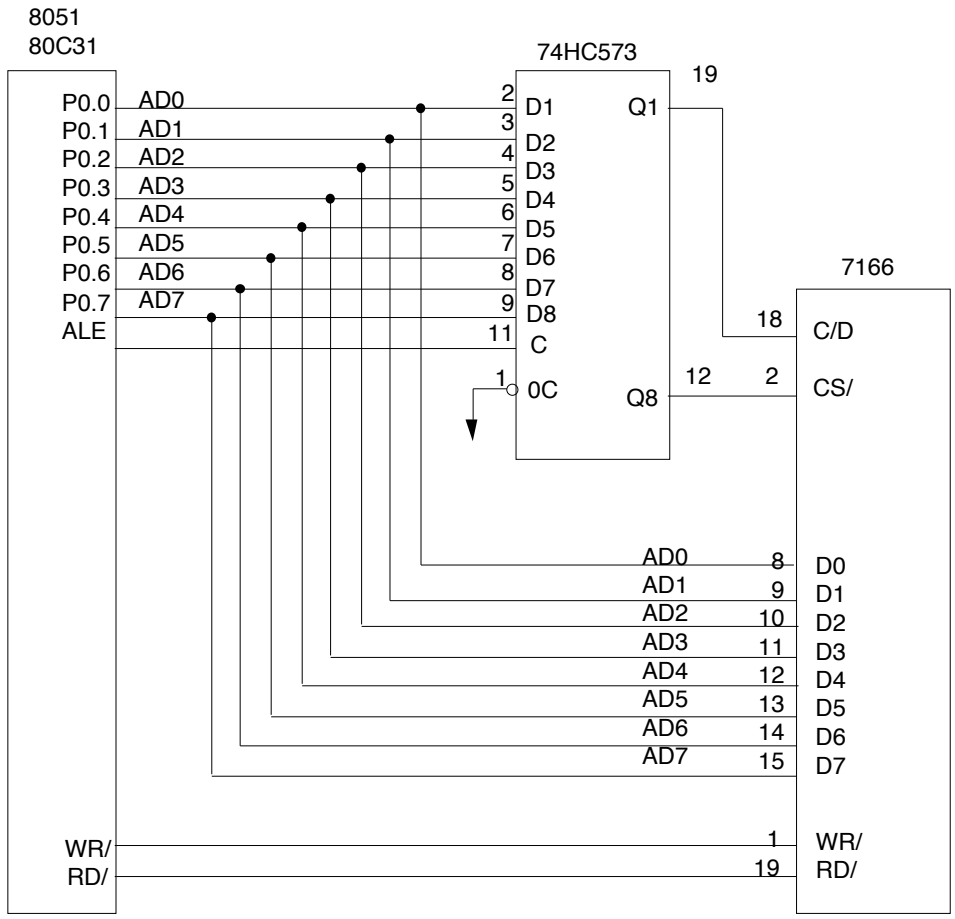
FIGURE 9. 80C31/8051 TO LS7166 INTERFACE IN EXTERNAL ADDRESS MODE



NOTE: Port_0 is open drain output. Add pull-up resistors to all Port_0 i/0 lines.

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FIGURE 10. 8751 INTERFACE TO LS7166 IN I/O MODE

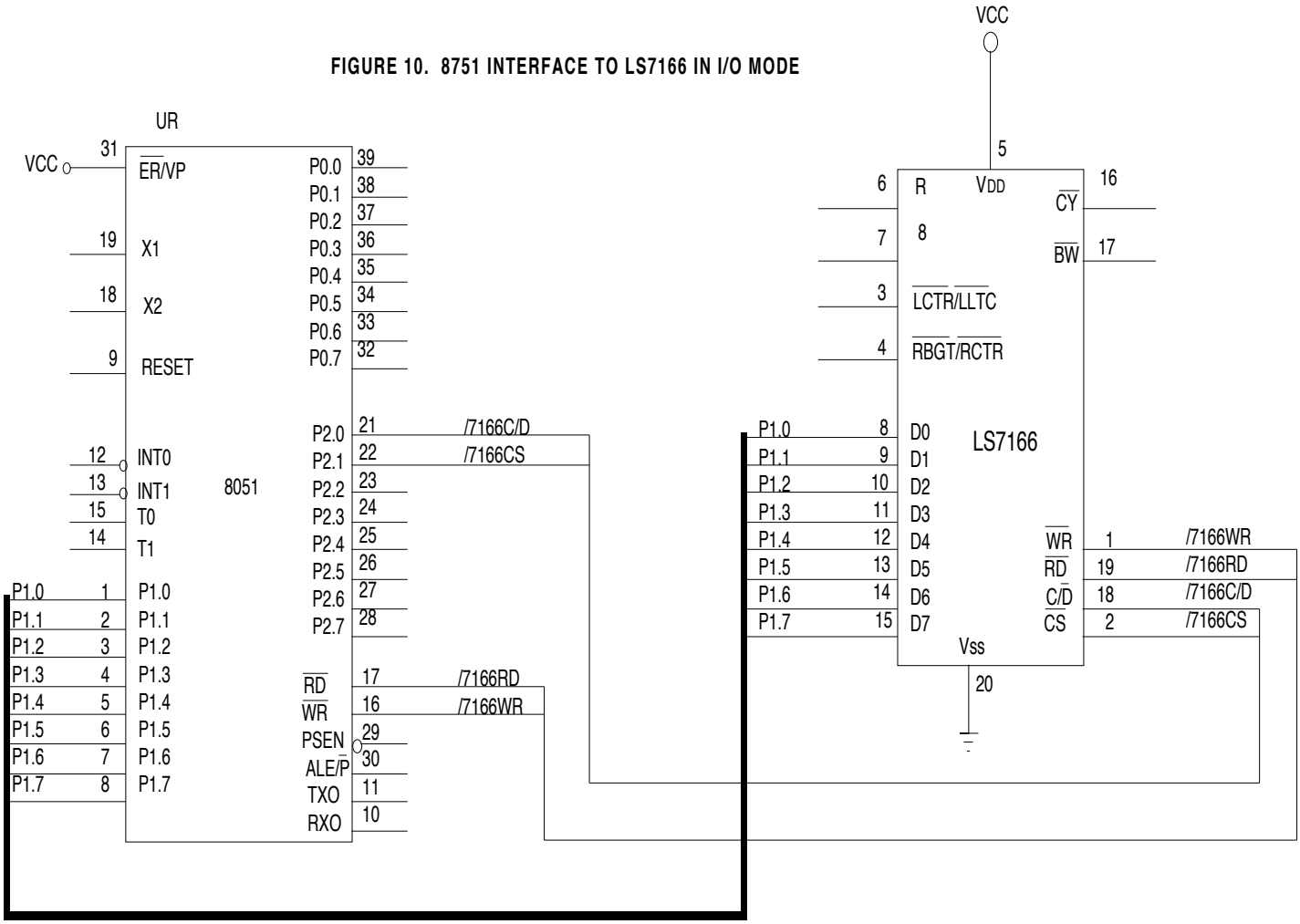

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FIGURE 11. LS7166 TO 68HC11 INTERFACE

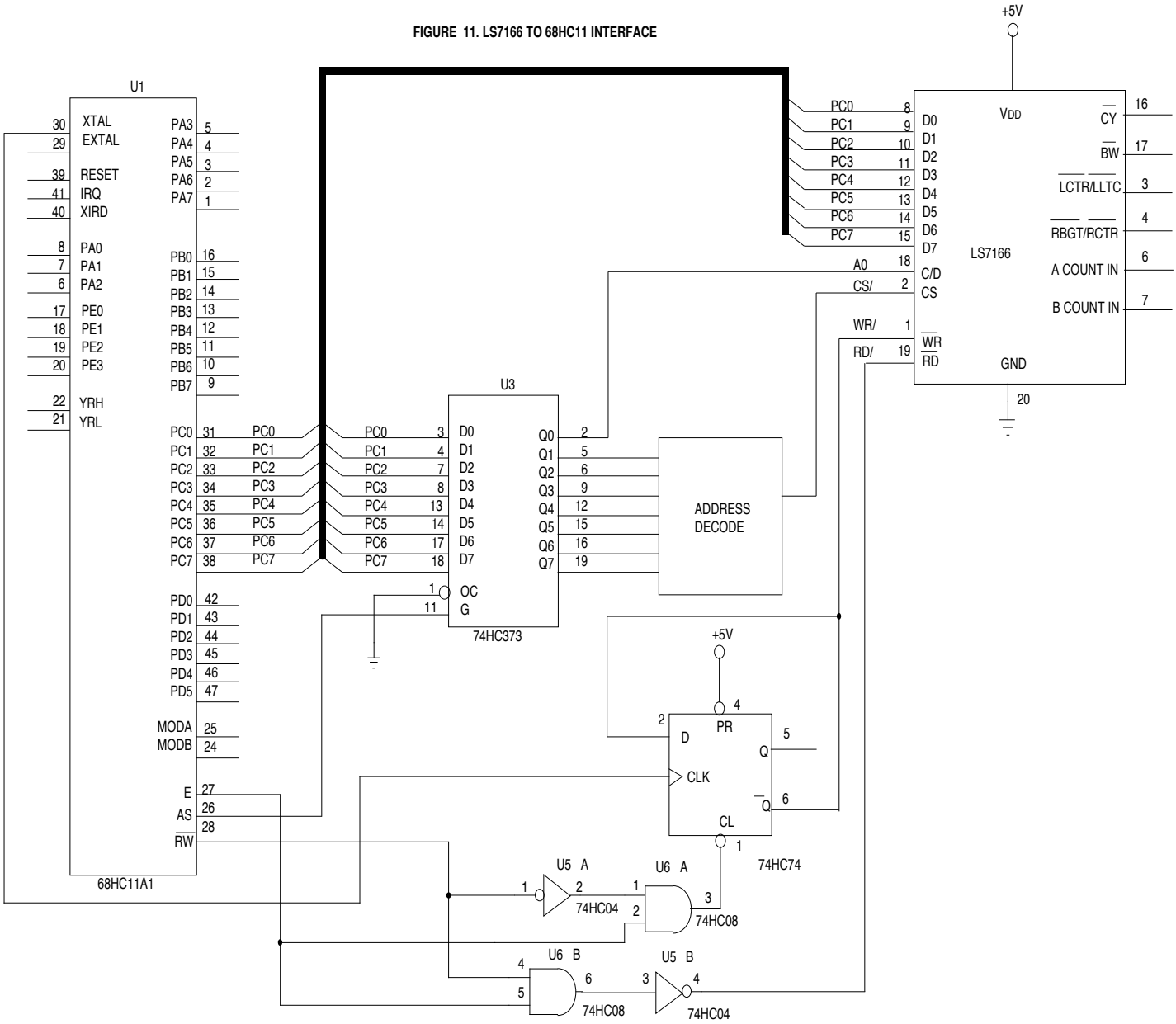

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FIGURE 12. LS7166 INTERFACE EXAMPLE

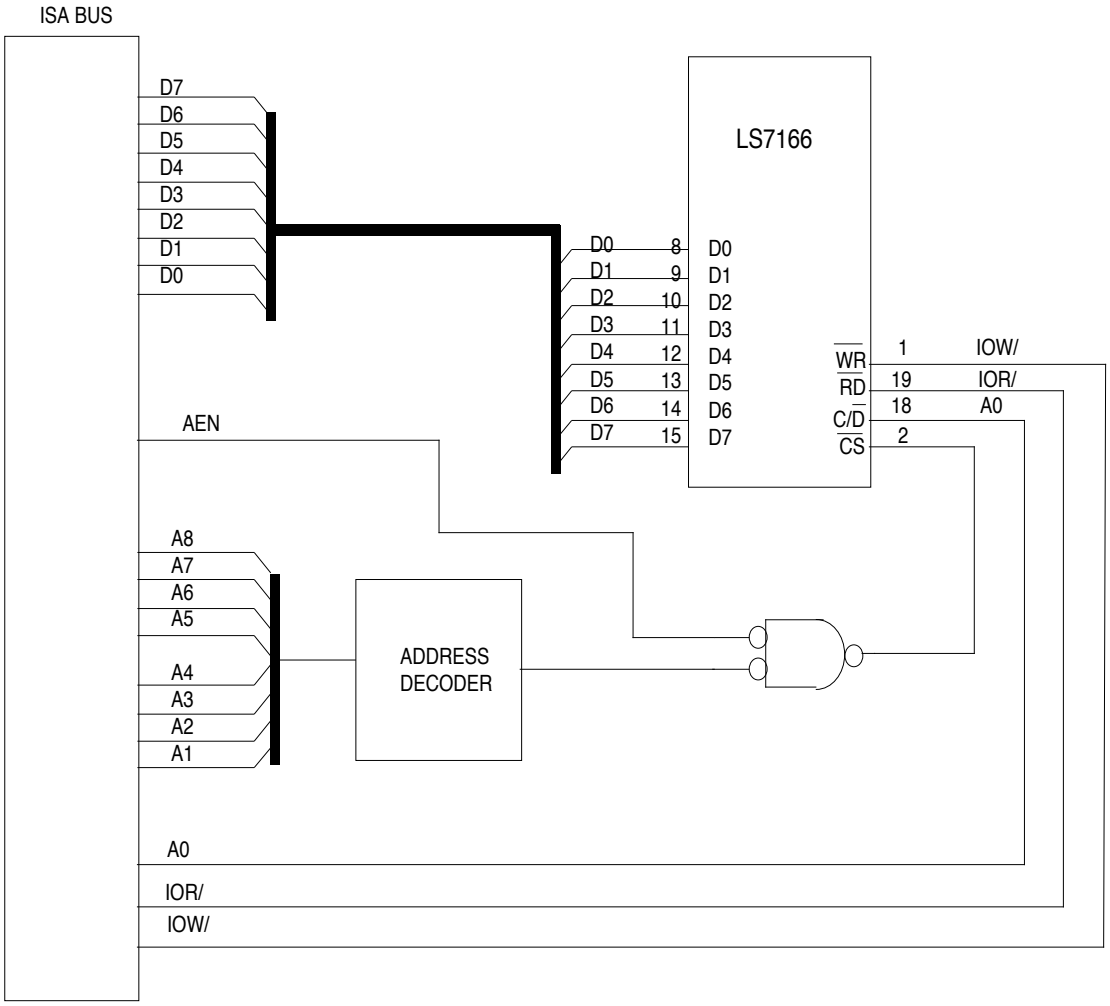

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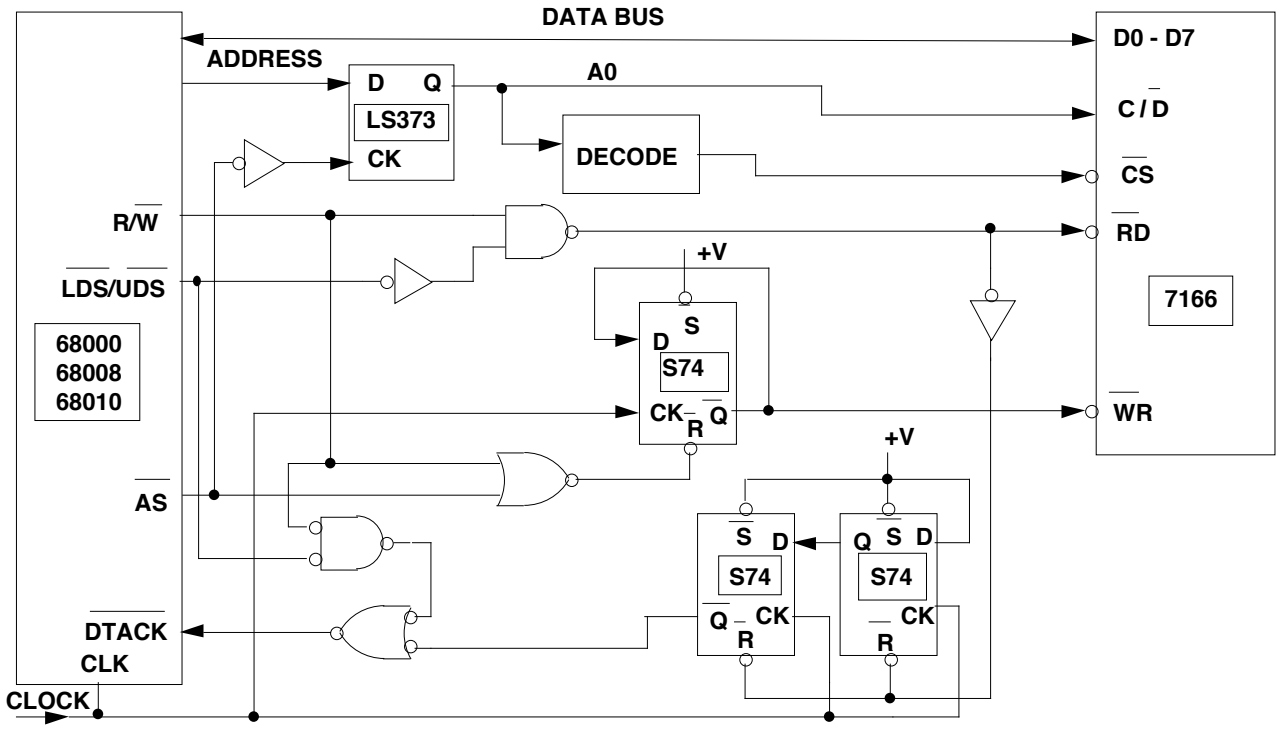
FIGURE 13. 68000 INTERFACE TO LS7166



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C Sample Routines for Interfacing with LS7166

```
#include  <stdio.h>
#include  <stdlib.h>
#include  <conio.h>

#define DATAMODE(arg)    (arg + 0)
#define CTRLMODE(arg)    (arg + 1)

/*************************************************************************/
/* MCR (Master Control Register) */

/* Select MCR */
#define MCR(arg)    (arg | 0x00)

/* Master Reset */
/* Reset CNTR, ICR, OCCR, QR, BWT, CYT, OL, COMPT, and PR/OL Byte Pointer */
/* Set PR and SIGN */
#define Rst_Master       0x20

/* Reset COMPT */
#define Rst_COMPT    0x10

/* Transfer PR to CNTR (24 bits) */
#define Trf_PR_CNTR    0x08

/* Reset CNTR, BWT and CYT */
/* Set SIGN bit */
#define Rst_CNTR_BWT_CYT_Set_SIGN        0x04

/* Transfer CNTR to OL (24 bits) */
#define Trf_CNTR_OL    0x02

/* Reset PR/OL Byte Pointer */
#define Rst_BP    0x01

/*************************************************************************/
/* ICR (Input Control Register) */

/* Select ICR */
#define ICR(arg)    (arg | 0x40)

/* Select LCTR / LLTC as Load-CNTR  Input */
#define LCNTR    0x00

/* Select LCTR / LLTC as Load-OL  Input */
#define LOL       0x20


/* Select ABGT / RCTR as Reset-CNTR Input */
#define RCNTR    0x00

/* Select ABGT / RCTR as Enable / Disable Gate for A / B Inputs */
#define ABGate    0x10

/* Disable A / B Inputs */
#define DisAB    0x00

/* Enable  A / B Inputs */
#define EnAB       0x08
```

```
/* Decrement CNTR once for A / B = 1, if A / B inputs are enabled */
#define Decr_CNTR       0x04

/* Increment CNTR once for A / B = 1, if A / B inputs are enabled */
#define Incr_CNTR       0x02

/* Set Input A = Up Count Input, Input B = Down Count Input */
#define AUP_BDN       0x00

/* Set Input A = Count Input, Input B = Count Direction  Input */

/* B = 0 selects Up Count Mode */
/* B = 1 selects Down Count Mode  */
#define AIN_BDIR    0x01

/*************************************************************************/
/* OCCR (Output Control Register)  */

/* Select OCCR */
#define OCCR(arg)    (arg | 0x80)

    ___   _____
/* Set CY = COMP Comparator Out (active "0")  */

    ___
/* Set BW = COMPT Comparator Toggle Output  */
#define COMPN_COMPT    0x30

    ___
/* Set CY = CY   */

    ___
/* Set BW = BW  */
#define CY_BW    0x20

    ___   ___
/* Set CY = CY   */

    _____   _____
/* Set BW = BW   */
#define CYN_BWN    0x00

/* Set Binary or BCD Count Mode  */
#define Bin_BCD_Cnt    0x00

/* Set 24 Hr Clock Mode – Overrides BCD / Binary Modes  */
#define Clk_24HR_Cnt    0x08

/* Set Normal Count Mode  */
#define Nrml_Cnt    0x00

/* Set Divide by N Count Mode  */
#define div_N_Cnt    0x04

/* Set Non Recycle Count Mode  */
#define Nrcyc_Cnt    0x02

/* Set Binary Count Mode  */
#define Bin_Cnt    0x00

/* Set BCD Count Mode  */
#define BCD_Cnt    0x01

/*************************************************************************/
```

```
/* QR (Quadrature Register)  */

/* Select QR */
#define QR(arg)    (arg | 0xC0)

/* Enable x4 Quadrature Mode  */
#define En_x4QM    0x03

/* Enable x2 Quadrature Mode  */
#define En_x2QM    0x02

/* Enable x1 Quadrature Mode  */
#define En_x1QM    0x01

/* Disable Quadrature Mode  */
#define Dis_QM    0x00

/*************************************************************************/
/* Initialize 7166 */

void Init_7166(int Addr)

/* Initialize 7166 as follows
Do a Master Reset
Set ICR as follows
Set Input A = Up Count
Set Input B = Down Count
Disable Inputs A/B
Enable Reset_CNTR input
Enable Load_CNTR input
Set OCCR – Normal Count Mode
Disable QM
Enable A and B Inputs
*/

void Init_7166(int Addr){
/* Master Reset */
outp(CTRLMODE(Addr), MCR(Rst_Master));

/* Set ICR */
outp(CTRLMODE(Addr), ICR(AUP_BDN + DisAB + RCNTR + LCNTR));

/* Set OCCR */
outp(CTRLMODE(Addr), OCCR(Nrml_Cnt));

/* Set QR */
outp(CTRLMODE(Addr), QR( Dis_QM));

/*Enable A and B inputs */
outp(CTRLMODE(Addr), ICR(EnAB));
}
```

```
/* Write data into 7166 Preset Register
Addr has address of 7166 counter
Data has 24 bit data to be written to PR register */

void Write_7166_PR(int Addr, unsigned long Data);

void Write_7166_PR(int Addr, unsigned long Data){
outp(CTRLMODE(Addr), MCR(Rst_BP));
outp(DATAMODE(Addr), (unsigned char)Data);
Data >>= 8;
outp(DATAMODE(Addr), (unsigned char)Data);
Data >>= 8;
outp(DATAMODE(Addr), (unsigned char)Data);
}
```

```
/* Read 7166 Output Latch
Addr has address of 7166 counter
Data returns 24 bit OL register value. */

unsigned long Read_7166_OL(int Addr);

unsigned long Read_7166_OL(int Addr){
unsigned long Data = 0;
outp(CTRLMODE(Addr), MCR(Rst_BP + Trf_CNTR_OL));
Data |= (unsigned long) inp(DATAMODE(Addr));
lrotr(Data,8);
Data |= (unsigned long) inp(DATAMODE(Addr));
lrotr(Data,8);
Data |= (unsigned long) inp(DATAMODE(Addr));
lrotr(Data,16);
return(Data);
}

/* Read Output Status Register
Addr has address of 7166 counter
returns OSR data  */

unsigned long Read_7166_OSR(int Addr);

unsigned long Read_7166_OSR(int Addr){
return(inp(CNTRLMODE(Addr)));
}
```