Navigator™ Motion Processor

MC2502 Series
Technical Specifications

for Stepping Motion Control

Performance Motion Devices, Inc.
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NOTICE

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Related Documents

Navigator Motion Processor User's Guide (MC2000UG)

How to set up and use all members of the Navigator Motion Processor family.

Navigator Motion Processor Programmer's Reference (MC2000PR)

Descriptions of all Navigator Motion Processor commands, with coding syntax and examples, listed alphabetically for quick reference.

Navigator Motion Processor Technical Specifications

Four booklets containing physical and electrical characteristics, timing diagrams, pinouts, and pin descriptions of each series:

MC2100 Series, for brushed servo motion control (MC2100TS);
MC2300 Series, for brushless servo motion control (MC2300TS);
MC2400 Series, for microstepping motion control (MC2400TS);
MC2500 Series, for stepping motion control (MC2500TS);
MC2502 Series, for stepping motion control (MC2502TS);
MC2800 Series, for brushed servo and brushless servo motion control (MC2800TS).

Navigator Motion Processor Developer's Kit Manual (DK2000M)

How to install and configure the DK2000 developer's kit PC board.

Table of Contents

1 The Navigator Family

	MC2100 Series	MC2300 Series	MC2400 Series	MC2502 Series	MC2800 Series
# of axes	4, 2, or 1	4, 2 or 1	4, 2 or 1	4, 2, or 1	4 or 2
Motor type supported	Brushed servo	Brushless servo	Stepping	Stepping	Brushed servo + brushless servo
Output format	Brushed servo (single phase)	Commutated (6-step or sinusoidal)	Microstepping	Pulse and direction	Brushed servo (single phase) + commutated (6-step or sinusoidal)
Incremental encoder input	√	√	√	√	√
Parallel word device input	√	√	√	√	√
Parallel communication	√	√	√	√	√
Serial communication	√	√	√	√	√
Diagnostic port	√	√	√	√	√
S-curve profiling	√	√	√	-	√
Electronic gearing	√	√	√	-	√
On-the-fly changes	√	√	√	√	√
Directional limit switches	√	√	√	√	√
Programmable bit output	√	√	√	√	√
Software-invertable signals	√	√	√	√	√
PID servo control	√	√	-	-	√
Feedforward (accel & vel)	√	√	-	-	√
Derivative sampling time	√	√	-	-	√
Data trace/diagnostics	√	√	√	√	√
PWM output	√	√	√	-	√
Motion error detection	√	√	√ (with encoder)	√ (with encoder)	√
Axis settled indicator	√	√	√ (with encoder)	√ (with encoder)	√
DAC-compatible output	√	√	√	-	√
Pulse & direction output	-	-	-	√	-
Index & Home signals	√	√	√	√	√
Position capture	√	√	√	√	√
Analog input	√	√	√	√	√
User-defined I/O	√	√	√	√	√
External RAM support	√	√	√	√	√
Chipset part numbers	MC2140 (4 axes) MC2120 (2 axes) MC2110 (1 axis)	MC2340 (4 axes) MC2320 (2 axes) MC2310 (1 axis)	MC2440 (4 axes) MC2420 (2 axes) MC2410 (1 axis)	MC2542 (4 axes) MC2522 (2 axes) MC2512 (1 axis)	MC2840 (4 axes) MC2820 (2 axes)
Developer's Kit p/n	DK2100	DK2300	DK2400	DK2502	DK2800

Introduction

This manual describes the operational characteristics of the MC2542, MC2522 and MC2512 Motion Processors from PMD. These devices are members of PMD's second-generation motion processor family, which consists of 17 separate products organized into 6 series.

Each of these devices is a complete chip-based motion processor. They provide trajectory generation and related motion control functions, and high speed pulse and direction outputs. Together these products provide a software-compatible family of dedicated motion processors that can handle a large variety of system configurations.

Each of these chips utilize a similar architecture, consisting of a high-speed computation unit, along with an ASIC (Application Specific Integrated Circuit). The computation unit contains special on-board hardware that makes it well suited for the task of motion control.

Each chipset consists of two PQFP (Plastic Quad Flat Pack) ICs: a 100-pin Input/Output (I/O) chip, and a 132-pin Command Processor (CP) chip.

Four of the series in the Navigator family are designed for a particular type of motor or control scheme. The fifth allows the user to control 2 servo motor types (brushed and brushless). Here is a summary description of each series.

Family Summary

MC2100 Series (MC2140, MC2120, MC2110) – This series outputs motor commands in either Sign/Magnitude PWM or DAC-compatible format for use with brushed servo motors, or with brushless servo motors having external commutation.

MC2300 Series (MC2340, MC2320, MC2310) – This series outputs sinusoidally or 6-step commutated motor signals appropriate for driving brushless motors. Depending on the motor type, the output is a two-phase or three-phase signal in either PWM or DAC-compatible format.

MC2400 Series (MC2440, MC2420, MC2410) – This series provides microstepping signals for stepping motors. Two phased signals per axis are generated in either PWM or DAC-compatible format.

MC2500 Series (MC2540, MC2520, MC2510) – These chipsets provide high-speed pulse and direction signals for stepping motor systems.

MC2502 Series (MC2542, MC2522, MC2512) – Reduced feature version of the MC2500, these chipsets provide high-speed pulse and direction signals for stepping motor systems.

MC2800 Series (MC2840, MC2820) – This series outputs sinusoidally or 6-step commutated motor signals appropriate for driving brushless servo motors as well as PWM or DAC- compatible outputs for driving brushed servo motors.

2 Functional Characteristics

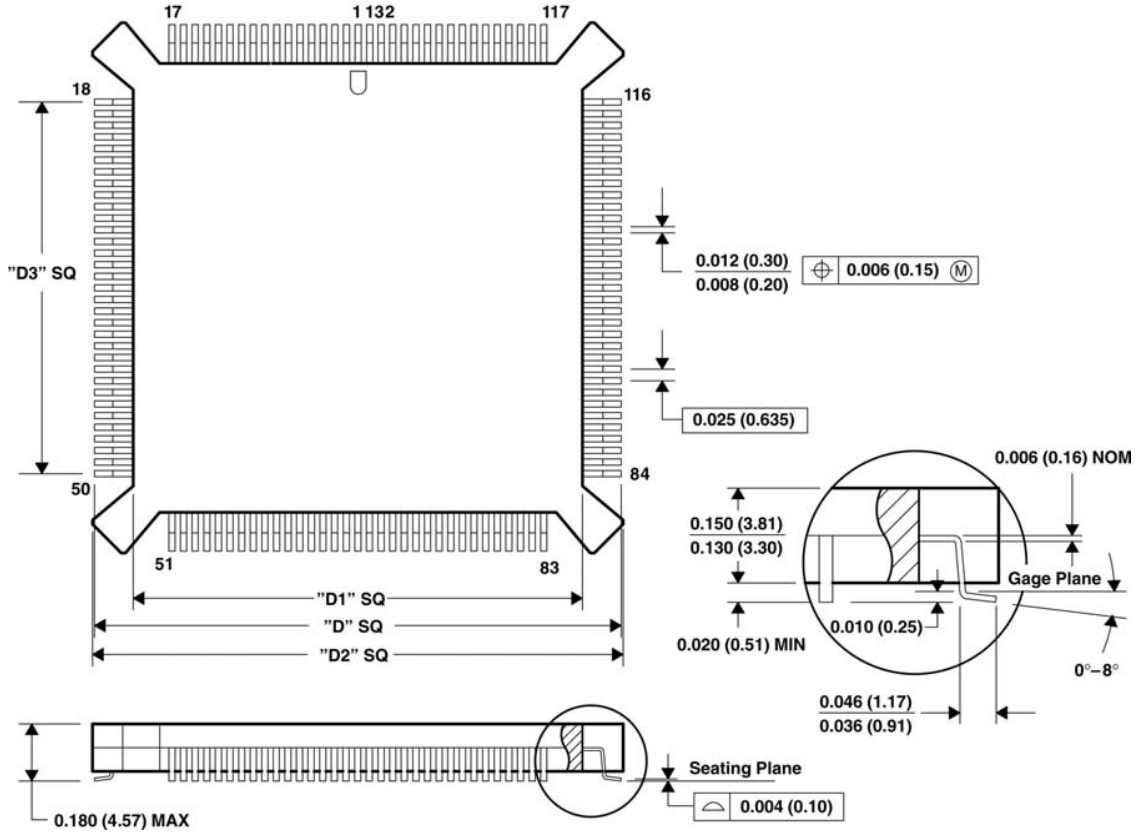
2.1 Configurations, parameters, and performance

Available configurations	4 axes (MC2542), 2 axes (MC2522), or 1 axis (MC2512)
Operating modes	Open loop (pulse generator is driven by trajectory generator output) Stall detection (pulse generator is driven by trajectory generator output and encoder feedback is used for stall detection)
Communication modes	8/8 parallel (8 bit external parallel bus with 8 bit internal command word size)
	8/16 parallel (8 bit external parallel bus with 16 bit internal command word size)
	16/16 parallel (16 bit external parallel bus with 16 bit internal command word size)
	Point to point asynchronous serial
	Multidrop asynchronous serial
Serial port baud rate range	1,200 baud to 416,667 baud
Position range	-2,147,483,648 to +2,147,483,647 counts
Velocity range	-32,768 to +32,767 counts/sample with a resolution of 1/65,536 counts/sample
Acceleration/deceleration ranges	-32,768 to +32,767 counts/sample^2 with a resolution of 1/65,536 counts/sample^2
Jerk range	0 to ½ counts/sample^3, with a resolution of 1/4,294,967,296 counts/sample^3
Profile modes	Trapezoidal point-to-point (Velocity, acceleration, deceleration, and position parameters)
	Velocity-contouring (Velocity, acceleration, and deceleration parameters)
Maximum pulse rate	1.00 M-pulses/sec
Maximum encoder rate	Incremental (up to 5 Mcounts/sec)
	Parallel-word (up to 160 Mcounts/sec)
Parallel encoder word size	16 bits
Parallel encoder read rate	20 kHz (reads all axes every 50 μsec)
Cycle rate timing range	102.4 μsec to 32.767 milliseconds
Minimum cycle time	102.4 μsec per enabled axis
Limit switches	2 per axis: one for each direction of travel
Position-capture triggers	2 per axis: index and home signals
Other digital signals (per axis)	1 AxisIn signal per axis, 1 AxisOut signal per axis
Software-invertable signals	Encoder A, Encoder B, Index, Home, AxisIn, AxisOut, PositiveLimit, NegativeLimit, Pulse, Direction (all individually programmable per axis)
Analog input	8 10-bit analog inputs
User defined discrete I/O	256 16-bit wide user defined I/O
RAM/external memory support	65,536 blocks of 32,768 16 bit words per block. Total accessible memory is 2,147,483,648 16 bit words
Trace modes	one-time
	continuous
Max. number of trace variables	4
Number of traceable variables	20
Number of host instructions	106

2.2 Physical characteristics and mounting dimensions

2.2.1 CP chip

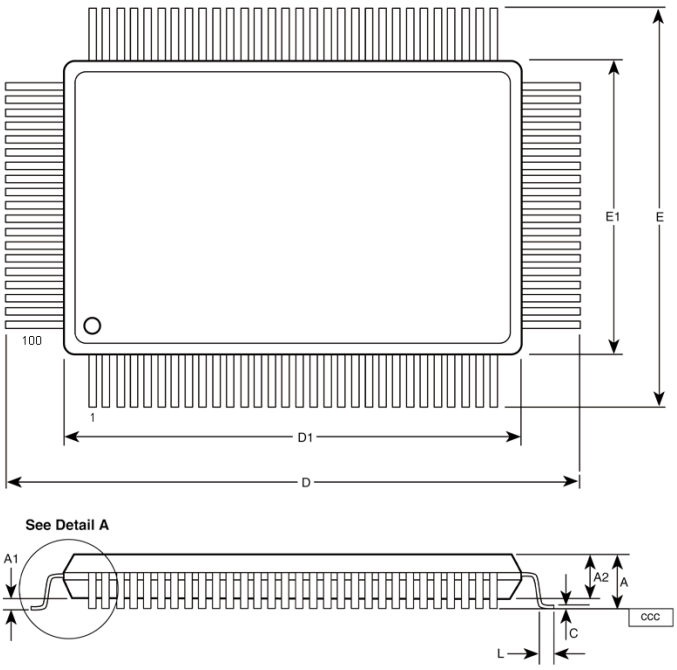
All dimensions are in inches (with millimeters in brackets).

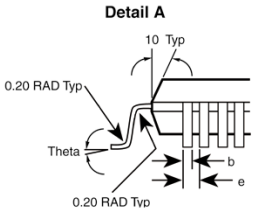


Dimension	Minimum (inches)	Maximum (inches)
D	1.070	1.090
D1	0.934	0.966
D2	1.088	1.112
D3	0.800 nominal	

2.2.2 I/O chip

All dimensions are in millimeters.





Dimension	Minimum (mm)	Nominal (mm)	Maximum (mm)
A			3.40
A1	0.25	0.33	
A2	2.55	2.80	3.05
b	0.22		0.38
c	0.13		0.23
D	22.95	23.20	23.45
D1	19.90	20.00	20.10
E	16.95	17.20	17.45
E1	13.90	14.00	14.01
e		0.65 BSC	
L	0.73	0.88	1.03
ccc			0.10
theta	0°		7°

2.3 Environmental and electrical ratings

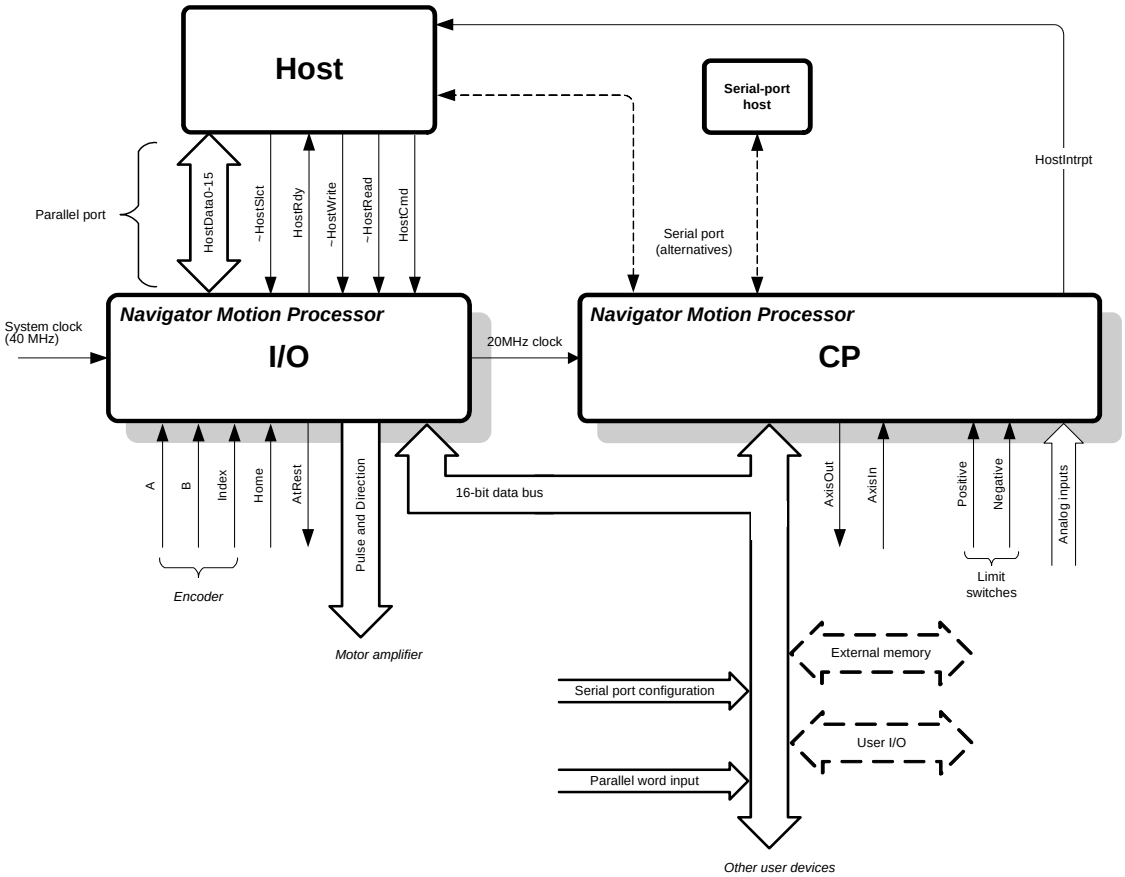
All ratings and ranges are for both the I/O and CP chips.

Storage Temperature (T_s)	-55 °C to 150 °C
Operating Temperature (T_a)	0 °C to 70 °C*
Power Dissipation (P_d)	600 mW (I/O and CP combined)
Nominal Clock Frequency (F_{clk})	40.0 MHz
Supply Voltage Limits (V_{cc})	-0.3V to +7.0V
Supply Voltage Operating Range (V_{cc})	4.75V to 5.25V

* An industrial version with an operating range of -40°C to 85°C is also available. Please contact PMD for more information.

2.4 System configuration

The following figure shows the principal control and data paths in an MC2502 system.



The CP chip contains the profile generator, which calculates velocity, acceleration, and position values for a trajectory. The output of the trajectory generator is used to produce pulse and direction signals that control motor position.

Optional axis position information returns to the motion processor through the I/O chip, in the form of encoder feedback, or through the CP chip, in the form of parallel-word feedback. This position feedback may be used to detect motor stalling errors.

2.5 Peripheral device address mapping

Device addresses on the CP chip's data bus are memory-mapped to the following locations:

Address	Device	Description
0200h	Serial port data	Contains the configuration data (transmission rate, parity, stop bits, etc) for the asynchronous serial port
0800h	Parallel-word encoder	Base address for parallel-word feedback devices
1000h	User-defined	Base address for user-defined I/O devices
2000h	RAM page pointer	Page pointer to external memory
4000h	Reserved	Reserved for future use
8000h	I/O chip	Base address for I/O chip communications

3 Electrical Characteristics

3.1 DC characteristics

(V_{cc} and T_a per operating ratings, F_{clk} = 40.0 MHz)

Symbol	Parameter	Minimum	Maximum	Conditions
V_{cc}	Supply Voltage	4.75 V	5.25 V	
I_{dd}	Supply Current		120 mA	open outputs
	Input Voltages			
V_{ih}	Logic 1 input voltage	2.0 V	V_{cc} + 0.3 V	
V_{il}	Logic 0 input voltage	-0.3 V	0.8 V	
$V_{ihreset}$	Logic 1 voltage for reset pin (reset)	2.2 V	V_{cc} + 0.3 V	
	Output Voltages			
V_{oh}	Logic 1 Output Voltage	2.4 V		@CP I_o = -23 mA @I/O I_o = -6 mA
V_{ol}	Logic 0 Output Voltage		0.33 V	@CP I_o = 6 mA @I/O I_o = 6 mA
	Other			
I_{out}	Tri-State output leakage current	-5 μA	5 μA	@CP $0 < V_{out} < V_{cc}$
I_{in}	Input current	-10 μA -10 μA	10 μA -10 μA	@CP @I/O $0 < V_i < V_{cc}$
C_{io}	Input/Output capacitance	15 pF	 10 pF	@CP typical @I/O
	Analog Input			
Z_{ai}	Analog input source impedance		9kΩ	
E_{dnl}	Differential nonlinearity error. Difference between the step width and the ideal value.	-1	1.5 LSB	
E_{inl}	Integral nonlinearity error. Maximum deviation from the best straight line through the ADC transfer characteristics, excluding the quantization error.		+/-1.5 LSB	

3.2 AC characteristics

See timing diagrams, section 4, for *Tn* numbers. The symbol "~" indicates active low signal.

Timing Interval	*Tn*	Minimum	Maximum
Clock Frequency (F_{clk})		> 0 MHz	40 MHz *(note 1)*
Clock Pulse Width	T1	10 nsec	
Clock Period *(note 3)*	T2	25 nsec	
Encoder Pulse Width	T3	150 nsec	
Dwell Time Per State	T4	75 nsec	

Timing Interval	*Tn*	Minimum	Maximum
Index Setup and Hold (relative to Quad A and Quad B low)	T5	0 nsec	
~HostSlct Hold Time	T6	0 nsec	
~HostSlct Setup Time	T7	0 nsec	
HostCmd Setup Time	T8	0 nsec	
HostCmd Hold Time	T9	0 nsec	
Read Data Access Time	T10		25 nsec
Read Data Hold Time	T11		10 nsec
~HostRead High to HI-Z Time	T12		20 nsec
HostRdy Delay Time	T13	100 nsec	150 nsec
~HostWrite Pulse Width	T14	70 nsec	
Write Data Delay Time	T15		25 nsec
Write Data Hold Time	T16	0 nsec	
Read Recovery Time *(note 2)*	T17	60 nsec	
Write Recovery Time *(note 2)*	T18	60 nsec	
Read Pulse Width	T19	70 nsec	
Address Setup Delay Time	T20		7 nsec
Data Access Time	T21		19 nsec
Data Hold Time	T22		2 nsec
Address Setup Delay Time	T23		7 nsec
Address Setup to WriteEnable High	T24	72 nsec	
RAMSlct Low to WriteEnable High	T25		79 nsec
Address Hold Time	T26	17 nsec	
WriteEnable Pulse Width	T27	39 nsec	
Data Setup Time	T28		3 nsec
Data Setup before Write High Time	T29		42 nsec
Address Setup Delay Time	T30		7 nsec
Data Access Time	T31		71 nsec
Data Hold Time	T32		2 nsec
Address Setup Delay Time	T33		7 nsec
Address Setup to WriteEnable High	T34	122 nsec	
PeriphSlct Low to WriteEnable High	T35		129 nsec
Address Hold Time	T36	17 nsec	
WriteEnable Pulse Width	T37	89 nsec	
Data Setup Time	T38		3 nsec
Data Setup before Write High Time	T39		92 nsec
Read to Write Delay Time	T40	50 nsec	
Reset Low Pulse Width	T50	5.0 μsec	
RAMSlct Low to Strobe Low	T51		1 nsec
Strobe High to RAMSlct High	T52		4 nsec
WriteEnable Low to Strobe Low	T53		1 nsec
Strobe High to WriteEnable High	T54		3 nsec
PeriphSlct Low to Strobe Low	T55		1 nsec
Strobe High to PeriphSlct High	T56		4 nsec

Note 1 Performance figures and timing information valid at F_{clk} = 40.0 MHz only. For timing information and performance parameters at F_{clk} < 40.0 MHz refer to section 6.1.

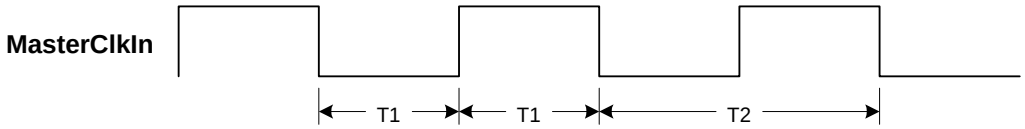
Note 2 For 8/8 and 8/16 interface modes only.

Note 3 The clock low/high split has an allowable range of 45-55%.

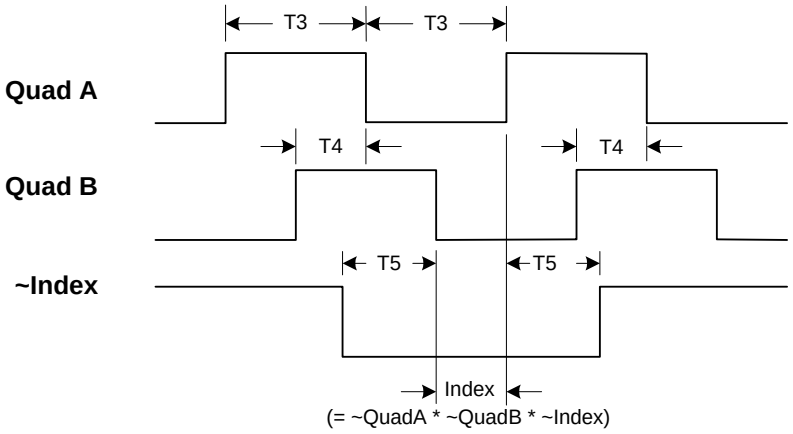
4 I/O Timing Diagrams

For the values of *Tn*, please refer to the table in Section 3.2.

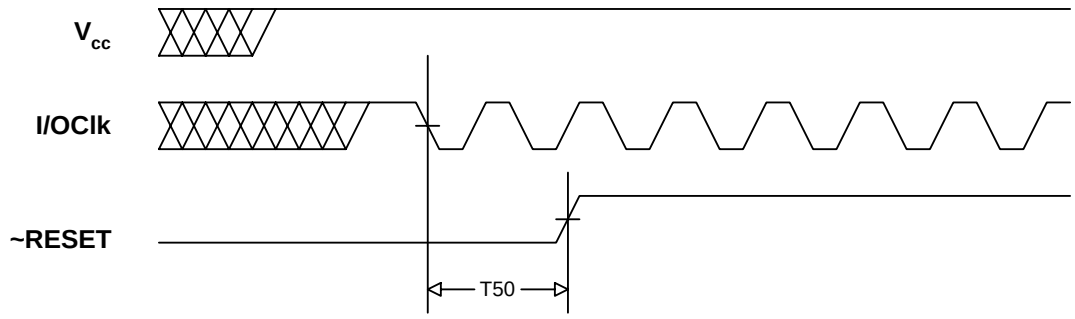
4.1 Clock



4.2 Quadrature encoder input

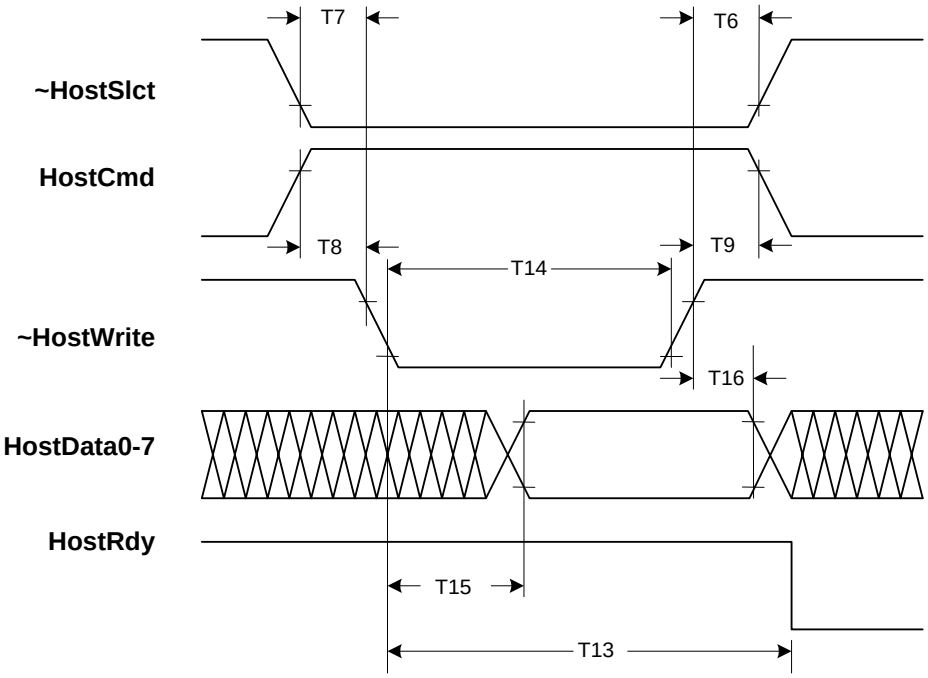


4.3 Reset

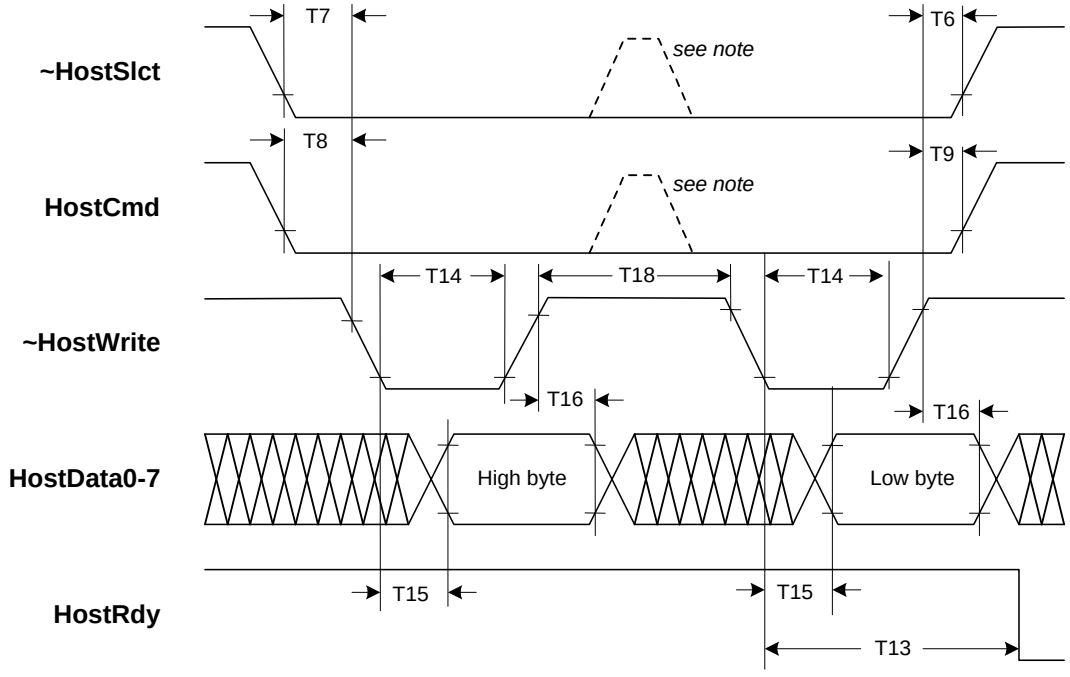


4.4 Host interface, 8/8 mode

4.4.1 Instruction write, 8/8 mode

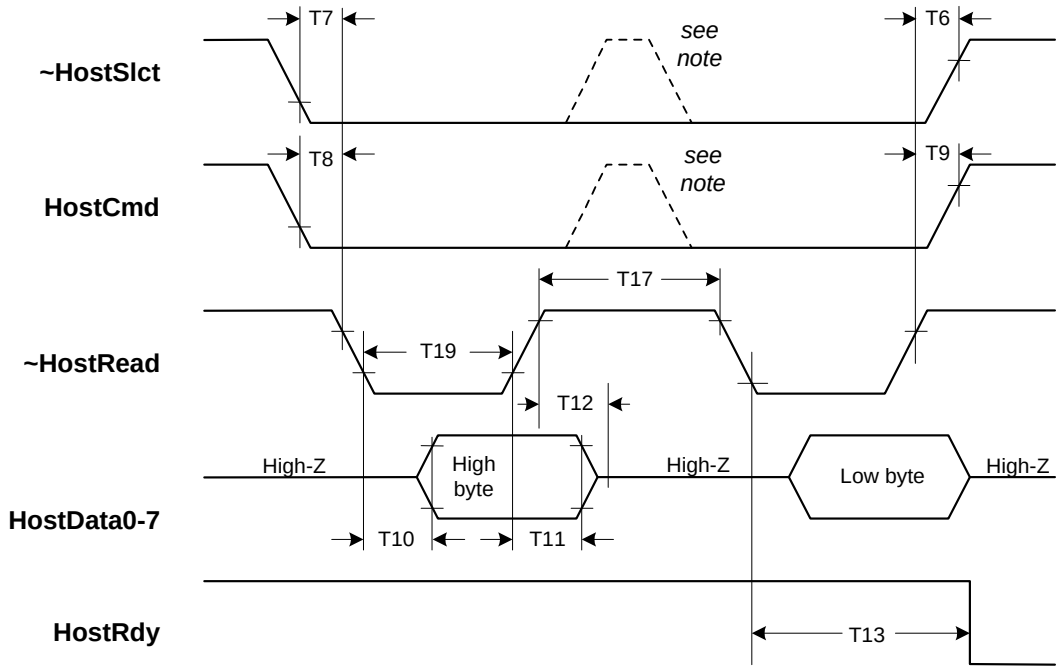


4.4.2 Data write, 8/8 mode



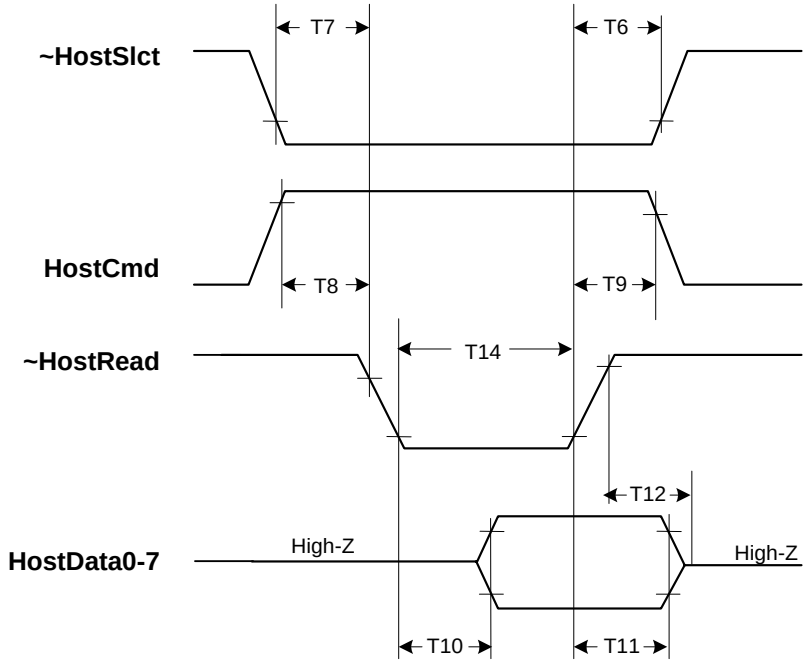
Note: If setup and hold times are met, ~HostSlct and HostCmd may be de-asserted at this point.

4.4.3 Data read, 8/8 mode



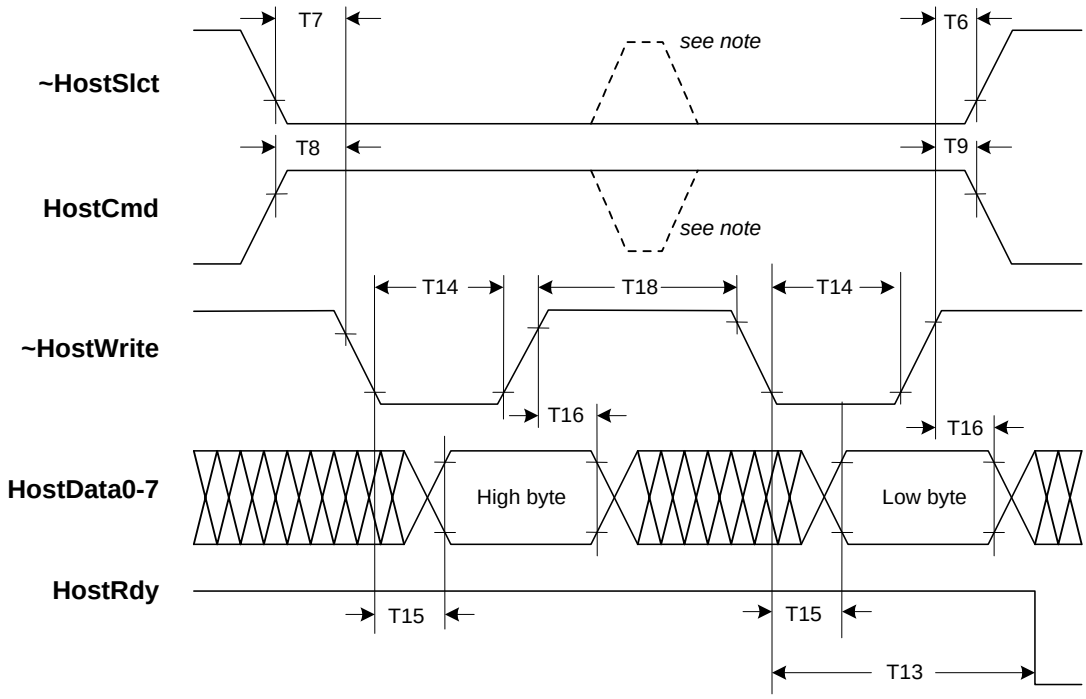
Note: If setup and hold times are met, ~HostSlct and HostCmd may be de-asserted at this point.

4.4.4 Status read, 8/8 mode



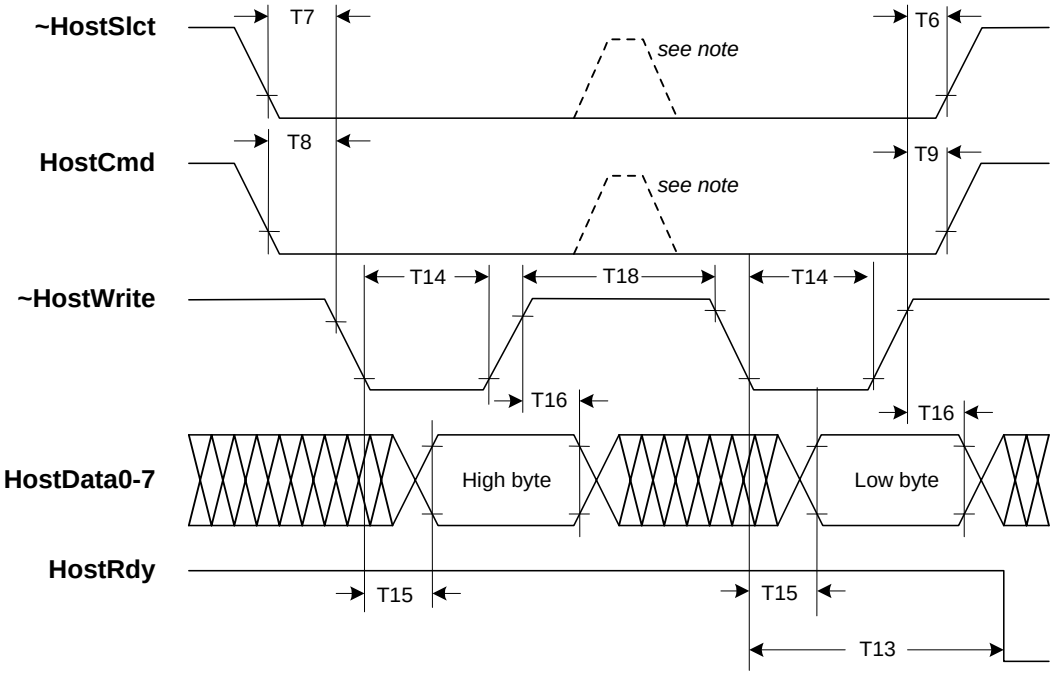
4.5 Host interface, 8/16 mode

4.5.1 Instruction write, 8/16 mode



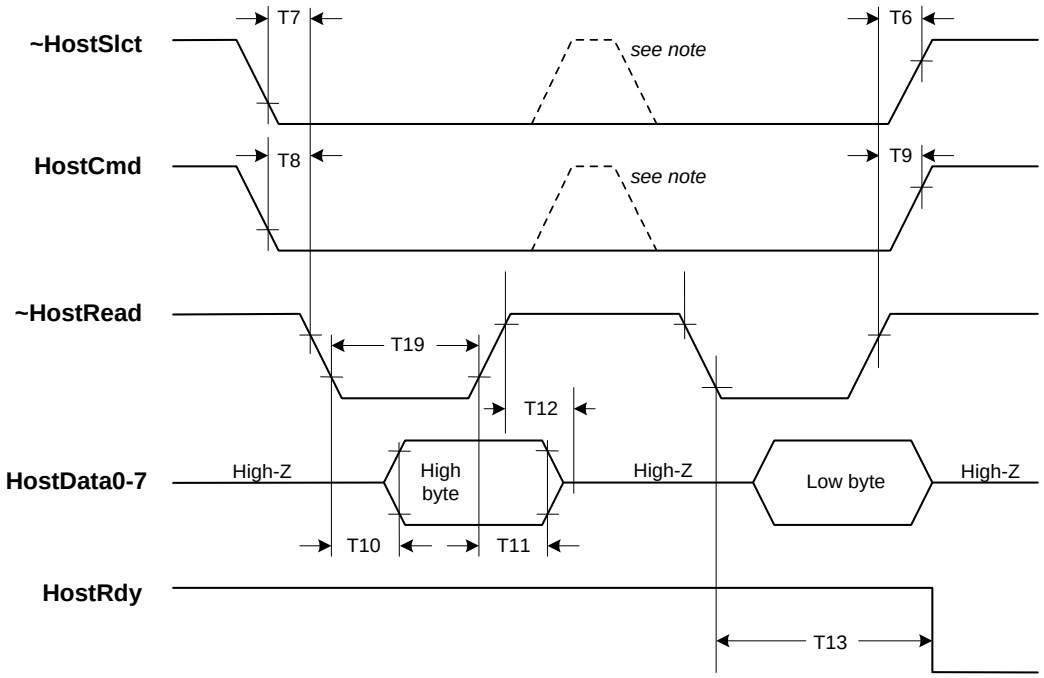
Note: If setup and hold times are met, ~HostSlct and HostCmd may be de-asserted at this point.

4.5.2 Data write, 8/16 mode



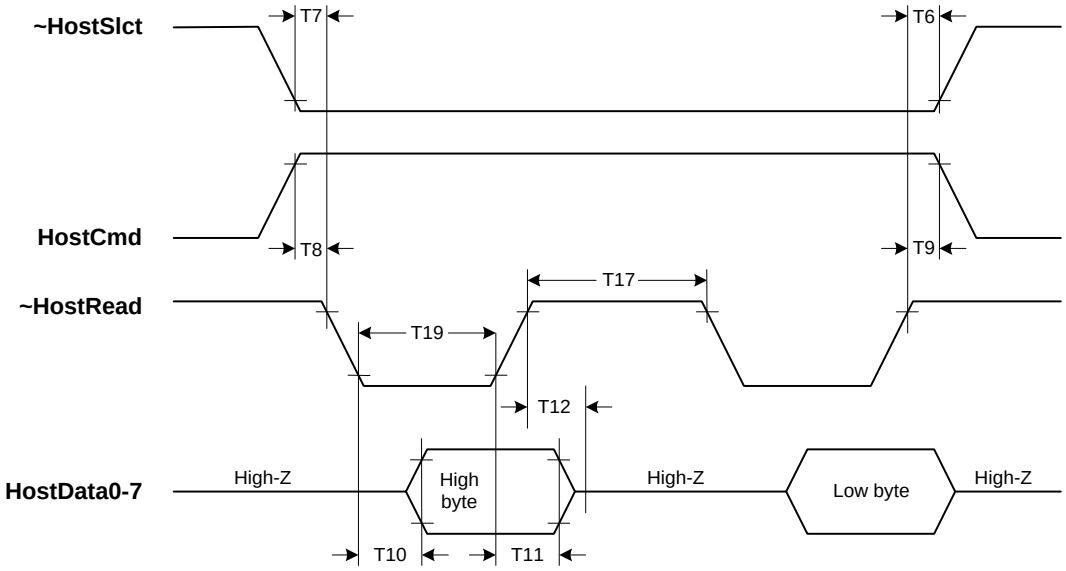
Note: If setup and hold times are met, ~HostSlct and HostCmd may be de-asserted at this point.

4.5.3 Data read, 8/16 mode



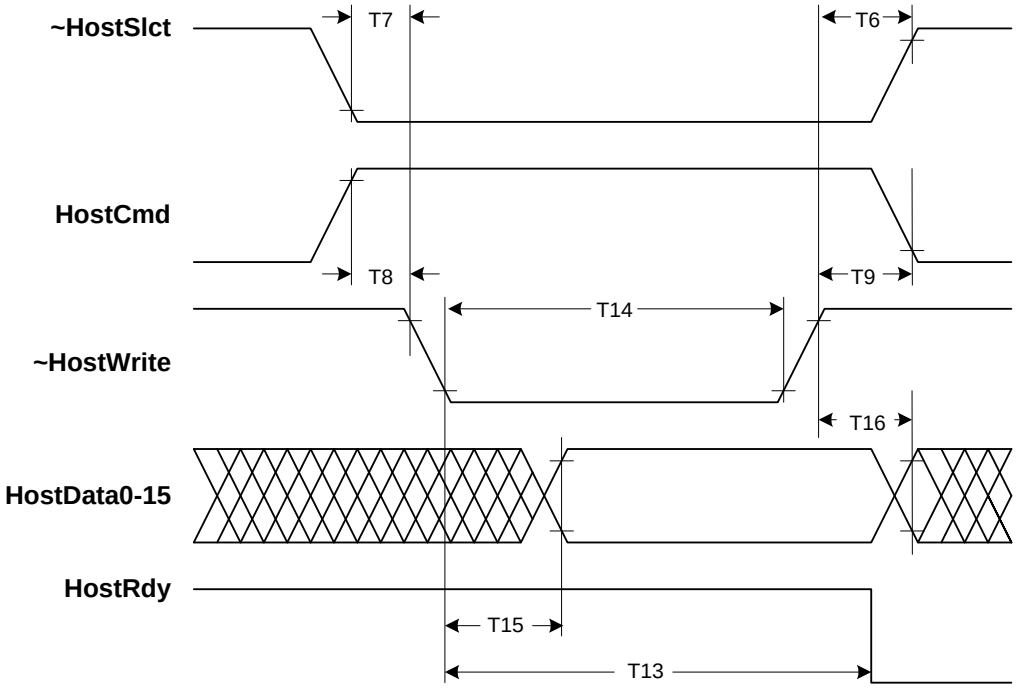
Note: If setup and hold times are met, ~HostSlct and HostCmd may be de-asserted at this point.

4.5.4 Status read, 8/16 mode

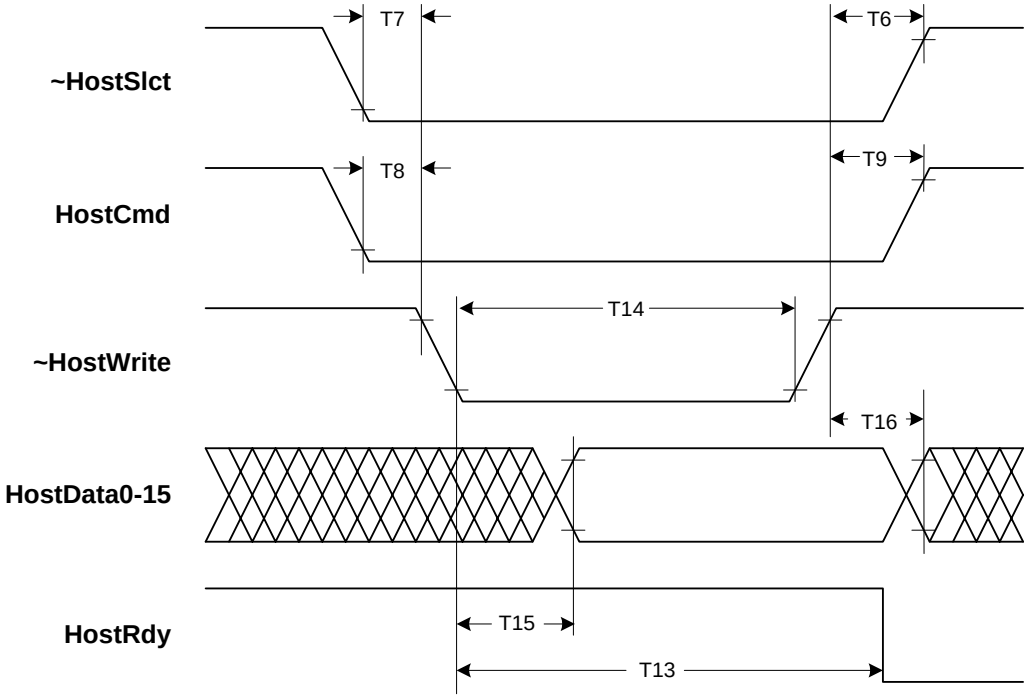


4.6 Host interface, 16/16 mode

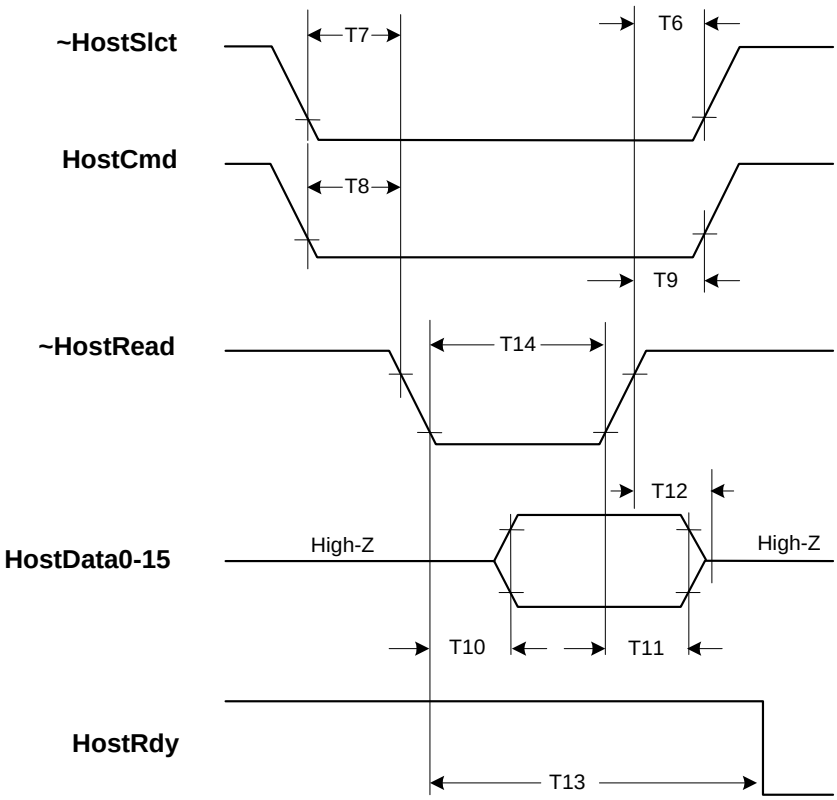
4.6.1 Instruction write, 16/16 mode



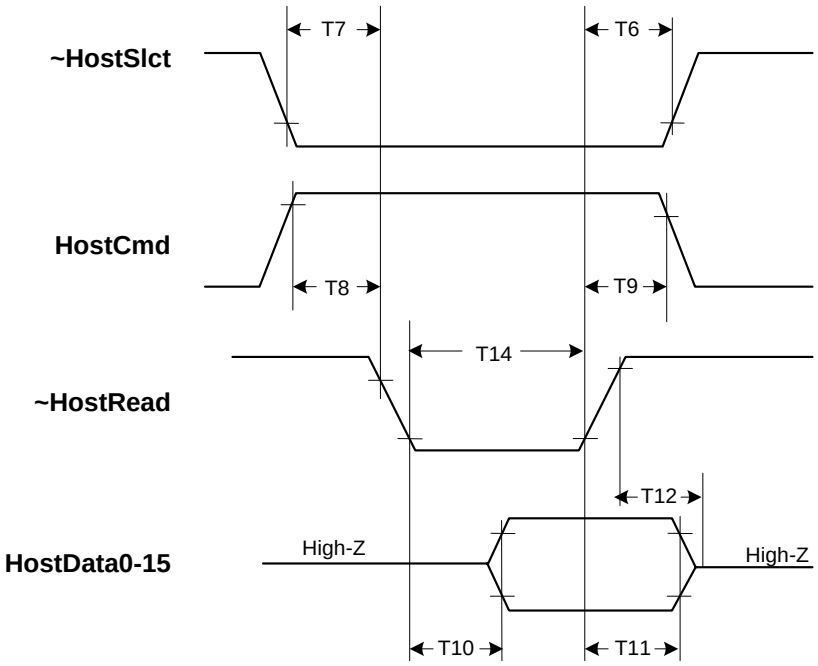
4.6.2 Data write, 16/16 mode



4.6.3 Data read, 16/16 mode



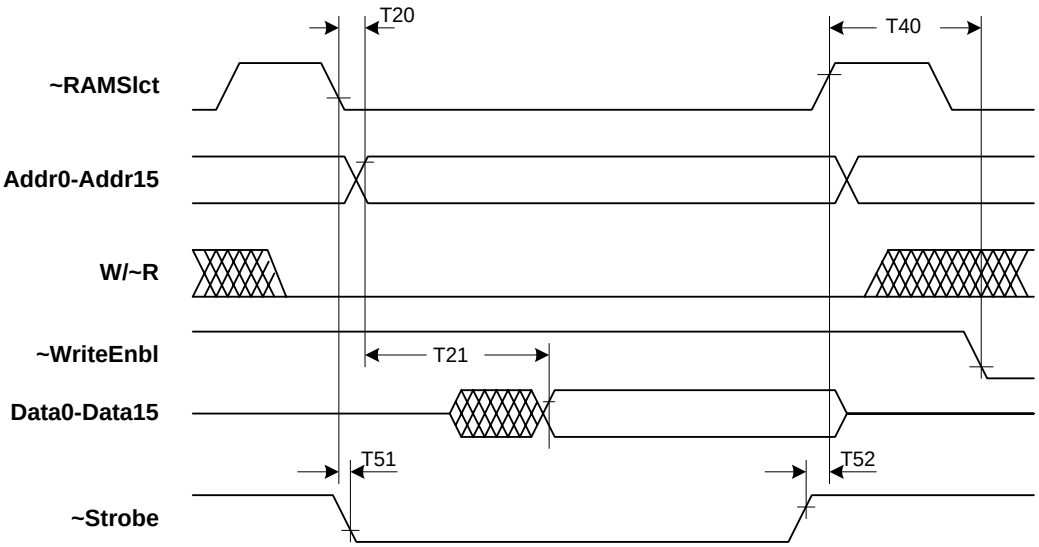
4.6.4 Status read, 16/16 mode



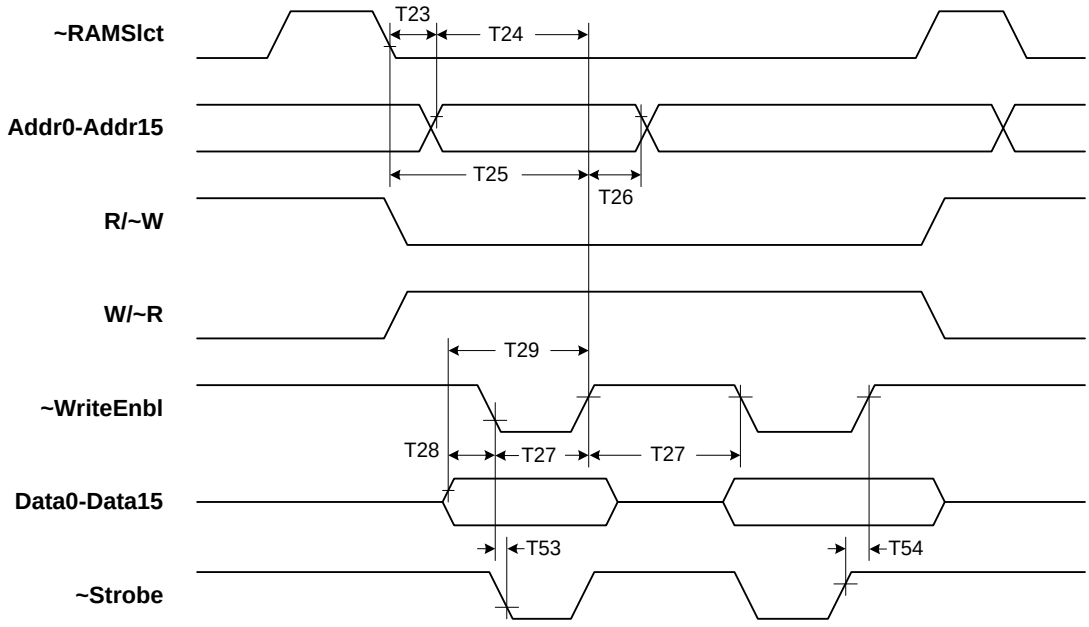
4.7 External memory timing

4.7.1 External memory read

Note: PMD recommends using memory with an access time no greater than 15 nsec.

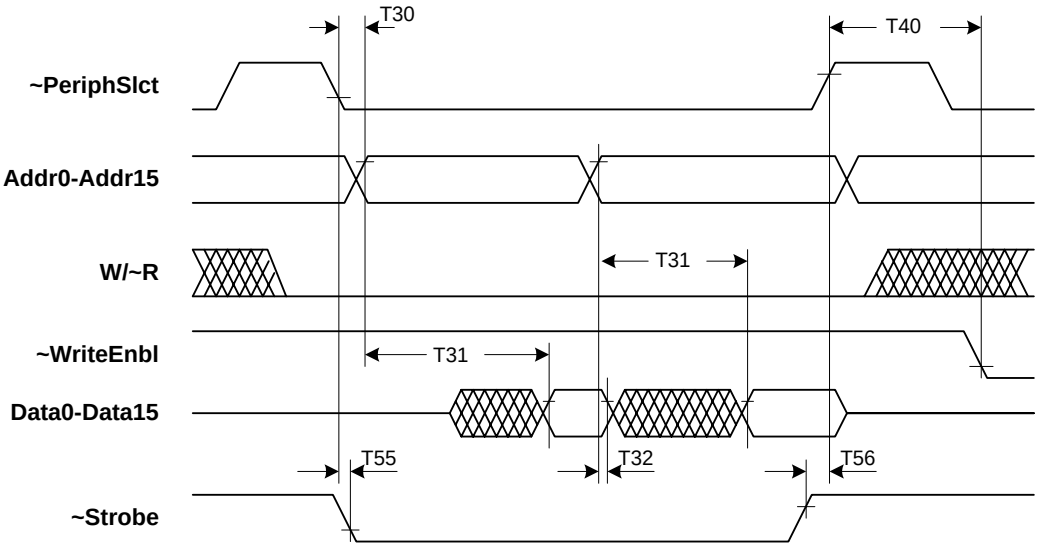


4.7.2 External memory write

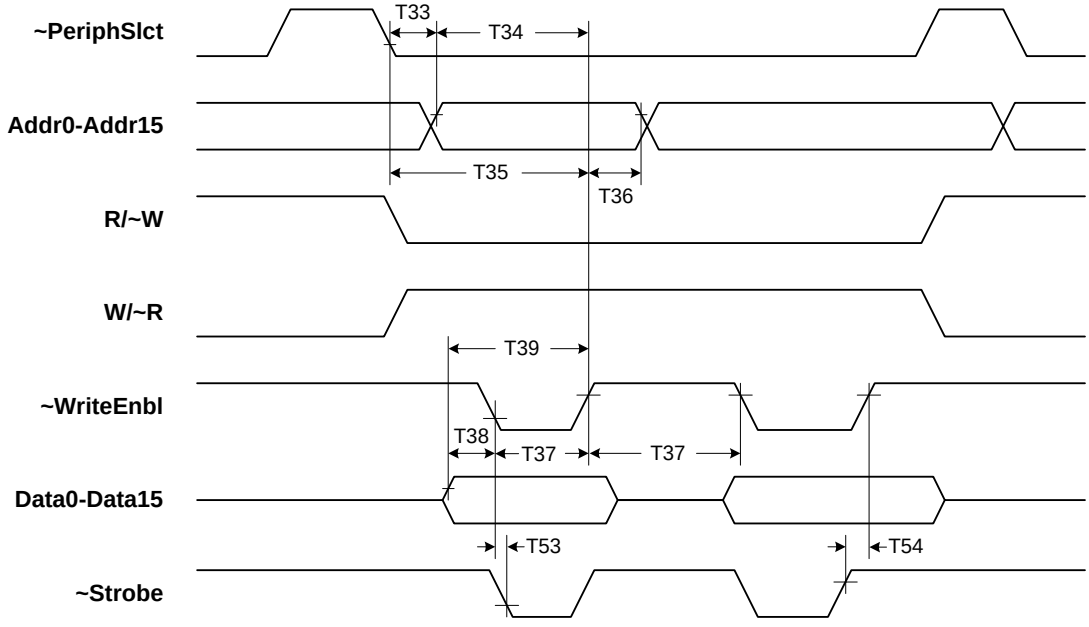


4.8 Peripheral device timing

4.8.1 Peripheral device read

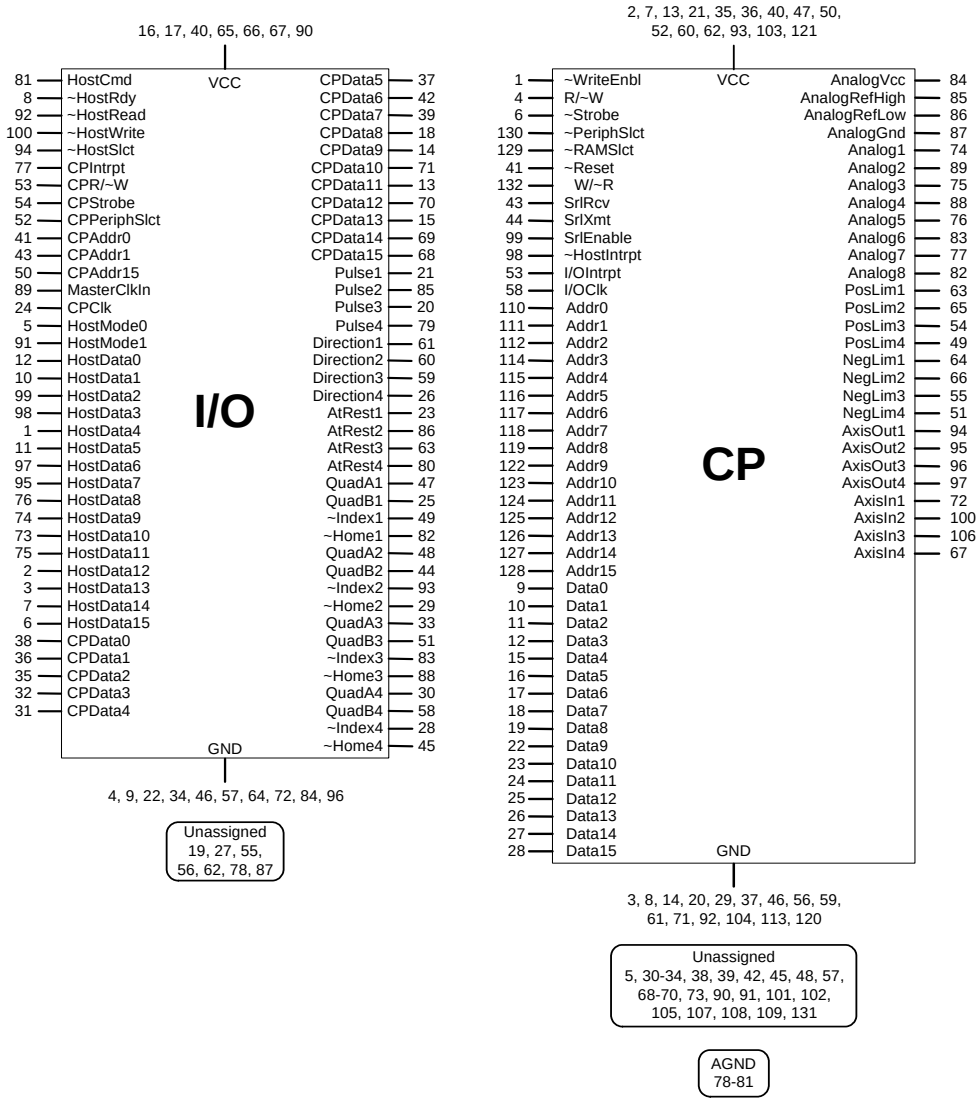


4.8.2 Peripheral device write

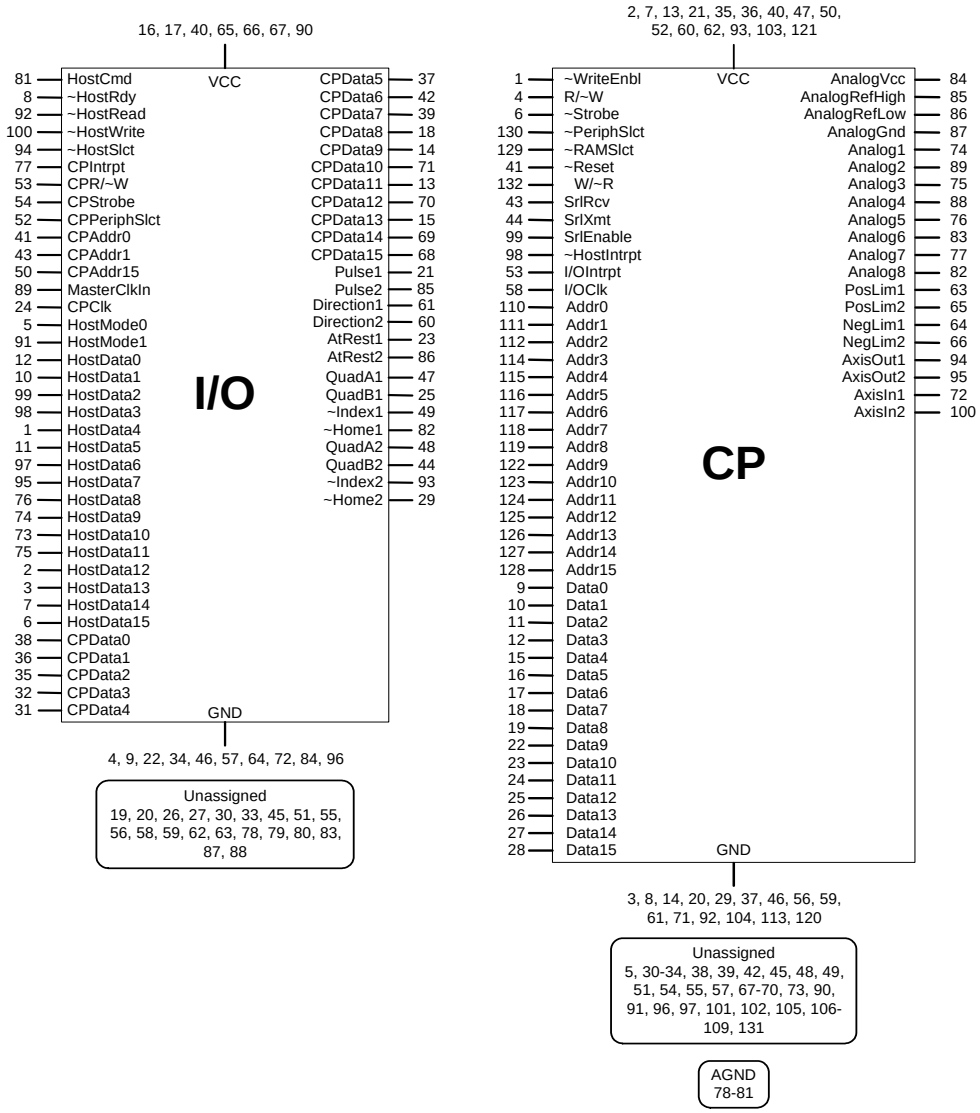


5 Pinouts and Pin Descriptions

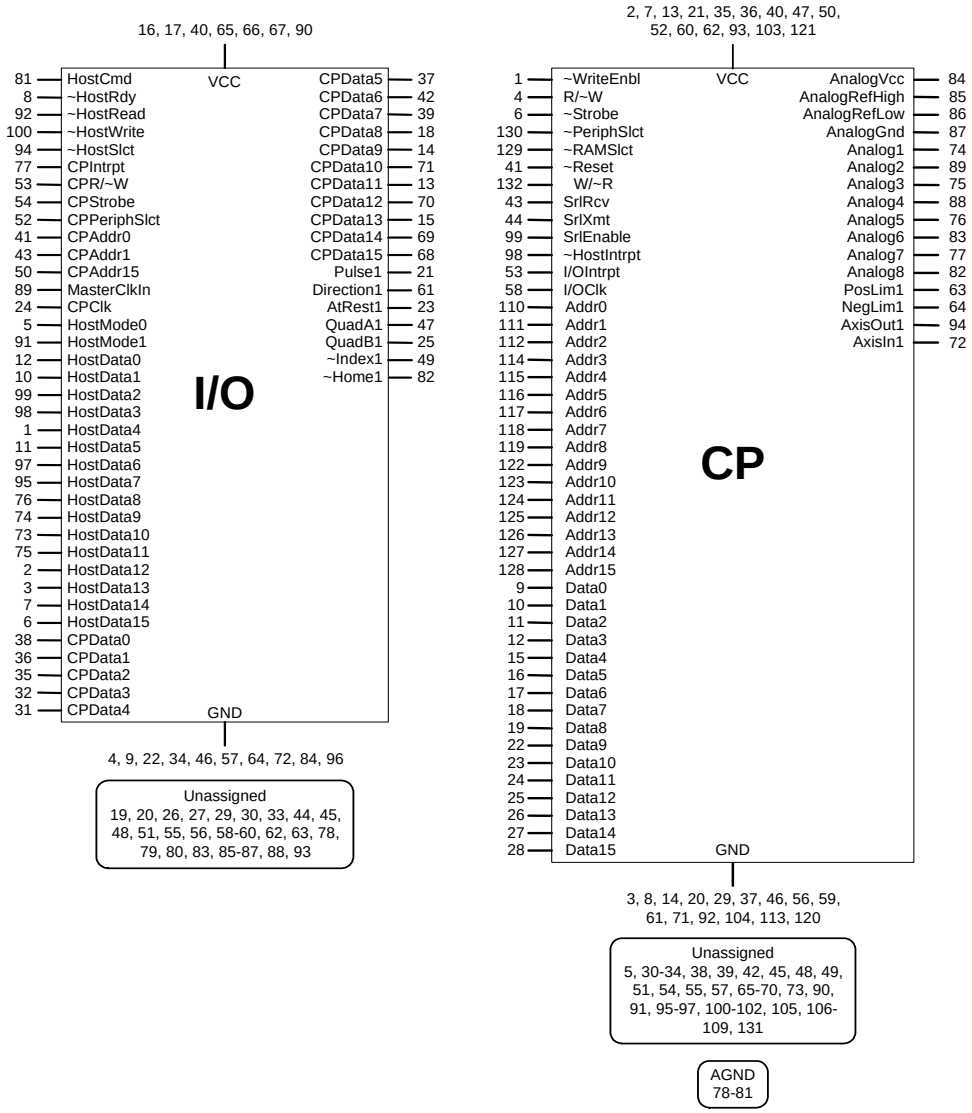
5.1 Pinouts for MC2542



5.2 Pinouts for MC2522



5.3 Pinouts for MC2512



5.4 Pin description tables

5.4.1 I/O chip

I/O Chip

Pin Name and Number		Direction	Description
HostCmd	81	Input	This signal is asserted *high* to write a host instruction to the Motion Processor, or to read the status of the HostRdy and HostIntrpt signals. It is asserted *low* to read or write a data word.
HostRdy	8	Output	This signal is used to synchronize communication between the Motion Processor and the host. HostRdy will go *low* (indicating host port busy) at the end of a read or write operation according to the interface mode in use, as follows: **Interface Mode** — **HostRdy goes low** 8/8 — after the instruction byte is transferred after the second byte of each data word is transferred 8/16 — after the second byte of the instruction word after the second byte of each data word is transferred 16/16 — after the 16-bit instruction word after each 16-bit data word serial — *n/a* HostRdy will go *high,* indicating that the host port is ready to transmit, when the last transmission has been processed. All host port communications must be made with HostRdy *high* (ready). A typical busy-to-ready cycle is 12.5 microseconds.
~HostRead	92	Input	When ~HostRead is *low*, a data word is read from the Motion Processor.
~HostWrite	100	Input	When ~HostWrite is *low*, a data word is written to the Motion Processor.
~HostSlct	94	Input	When ~HostSlct is *low*, the host port is selected for reading or writing operations.
CPIntrpt	77	Output	I/O chip to CP chip interrupt. This signal sends an interrupt to the CP chip whenever a host–chipset transmission occurs. It should be connected to CP chip pin 53, I/OIntrpt.
CPR/~W	53	Input	This signal is *high* when the I/O chip is reading data from the I/O chip, and *low* when it is writing data. It should be connected to CP chip pin 4, R/W.
CPStrobe	54	Input	This signal goes *low* when the data and address become valid during Motion Processor communication with peripheral devices on the data bus, such as external memory or a DAC. It should be connected to CP chip pin 6, Strobe.
CPPeriphSlct	52	Input	This signal goes *low* when a peripheral device on the data bus is being addressed. It should be connected to CP chip pin 130, PeriphSlct.
CPAddr0 CPAddr1 CPAddr15	41 43 50	Input	These signals are *high* when the CP chip is communicating with the I/O chip (as distinguished from any other device on the data bus). They should be connected to CP chip pins 110 (Addr0), 111 (Addr1), and 128 (Addr15).
MasterClkIn	89	Input	This is the master clock signal for the Motion Processor. It is driven at a nominal 40 MHz
CPClk	24	Output	This signal provides the clock pulse for the CP chip. Its frequency is half that of MasterClkIn (pin 89), or 20 MHz nominal. It is connected directly to the CP chip I/Oclk signal (pin 58).

I/O Chip

Pin Name and Number		Direction	Description
HostMode1 HostMode0	91 5	Input	These two signals determine the host communications mode, as follows: HostMode1 HostMode0 0 0 16/16 parallel (16-bit bus, 16-bit instruction) 0 1 8/8 parallel (8-bit bus, 8-bit instruction) 1 0 8/16 parallel (8-bit bus, 16-bit instruction) 1 1 serial
HostData0 HostData1 HostData2 HostData3 HostData4 HostData5 HostData6 HostData7 HostData8 HostData9 HostData10 HostData11 HostData12 HostData13 HostData14 HostData15	12 10 99 98 1 11 97 95 76 74 73 75 2 3 7 6	Bi-directional, tri-state	These signals transmit data between the host and the Motion Processor through the parallel port. Transmission is mediated by the control signals ~HostSlct, ~HostWrite, ~HostRead and HostCmd. In 16 bit mode, all 16 bits are used (HostData0-15). In 8 bit mode, only the low-order 8 bits of data are used (HostData0-7). The HostMode0 and HostMode1 signals select the communication mode this port operates in.
CPData0 CPData1 CPData2 CPData3 CPData4 CPData5 CPData6 CPData7 CPData8 CPData9 CPData10 CPData11 CPData12 CPData13 CPData14 CPData15	38 36 35 32 31 37 42 39 18 14 71 13 70 15 69 68	Bi-directional	These signals transmit data between the I/O chip and pins Data0-15 of the CP chip, via the Motion Processor data bus.
Pulse1 Pulse2 Pulse3 Pulse4	21 85 20 79	Output	These pins provide the Pulse signal to the motor. This signal is always a square wave, regardless of the pulse rate. A "step" occurs when the signal transitions from a high state to a low state. For the MC2542 all 4 pins are valid. For MC2522 only Pulse1 and Pulse2 are valid. For MC2512 only Pulse1 is valid. Invalid axis pins may be left unconnected.
Direction1 Direction2 Direction3 Direction4	61 60 59 26	Output	These pins indicate the direction of motion and work in conjunction with the pulse signal. A high level on this signal indicates a positive direction move and a low level indicates a negative direction move. For MC2542 all 4 pins are valid. For MC2522 only Direction1 and Direction2 are valid. For MC2512 only Direction1 is valid. Invalid axis pins may be left unconnected.

I/O Chip

Pin Name and Number		Direction	Description
AtRest1 AtRest2 AtRest3 AtRest4	23 86 63 80	Output	The AtRest signal indicates the axis is at rest and the step motor can be switched to low power or standby. A high level on this signal indicates the axis is at rest. A low signal indicates the axis is in motion. For MC2542 all 4 pins are valid. For MC2522 only AtRest1 and AtRest2 are valid. For MC2512 only AtRest1 is valid. Invalid axis pins may be left unconnected.
QuadA1 QuadB1 QuadA2 QuadB2 QuadA3 QuadB3 QuadA4 QuadB4	47 25 48 44 33 51 30 58	Input	These pins provide the A and B quadrature signals for the incremental encoder for each axis. When the axis is moving in the positive (forward) direction, signal A leads signal B by 90°. The theoretical maximum encoder pulse rate is 5.1 MHz. Actual maximum rate will vary, depending on signal noise. **NOTE**: Many encoders require a pull-up resistor on each signal to establish a proper high signal. Check your encoder's electrical specifications. For MC2542, all 8 pins are valid. For MC2522, only the first four pins (axes 1 and 2) are valid. For MC2512, only the first two pins (axis 1) are valid. **WARNING! If a valid axis pin is not used, its signal should be tied high.** Invalid axis pins may be left unconnected.
~Index1 ~Index2 ~Index3 ~Index4	49 93 83 28	Input	These pins provide the Index quadrature signals for the incremental encoders. A valid index pulse is recognized by the chipset when ~Index, A, and B are all *low*. For MC2542, all 4 pins are valid. For MC2522, only ~Index1 and ~Index2 are valid. For MC2512, only ~Index1 is valid. **WARNING! If a valid axis pin is not used, its signal should be tied high.** Invalid axis pins may be left unconnected.
~Home1 ~Home2 ~Home3 ~Home4	82 29 88 45	Input	These pins provide the Home signals, general-purpose inputs to the position-capture mechanism. A valid Home signal is recognized by the chipset when ~Home*n* goes *low*. These signals are similar to ~Index, but are not gated by the A and B encoder channels. For MC2142, all 4 pins are valid. For MC2122, only ~Home1 and ~Home2 are valid. For MC2112, only ~Home1 is valid. **WARNING! If a valid axis pin is not used, its signal should be tied high.** Invalid axis pins may be left unconnected.
Vcc	16, 17, 40, 65, 66, 67, 90		All of these pins must be connected to the I/O chip's digital supply voltage, which should be in the range 4.75 to 5.25 V.
GND	4, 9, 22, 34, 46, 57, 64, 72, 84, 96		I/O chip ground. All of these pins must be connected to the digital power supply return.
unassigned	19, 27, 55, 56, 62, 78, 87		These pins must be left unconnected (floating).

5.4.2 CP chip

CP chip

Pin Name and Number		Direction	Description
~WriteEnbl	1	Output	When *low*, this signal enables data to be written to the bus.
R/~W	4	Output	This signal is *high* when the CP chip is performing a read, and *low* when it is performing a write. It should be connected to I/O chip pin 53, CPR/~W.
~Strobe	6	Output	This signal is *low* when the data and address are valid during CP communications. It should be connected to I/O chip pin 54, CPStrobe.
~PeriphSlct	130	Output	This signal is *low* when peripheral devices on the data bus are being addressed. It should be connected to I/O chip pin 52, CPPeriphSlct.
~RAMSlct	129	Output	This signal is *low* indicates that external memory is being accessed.
~Reset	41	Input	This is the master reset signal. When brought *low*, this pin resets the chipset to its initial conditions.
W/~R	132	Output	This signal is the inverse of R/~W; it is *high* when R/~W is low, and vice versa. For some decode circuits, this is more convenient than R/~W.
SrlRcv	43	Input	This pin receives serial data from the serial transceiver. **NOTE! If this signal is not used, it should be tied high.**
SrlXmt	44	Output	This pin transmits serial data to the asynchronous serial port.
SrlEnable	99	Output	This pin sets the serial port enable line. SrlEnable is always *high* for the point-to-point protocol and is *high* during transmission for the multi-drop protocol.
~HostIntrpt	98	Output	When *low*, this signal causes an interrupt to be sent to the host processor.
I/OIntrpt	53	Input	This signal interrupts the CP chip when a host I/O transfer is complete. It should be connected to I/O chip pin 77, CPIntrpt.
Data0 Data1 Data2 Data3 Data4 Data5 Data6 Data7 Data8 Data9 Data10 Data11 Data12 Data13 Data14 Data15	9 10 11 12 15 16 17 18 19 22 23 24 25 26 27 28	Bi-directional	Multi-purpose data lines. These pins comprise the CP chip's external data bus, used for all communications with the I/O chip and peripheral devices such as external memory or DACs. They may also be used for parallel-word input and for user-defined I/O operations.

CP chip

Pin Name and Number		Direction	Description
Addr0 Addr1 Addr2 Addr3 Addr4 Addr5 Addr6 Addr7 Addr8 Addr9 Addr10 Addr11 Addr12 Addr13 Addr14 Addr15	110 111 112 114 115 116 117 118 119 122 123 124 125 126 127 128	Output	Multi-purpose Address lines. These pins comprise the CP chip's external address bus, used to select devices for communication over the data bus. Addr0, Addr1, and Addr15 are connected to the corresponding CPAddr pins on the I/O chip, and are used to communicate between the CP and I/O chips. Other address pins may be used for DAC output, parallel word input, or user-defined I/O operations. See the *Navigator Motion Processor User's Guide* for a complete memory map.
I/OClk	58	Input	This is the CP chip clock signal. It should be connected to I/O chip pin 24, CPClk.
AnalogVcc	84	Input	CP chip analog power supply voltage. This pin must be connected to the analog input supply voltage, which must be in the range 4.5-5.5 V If the analog input circuitry is not used, this pin must be connected to V_{cc}.
AnalogRefHigh	85	Input	CP chip analog high voltage reference for A/D input. The allowed range is AnalogRefLow to AnalogVcc. If the analog input circuitry is not used, this pin must be connected to V_{cc}.
AnalogRefLow	86	Input	CP chip analog low voltage reference for A/D input. The allowed range is AnalogGND to AnalogRefHigh. If the analog input circuitry is not used, this pin must be connected to GND.
AnalogGND	87	Input	CP chip analog input ground. This pin must be connected to the analog input power supply return. If the analog input circuitry is not used, this pin must be connected to GND.
Analog1 Analog2 Analog3 Analog4 Analog5 Analog6 Analog7 Analog8	74 89 75 88 76 83 77 82	Input	These signals provide general-purpose analog voltage levels, which are sampled by an internal A/D converter. The A/D resolution is 10 bits. The allowed range is AnalogRefLow to AnalogRefHigh. Any unused pins should be tied to AnalogGND. If the analog input circuitry is not used, these pins should be tied to GND.
PosLim1 PosLim2 PosLim3 PosLim4	63 65 54 49	Input	These signals provide inputs from the positive-side (forward) travel limit switches. On power-up or Reset these signals default to active *low* interpretation, but the interpretation can be set explicitly using the SetSignalSense instruction. For MC2542, all 4 pins are valid. For MC2522, only PosLim1 and PosLim2 are valid. For MC2512, only PosLim1 is valid. **WARNING! If a valid axis pin is not used, its signal must be tied high. PosLim2 is an output during device reset and as such any connection to GND or V_{cc} must be via a series resistor.** Invalid axis pins may also be left unconnected or connected to GND.

CP chip

Pin Name and Number		Direction	Description
NegLim1 NegLim2 NegLim3 NegLim4	64 66 55 51	Input	These signals provide inputs from the negative-side (reverse) travel limit switches. On power-up or Reset these signals default to active *low* interpretation, but the interpretation can be set explicitly using the SetSignalSense instruction. For MC2542, all 4 pins are valid. For MC2522, only NegLim1 and NegLim2 are valid. For MC2512, only NegLim1 is valid. **WARNING! If a valid axis pin is not used, its signal must be tied high. NegLim1 is an output during device reset and as such any connection to GND or V_{cc} must be via a series resistor.** Invalid axis pins may also be left unconnected or connected to GND.
AxisOut1 AxisOut2 AxisOut3 AxisOut4	94 95 96 97	Output	Each of these pins can be conditioned to track the state of any bit in the Status registers associated with its axis. For MC2542, all 4 pins are valid. For MC2522, only AxisOut1 and AxisOut2 are valid. For MC2512, only AxisOut1 is valid. Invalid or unused pins may be left unconnected.
AxisIn1 AxisIn2 AxisIn3 AxisIn4	72 100 106 67	Input	These are general-purpose programmable inputs. They may be used as a breakpoint input, to stop a motion axis, or to cause an UPDATE to occur. For MC2542, all 4 pins are valid. For MC2522, only AxisIn1 and AxisIn2 are valid. For MC2512, only AxisIn1 is valid. Invalid or unused pins may be left unconnected or connected to GND.
V_{cc}	2, 7, 13, 21, 35, 36, 40, 47, 50, 52, 60, 62, 93, 103, 121		CP digital supply voltage. All of these pins must be connected to the supply voltage. V_{cc} must be in the range 4.75 - 5.25 V **WARNING! Pin 35 must be tied HIGH with a pull-up resistor. A nominal value of 22K Ohms is suggested.**
GND	3, 8, 14, 20, 29, 37, 46, 56, 59, 61, 71, 92, 104, 113, 120		CP ground. All of these pins must be connected to the power supply return.
AGND	78-81		These signals must be tied to AnalogGND. If the analog input circuitry is not used, these pins must be tied to GND.
unassigned (MC2542)	45, 48, 68, 69, 70, 73, 90, 91, 101, 102, 105, 107, 108, 109		These signals may be connected to GND for better noise immunity and reduced power consumption or they can be left unconnected (floating).
unassigned	5, 30-34, 38, 39, 42, 57, 131		These signals must be left unconnected (floating).

6 Application Notes

6.1 Design Tips

The following are recommendations for the design of circuits that utilize a PMD Motion Processor.

Serial Interface

The serial interface is a convenient interface that can be used before host software has been written to communicate through the parallel interface. It is recommended that even if the serial interface is not utilized as a standard communication interface, that the serial receive and transmit signals are brought to test points so that they may be connected during initial board configuration/debugging. This is especially important during the prototype phase. The serial receive line should include a pull-up resistor to avoid spurious interrupts when it is not connected to a transceiver.

If the serial configuration decode logic is not implemented (see section 6.3) and the serial interface may be used for debugging as mentioned above, the CP data bus should be tied high. This places the serial interface in a default configuration of 9600,n,8,1 after power on or reset.

Controlling pulse output during reset

When the motion processor is in a reset state (when the reset line is held low) or immediately after a power on, the pulse outputs can be in an unknown state, causing undesirable motor movement. It is recommended that the enable line of any motor amplifier be held in a disabled state by the host processor or some logic circuitry until communication to the motion processor is established. This can be in the form of a delay circuit on the amplifier enable line after power up, or the enable line can be ANDed with the CP reset line.

Parallel word encoder input

When using parallel word input for motor position, it is useful to also decode this information into the User I/O space. This allows the current input value to be read using the chip instruction ReadIO for diagnostic purposes.

Using a non standard system clock frequency

It is often desirable to share a common clock among several components in a design. In the case of the PMD Motion Processors it is possible to use a clock below the standard value of 40MHz. In this case all system frequencies will be reduced as a fraction of the input clock verses the standard 40MHz clock. The list below shows the affected system parameters:-

- Serial baud rate
- Maximum pulse rate
- Timing characteristics as shown in section 3.2
- Cycle time

For example, if an input clock of 34MHz is used with a serial baud rate of 9600 and the step range (SetStepRange) set to 625KHz the following timing changes will result:-

- Serial baud rate decreases to 9600 bps *34/40 = 8160 bps
- Maximum step rate decreases to 625 KHz *34/40 = 531.25 KHz
- Cycle time per axis increases to 102.4 μsec *40/34 = 120.48 μsec

6.2 ISA Bus Interface

A complete, ready-to-use ISA (PC/AT) bus interface circuit has been provided to illustrate Navigator host interfacing, as well as to make it easier for the customer to build a Navigator development system.

The interface between the PMD Navigator chipset and the ISA (PC-AT) bus is shown on the following page.

Comments on Schematic

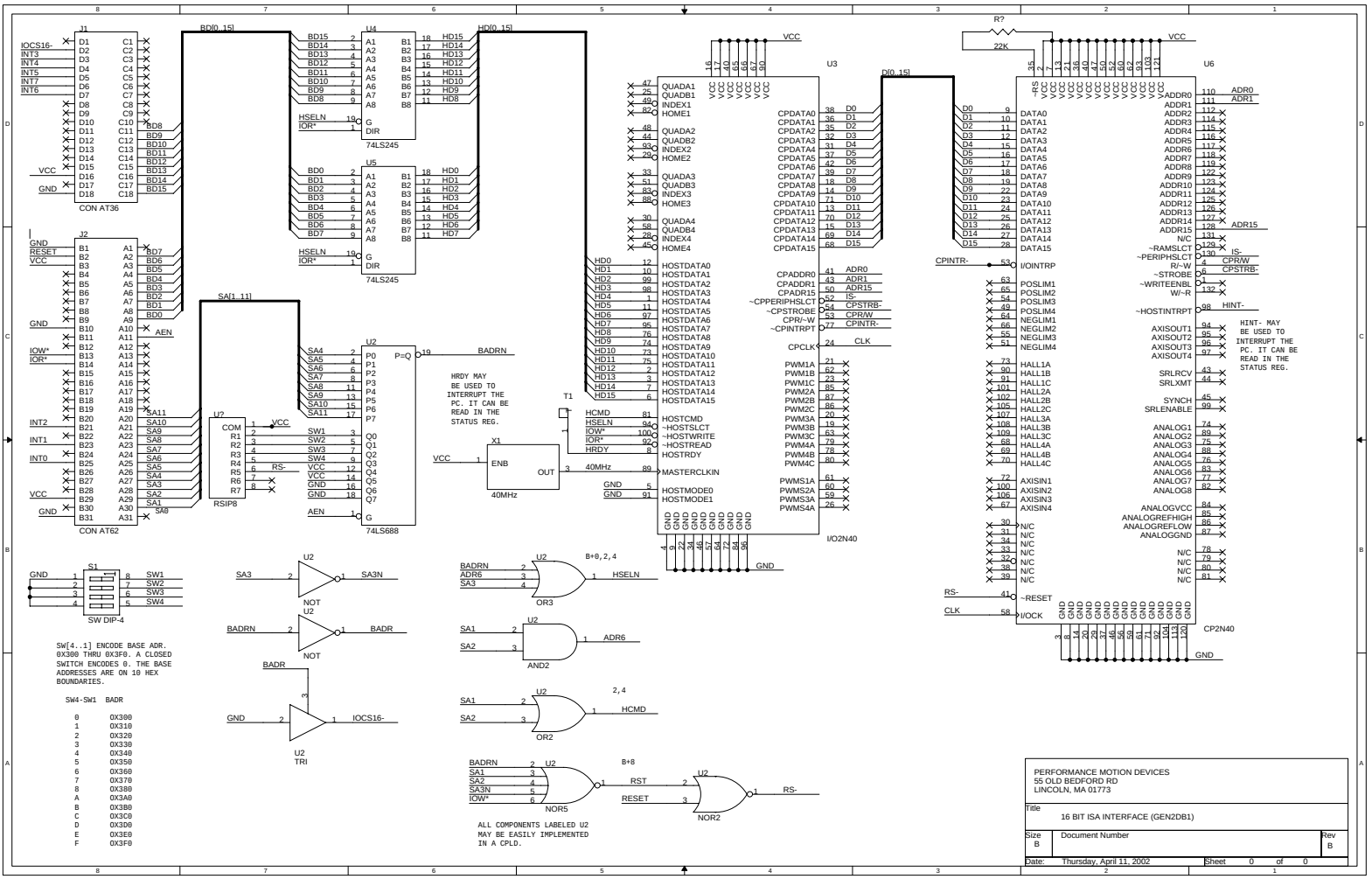
This interface uses a CPLD and two 74LS245s to buffer the data lines. This interface assumes a base address is assigned in the address space of A9-A0, 300-400 hex. These addresses are generally available for prototyping and other system-specific uses without interfering with system assignments. This interface occupies 16 addresses from XX0 to XXF hex though it does not use all the addresses. Four select lines are provided allowing the base address to be set from 300 to 3F0 hex for the select lines SW1-SW4 equal to 0- F respectively. The address assignments used are as follows, where BADR is the base address, 340 hex for example:

Address	use
340h	read-write data
342h	write command -read status
344h	write command -read status
348h	write reset [Data = don't care]

The base address (BADR) is decoded in the 74LS688. It is combined with SA1, SA2, and SA3, (BADR+0,2,4) to form HSELN to select the I/O chip and the 245's. (BADR+2,4) asserts HCMD.

Two addresses are used to be compatible with the first generation products, which used BADR+2 to write command and BADR+4 to read status.

B+8 and IOW* generate a reset pulse, -RS, for the CP chip. The reset instruction is OR'd with RESET on the bus to initialize the PMD chipset when the PC is reset.

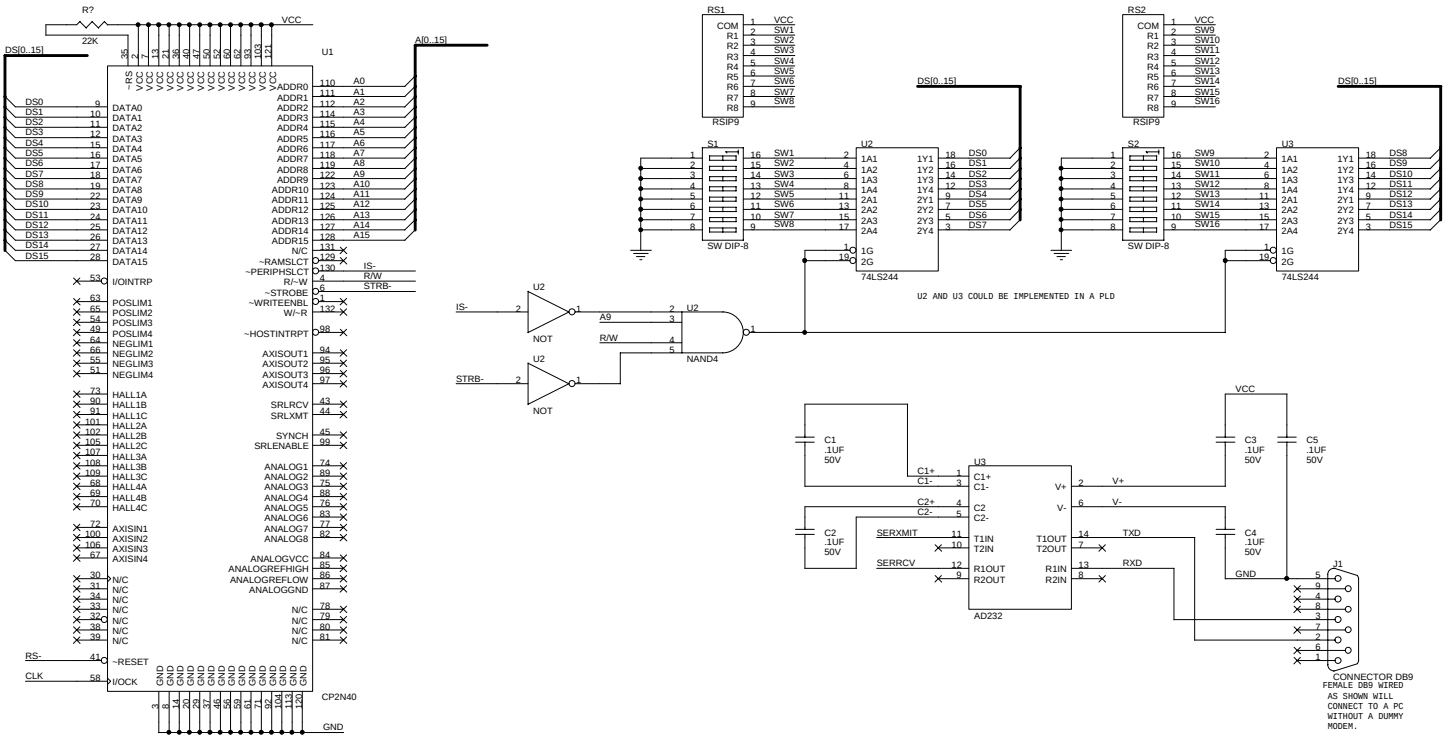

J1
CON AT36
J2
CON AT62
U4
74LS245
U5
74LS245
U2
74LS688
U3
I/O2N40
U6
CP2N40
R?
22K
VCC
GND
BD[0..15]
HD[0..15]
SA[1..11]
P[0..15]
HSELN
IOR*
DIR
AEN
BADRN
HRDY MAY BE USED TO INTERRUPT THE PC. IT CAN BE READ IN THE STATUS REG.
HINT- MAY BE USED TO INTERRUPT THE PC. IT CAN BE READ IN THE STATUS REG.
T1
X1
40MHz
ENB
OUT
RSIP8
COM
S1
SW DIP-4
SW[4..1] ENCODE BASE ADR. 0X300 THRU 0X3F0. A CLOSED SWITCH ENCODES 0. THE BASE ADDRESSES ARE ON 10 HEX BOUNDARIES.
SW4-SW1 BADR
0 0X300
1 0X310
2 0X320
3 0X330
4 0X340
5 0X350
6 0X360
7 0X370
8 0X380
A 0X3A0
B 0X3B0
C 0X3C0
D 0X3D0
E 0X3E0
F 0X3F0
NOT
TRI
AND2
OR2
OR3
NOR5
NOR2
B+0,2,4
2,4
B+8
ALL COMPONENTS LABELED U2 MAY BE EASILY IMPLEMENTED IN A CPLD.
PERFORMANCE MOTION DEVICES
55 OLD BEDFORD RD
LINCOLN, MA 01773
Title
16 BIT ISA INTERFACE (GEN2DB1)
Size B
Document Number
Rev B
Date: Thursday, April 11, 2002
Sheet 0 of 0

6.3 RS-232 Serial Interface

The interface between the Navigator chipset and an RS-232 serial port is shown in the following figure.

Comments on Schematic

S1 and S2 encode the characteristics of the serial port such as baud rate, number of stop bits, parity, etc. The CP will read these switches during initialization, but these parameters may also be set or changed using the SetSerialPort chipset command. The DB9 connector wired as shown can be connected directly to the serial port of a PC without requiring a null modem cable.



PERFORMANCE MOTION DEVICES
55 OLD BEDFORD RD
LINCOLN, MA 01773

Title: RS232 SERIAL INTERFACE (GEN2DG1)

Size: B | Document Number | Rev: B

Date: Thursday, April 11, 2002 | Sheet 1 of 0

6.4 RS 422/485 Serial Interface

The interface between the Navigator chipset and an RS-422/485 serial port is shown in the following figure.

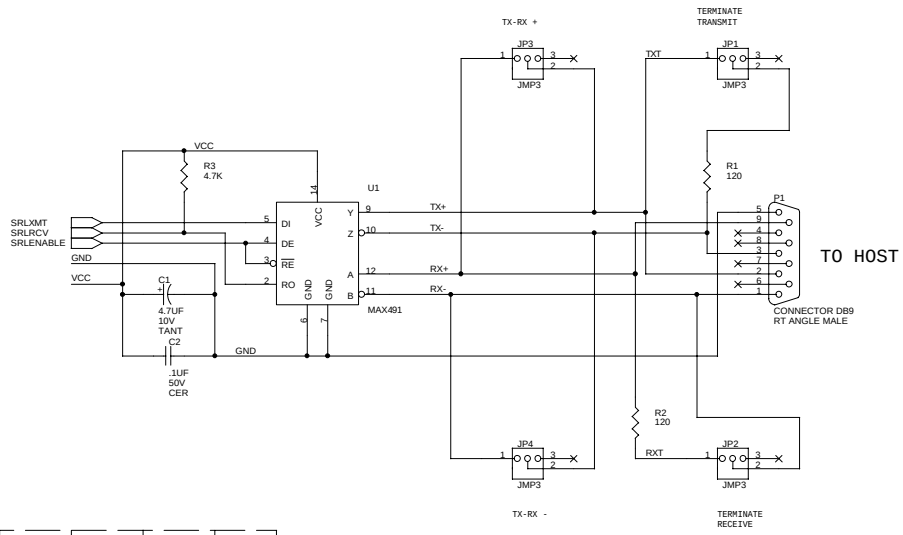
Comments on Schematic

Use the included table to determine the jumper setup that matches the chosen configuration. If using RS485, the last CP must have its jumpers set to RS485 LAST. The DB9 connector wiring is for example only. The DB9 should be wired according to the specification that accompanies the connector to which it is attached.

For correct operation, logic should be provided that contains the start up serial configuration for the chipset. Refer to the RS232 Serial Interface schematic for an example of the required logic.

Note that the RS485 interface cannot be used in point to point mode. It can only be used in a multi-drop configuration where the chip SrlEnable line is used to control transmit/receive operation of the serial transceiver.

Chips in a multi-drop environment should not be operated at different baud rates. This will result in communication problems.



COM TYPE	JP1	JP2	JP3	JP4
RS422	1-2	1-2	2-3	2-3
RS485	2-3	2-3	1-2	1-2
RS485 LAST	1-2	2-3	1-2	1-2

NOTE:RS422 IS CAPABLE OF FULL DUPLEX AND USES 2 PAIRS.
RS485 IS HALF-DUPLEX ON 1 PAIR AND MAY BE DAISY CHAINED
THE CP USES RS485. A SINGLE CP MAY COMMUNICATE WITH AN
RS422 HOST AS SHOWN IN THE TABLE.
A SINGLE PAIR MAY BE WIRED TO EITHER P1-1,9 OR P1-2,3
FOR RS485.

PERFORMANCE MOTION DEVICES
55 OLD BEDFORD RD
LINCOLN, MA 01773

Title: RS422/485 Interface (GENDO1)

Size: B | Document Number | Rev: A

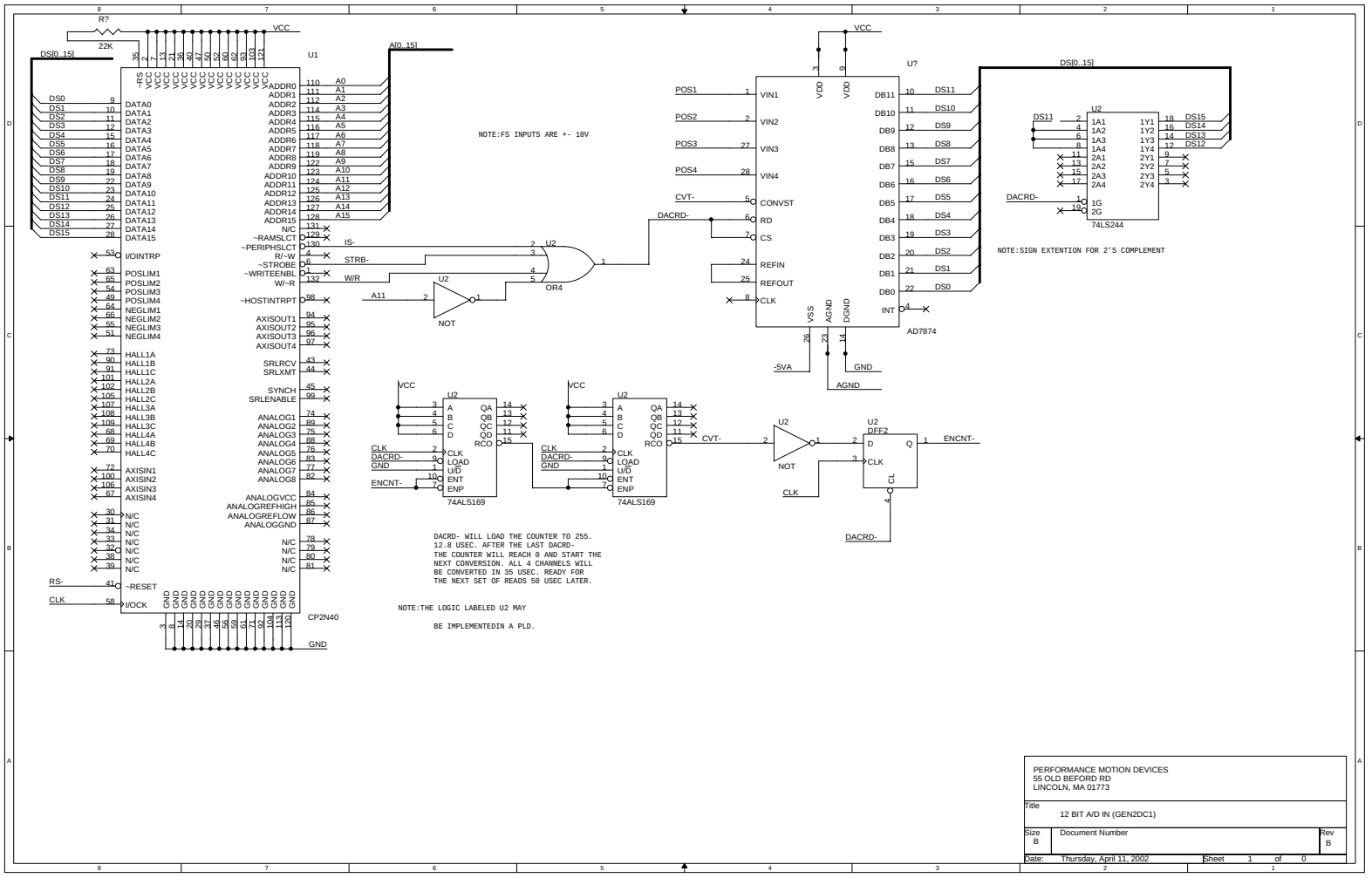
Date: Thursday, April 11, 2002 | Sheet 1 of 1

6.5 12-bit A/D Interface

The following schematic shows a typical interface circuit between the Navigator chipset and a quad 12 bit 2's complement A/D converter used as a position input device.

Comments on Schematic

The A/D converter samples all 4 axes and sequentially converts and stores the 2's complement digital words. The data is read out sequentially, axis 1 to 4. DACRD- is used to perform the read and is also used to load the counter to FFh. The counter will be reloaded for each read and will not count significantly between reads. The counter will therefore start counting down after the last read and will generate the cvt- pulse after 12.75 μsec. The conversions will take approximately 35 μsec, and the data will be available for the next set of reads after 50 μsec. The 12 bit words from the A/D are extended to 16 bits with the 74LS244.



PERFORMANCE MOTION DEVICES
55 OLD BEFORD RD
LINCOLN, MA 01773

Title: 12 BIT A/D IN (GEN2DC1)

Size: B | Document Number | Rev: B

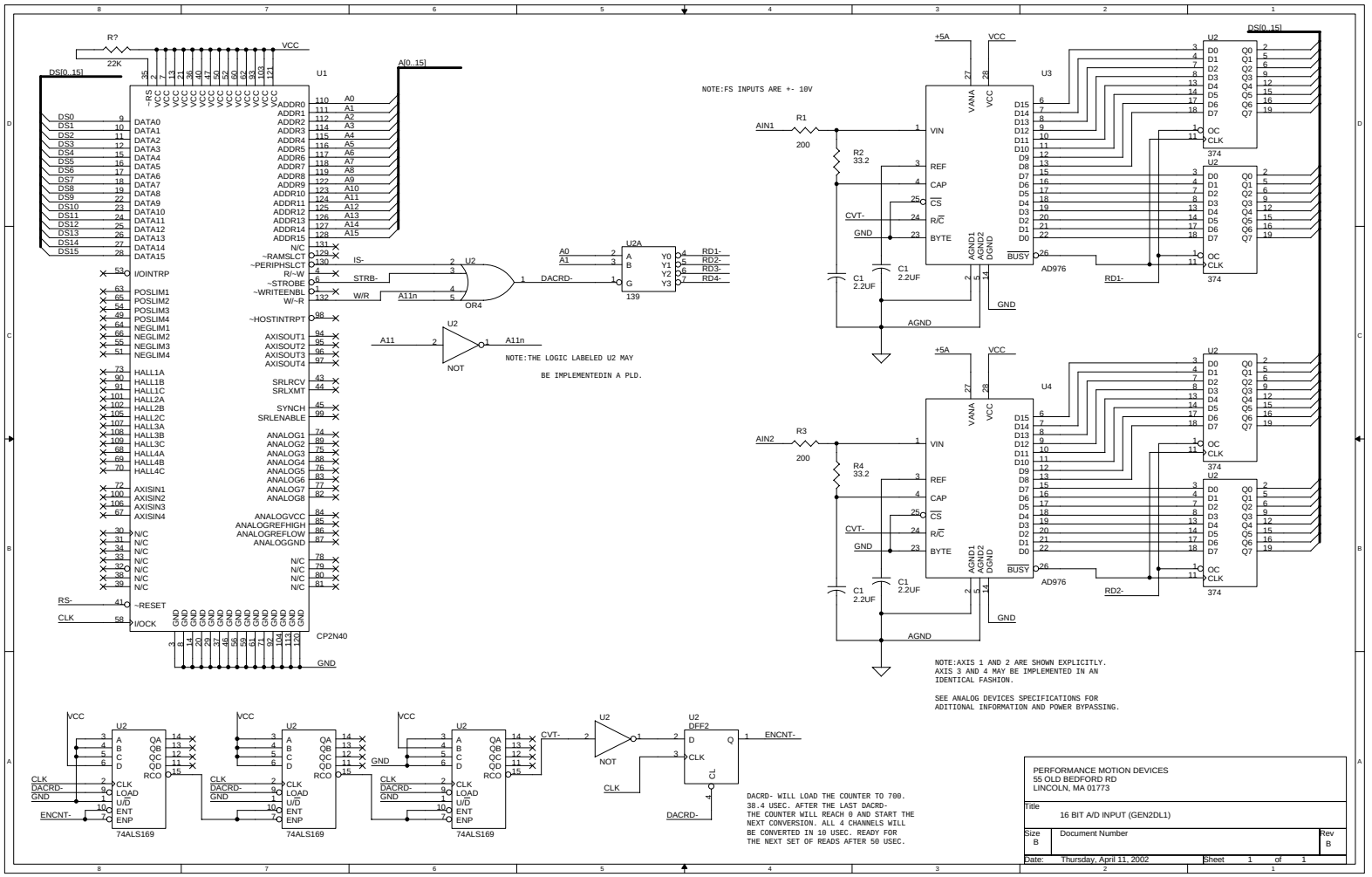
Date: Thursday, April 11, 2002 | Sheet 1 of 0

6.6 16-bit A/D Input

The interface between the Navigator chipset and 16 bit A/D converters as parallel input position devices is shown in the following figure.

Comments on Schematic

The schematic shows a 16 bit A/D used to provide parallel position input to axis 1 and axis 2. The expansion to the remaining two axes is easily implemented. The 374 registers are required on the output of the A/D converters to make the 68-nanosecond access time of the CP. The worst-case timing of the A/D's specify 83 nanoseconds for data on the bus and 83 nanoseconds from data to tri-state on the bus. Each time the data is read the 169 counter is set to 703 decimal. This provides a 35.2-microsecond delay before the next conversion. With a 10-microsecond conversion time the data will be available for the next set of reads after 50 microseconds. The delay is used to provide a position sample close to the actual position.

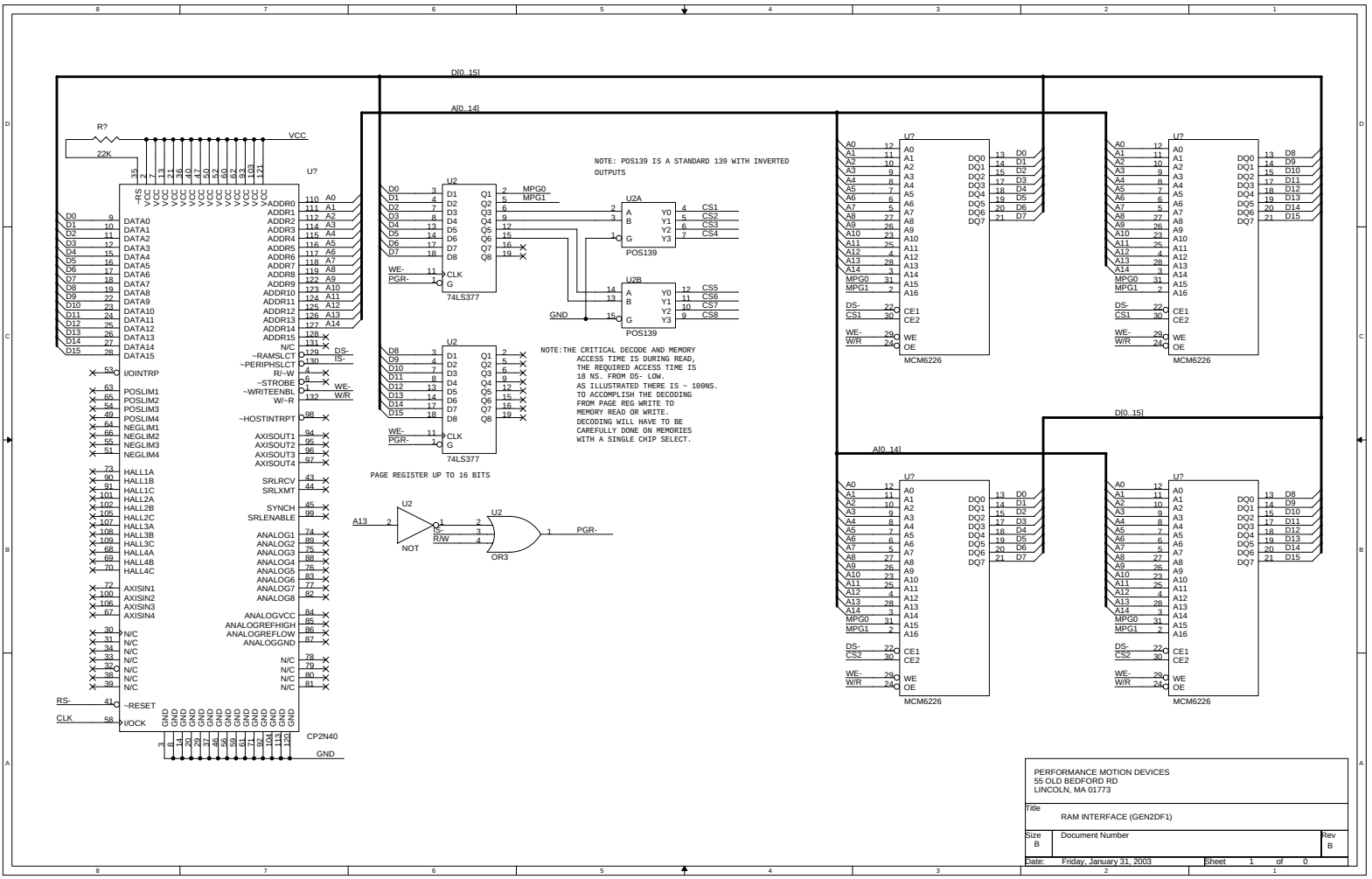

R?
22K
VCC
DS[0..15]
A[0..15]
U1
CP2N40
~RS
~RESET
I/OCK
I/OINTRP
~RAMSLCT
~PERIPHSLCT
R/~W
~STROBE
~WRITEENBL
W/~R
~HOSTINTRPT
SRLRCV
SRLXMT
SYNCH
SRLENABLE
GND
NOTE:FS INPUTS ARE +- 10V
AIN1
AIN2
R1
R2
R3
R4
200
33.2
+5A
U3
U4
AD976
VANA
VCC
VIN
REF
CAP
CVT-
BYTE
BUSY
AGND1
AGND2
DGND
C1
2.2UF
RD1-
RD2-
374
U2A
139
OR4
NOT
IS-
STRB-
W/R
A11n
DACRD-
RD1-
RD2-
RD3-
RD4-
NOTE:THE LOGIC LABELED U2 MAY
BE IMPLEMENTEDIN A PLD.
NOTE:AXIS 1 AND 2 ARE SHOWN EXPLICITLY.
AXIS 3 AND 4 MAY BE IMPLEMENTED IN AN
IDENTICAL FASHION.
SEE ANALOG DEVICES SPECIFICATIONS FOR
ADITIONAL INFORMATION AND POWER BYPASSING.
74ALS169
DFF2
ENCNT-
DACRD- WILL LOAD THE COUNTER TO 700.
38.4 USEC. AFTER THE LAST DACRD-
THE COUNTER WILL REACH 0 AND START THE
NEXT CONVERSION. ALL 4 CHANNELS WILL
BE CONVERTED IN 10 USEC. READY FOR
THE NEXT SET OF READS AFTER 50 USEC.
PERFORMANCE MOTION DEVICES
55 OLD BEDFORD RD
LINCOLN, MA 01773
Title
16 BIT A/D INPUT (GEN2DL1)
Size B
Document Number
Rev B
Date: Thursday, April 11, 2002
Sheet 1 of 1

6.7 RAM Interface

The following schematic shows an interface circuit between the Navigator chipset and external ram.

Comments on Schematic

The CP is capable of directly addressing 32K words of 16-bit memory. It will also use a 16 bit paging register to address up to 32K word pages. The schematic shows the paging and addressing for 128KB RAM chips, i.e. 4 pages per RAM chip. The page address decoding is shown for only 6 of the 16 possible paging bits. The decoding time from W/R and DS- to the memory output must not exceed 18 ns. for a read with no wait states. The writes provide 25 extra ns access time for W/R and DS- to reverse the CP data bus.

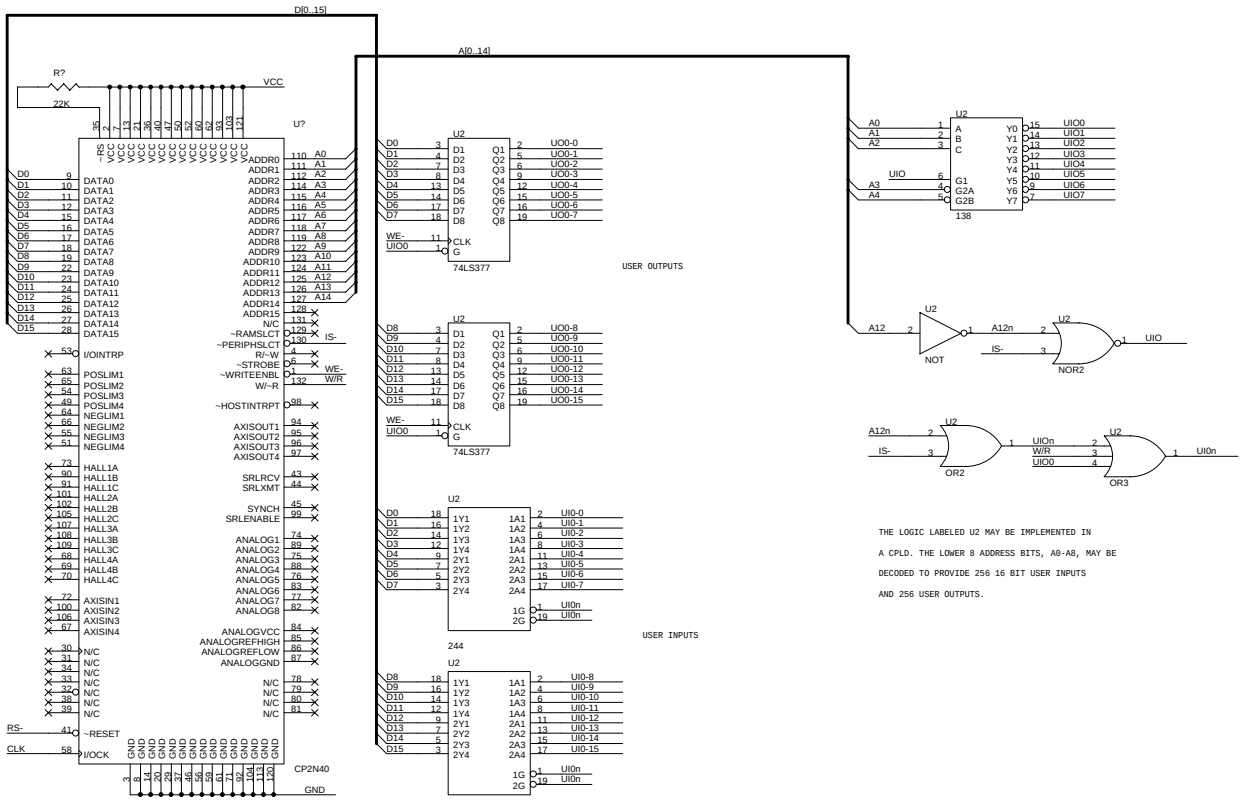

D[0..15]
A[0..14]
R?
22K
VCC
U?
CP2N40
GND
RS-
CLK
~RESET
I/OCK
I/OINTRP
~HOSTINTRPT
~RAMSLCT
~PERIPHSLCT
R/~W
~STROBE
~WRITEENBL
W/~R
DS-
IS-
WE-
W/R
SYNCH
SRLENABLE
SRLRCV
SRLXMT
AXISOUT1
AXISOUT2
AXISOUT3
AXISOUT4
POSLIM1
POSLIM2
POSLIM3
POSLIM4
NEGLIM1
NEGLIM2
NEGLIM3
NEGLIM4
HALL1A
HALL1B
HALL1C
HALL2A
HALL2B
HALL2C
HALL3A
HALL3B
HALL3C
HALL4A
HALL4B
HALL4C
AXISIN1
AXISIN2
AXISIN3
AXISIN4
ANALOG1
ANALOG2
ANALOG3
ANALOG4
ANALOG5
ANALOG6
ANALOG7
ANALOG8
ANALOGVCC
ANALOGREFHIGH
ANALOGREFLOW
ANALOGGND
U2
74LS377
MPG0
MPG1
PGR-
U2A
U2B
POS139
CS1
CS2
CS3
CS4
CS5
CS6
CS7
CS8
NOTE: POS139 IS A STANDARD 139 WITH INVERTED OUTPUTS
NOTE:THE CRITICAL DECODE AND MEMORY ACCESS TIME IS DURING READ, THE REQUIRED ACCESS TIME IS 18 NS. FROM DS- LOW. AS ILLUSTRATED THERE IS ~ 100NS. TO ACCOMPLISH THE DECODING FROM PAGE REG WRITE TO MEMORY READ OR WRITE. DECODING WILL HAVE TO BE CAREFULLY DONE ON MEMORIES WITH A SINGLE CHIP SELECT.
PAGE REGISTER UP TO 16 BITS
A13
NOT
OR3
MCM6226
PERFORMANCE MOTION DEVICES
55 OLD BEDFORD RD
LINCOLN, MA 01773
Title
RAM INTERFACE (GEN2DF1)
Size B
Document Number
Rev B
Date: Friday, January 31, 2003
Sheet 1 of 0

6.8 User-defined I/O

The interface between the Navigator chipset and 16 bits of user output and 16 bits of user input is shown in the following figure.

Comments on Schematic

The schematic implements 1 word of user output registered in the 74LS377's and 1 word of user inputs read via the 244's. The schematic decodes the low 3 bits of the address to 8 possible UIO addresses UIO0 through UIO7. Registers and buffers are shown for only UIO0, but the implementation shown may be easily extended. The lower 8 address bits may be decoded to provide up to 256 user output words and 256 user input words of 16 bits.



PERFORMANCE MOTION DEVICES
55 OLD BEDFORD RD
LINCOLN, MA 01773

Title: USER I/O (GEN2DK1)

Size: B | Document Number | Rev: D

Date: Monday, April 22, 2002 | Sheet 1 of 0