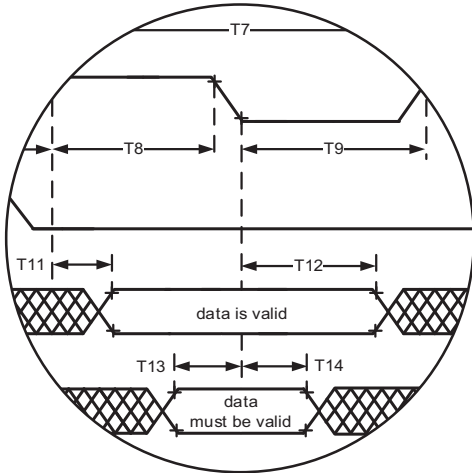


**PERFORMANCE
MOTION DEVICES**
MOTION CONTROL AT ITS CORE



Magellan[®] Motion Control IC

MC55000 Electrical Specifications

Revision 2.7/ January 2024

Performance Motion Devices, Inc.

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Related Documents

Magellan® Motion Control IC User Guide

Complete description of the Magellan Motion Control IC features and functions with detailed theory of operation.

C-Motion Magellan Programming Reference

Descriptions of all Magellan Motion Control IC commands, with coding syntax and examples, listed alphabetically for quick reference.

DK58420 Developer Kit User Manual

How to install and configure the DK58420 and DK55420 developer kits.

Table of Contents

1. The MC50000 Family	9
1.1 Magellan Motion Control IC Family Overview	9
1.2 MC55420-Series ICs & Developer Kit	10
2. Functional Characteristics	13
2.1 Configurations, Parameters, and Performance	13
2.2 Physical Characteristics and Mounting Dimensions	15
2.3 Absolute Maximum Environmental and Electrical Ratings	17
2.4 MC55110 System Configuration — Single Chip, 1 Axis Control	17
2.5 MC55x20 System Configuration — Two Chip, 1 to 4 Axis Control	18
3. Electrical Characteristics	21
3.1 DC Characteristics for 55110, 55x20 CP	21
3.2 DC Characteristics for 55x20 IO	22
3.3 AC Characteristics	22
4. I/O Timing Diagrams	25
4.1 Clock	25
4.2 Quadrature Encoder Input	26
4.3 Reset	26
4.4 Host Interface, 8/16 Mode	27
4.5 Host Interface, 16/16 Mode	29
4.6 External Memory Timing	31
4.7 Peripheral Device Timing	33
5. Pinouts and Pin Descriptions	35
5.1 Pinouts for the MC55110	35
5.2 MC55110 Pin Descriptions	36
5.3 Pinouts for the MC55x20	40
5.4 MC55x20 Pin Descriptions	44
6. Application Notes — MC55110 and MC55x20	51
6.1 General Design Notes	51
6.2 Peripheral Device Access	52
6.3 Power Supplies	54
6.4 Clock Generator, Grounding and Decoupling, and Device Reset	56
6.5 Serial Communication Interface (SCI)	62
6.6 CAN Communication Interface	67
6.7 External Memory	69
6.8 Asynchronous SRAM	69
6.9 Using the On-chip ADC	73
6.10 User I/O Space	79
6.11 Parallel Communication Interface	81
6.12 Pulse & Direction Mode Output Connected to Atlas	85
6.13 Using the Allegro A3977 to Drive Microstepping Motors	88

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List of Figures

1-1	DK55420 Board	10
2-1	CP chip (all dimensions in millimeters)	15
2-2	IO Chip (all dimensions in millimeters)	16
2-3	MC55110 control and data paths	18
2-4	MC55x20 control and data paths	19
4-1	Clock timing	25
4-2	Quad encoder timing	26
4-3	Reset timing	26
4-4	Instruction write, 8/16 mode	27
4-5	Data write, 8/16 mode	27
4-6	Data read, 8/16 mode	28
4-7	Status read, 8/16 mode	28
4-8	Instruction write, 16/16 mode	29
4-9	Data write, 16/16 mode	29
4-10	Data read, 16/16 mode	30
4-11	Status read, 16/16 mode	30
4-12	External memory read	31
4-13	External memory write	32
4-14	Peripheral device read	33
4-15	Peripheral device write	34
5-1	MC55110 pinouts	35
5-2	MC55420 pinouts	40
5-3	MC55320 pinouts	41
5-4	MC55220 pinouts	42
5-5	MC55120 pinouts	43
6-1	Basics, power supplies, 55000	55
6-2	Basics, clock and bypass caps, 55110	57
6-3	Basics, clock and bypass caps, 55420	58
6-4	Oscillator filter circuit	59
6-5	Basics, reset	61
6-6	Host communication, SCI	63
6-7	Host communication, RS232 and RS485/422	66
6-8	Host communication, CAN bus	68
6-9	External memory, SRAM 512Kx16	70
6-10	External memory, Ready signal generator	72
6-11	External memory, DPRAM, host management	74
6-12	ADC, single-ended temperature sensor	76
6-13	ADC, differential interface	78
6-14	User I/O space, red LED	80
6-15	Host communication, parallel interface, 16/16 mode	82
6-16	Host communication, parallel interface, 8/16 mode	84
6-17	Step Motor Atlas Operating In Pulse & Direction Mode	87
6-18	Pulse and direction, A3977	89

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1. The MC50000 Family

In This Chapter

- ▶ Magellan Motion Control IC Family Overview
- ▶ MC58420-Series ICs & Developer Kits

1.1 Magellan Motion Control IC Family Overview

	MC58000 Series (Except MC58113)	MC55000 Series	MC58113 Series
# of axes	1, 2, 3, 4	1, 2, 3, 4	1+ (primary & aux channel encoder input)
Motor types supported	DC Brush, Brushless DC, step motor	Step motor	DC Brush, Brushless DC, step motor
Output format	SPI Atlas, PWM, DAC, pulse & direction	Pulse & direction	SPI Atlas, PWM, DAC, pulse & direction
Parallel host communication	✓	✓	
Serial host communication	✓	✓	✓
CAN 2.0B host communication	✓	✓	✓
SPI host communication			✓
Incremental encoder input	✓	✓	✓
Parallel word device input	✓	✓	
Index & Home signals	✓	✓	✓
Position capture	✓	✓	✓
Directional limit switches	✓	✓	✓
PWM output	✓		✓
Parallel DAC output	✓		
SPI Atlas interface	✓		✓
SPI DAC output	✓		✓
Pulse & direction output	✓	✓	✓
Digital current control	✓ (with Atlas)		✓
Field oriented control	✓ (with Atlas)		✓
Under/overvoltage sense	✓ (with Atlas)		✓
I ² T Current foldback	✓ (with Atlas)		✓
DC Bus shunt resistor control			✓
Overtemperature sense	✓ (with Atlas)		✓
Short circuit sense	✓ (with Atlas)		✓
Trapezoidal profiling	✓	✓	✓
Velocity profiling	✓	✓	✓
S-curve profiling	✓	✓	✓
Electronic gearing	✓	✓	✓
On-the-fly changes	✓	✓	✓
PID position servo loop	✓		✓
Dual biquad filters	✓		✓
Dual encoder loop	✓ (multi-axis configurations only)		✓
Programmable derivative sampling time	✓		✓
Feedforward (accel & vel)	✓		✓

	MC58000 Series (Except MC58113)	MC55000 Series	MC58113 Series
Data trace/diagnostics	✓	✓	✓
Motion error detection	✓	✓ (with encoder)	✓
Axis settled indicator	✓	✓ (with encoder)	✓
Analog input	✓	✓	✓
Programmable bit output	✓	✓	✓
Software-invertible signals	✓	✓	✓
User-defined I/O	✓	✓	
Internal Trace Buffer			✓
External RAM support	✓	✓	
Multi-chip synchronization	✓		✓
Chipset configurations	MC58420 (4 axes, 2 ICs) MC58320 (3 axes, 2 ICs) MC58220 (2 axes, 2 ICs) MC58120 (1 axis, 2 ICs) MC58110 (1 axis, 1 IC)	MC55420 (4 axes, 2 ICs) MC55320 (3 axes, 2 ICs) MC55220 (2 axes, 2 ICs) MC55120 (1 axis, 2 ICs) MC55110 (1 axis, 1 IC)	MC51113 (1+ axis, 1 IC) MC53113 (1+ axis, 1 IC) MC54113 (1+ axis, 1 IC) MC58113 (1+ axis, 1 IC)
IC Package: CP chip	MC58x20: 144 pin TQFP MC58110: 144 pin TQFP	MC55x20: 144 pin TQFP MC55110: 144 pin TQFP	100 pin TQFP
IC Package: IO chip	MC58x20: 100 pin TQFP MC58110: NA	MC55x20: 100 pin TQFP MC55110: NA	N/A

1.2 MC55420-Series ICs & Developer Kit

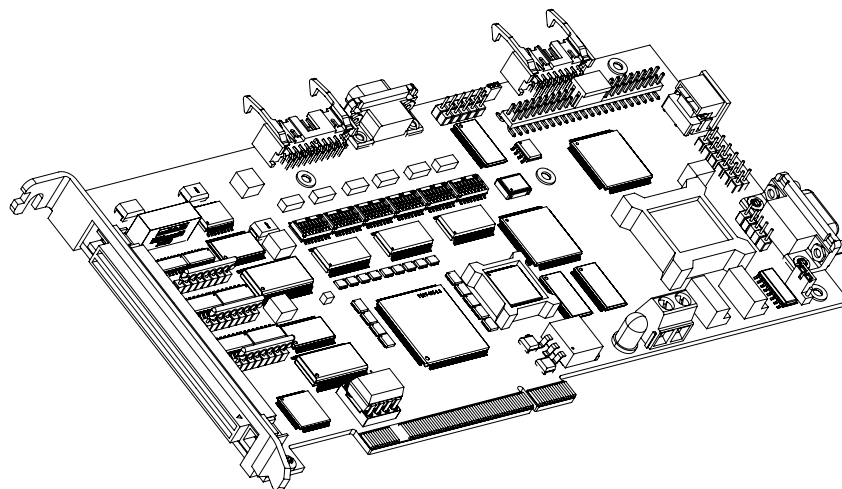


Figure 1-1:
DK55420
Board

There are five members of the MC55420-series ICs; MC55420, MC55320, MC55220, MC55120, and MC55110. A single developer kit supports all of these ICs:

Developer Kit p/n	Installed IC	Motors Supported
DK55420	MC55420	pulse & direction output

The DK55420 developer kit comes installed with the four axis MC55420CP chip. For users interested in other MC55000 chips, for example MC55320, MC55220, MC55120, or MC55110 (three, two, one, and one axes respectively) there are two options. The first is to separately order the desired MC55000 family CP IC and take advantage of the fact that the CP chip is socketed by swapping the desired IC with the MC55420CP.

The second option is to leave the MC55420 installed and disable one or more higher order axes and reduce the sample time to match the default sample time of the desired IC. For example to make the installed four axis MC55420 mimic a two axis MC55220 the **SetOperatingMode** command would be used to disable axes #3 and #4, and the **SetSampleTime** command would be used to set the sample time to 153.6 μ Sec.

Note that the Magellan IO chip that accompanies the CP chip supports one, two, three, and four axes CP chips so there is no need to swap or change the functionality of the Magellan IO chip installed in the developer kit.

Note that throughout this manual the term MC55000 means the complete product family; MC55420, MC55320, MC55220, MC55120, and MC55110.



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2. Functional Characteristics

In This Chapter

- ▶ Configurations, Parameters, and Performance
- ▶ Physical Characteristics and Mounting Dimensions
- ▶ Absolute Maximum Environmental and Electrical Ratings — CP 55110, 55x20
- ▶ Absolute Maximum Environmental and Electrical Ratings — IO 55x20
- ▶ System Configuration — Single Chip, 1 Axis Control
- ▶ MC55x20 System Configuration — Two Chip, 1 To 4 Axis Control

2.1 Configurations, Parameters, and Performance

Configuration	4 axes (MC55420) 3 axes (MC55320) 2 axes (MC55220) 1 axis (MC55120 or MC55110)
Operating mode	Open loop (pulse generator is driven by trajectory generator output, encoder input used for stall detection)
Communication modes	8/16 parallel 8-bit external parallel bus with 16-bit command word size 16/16 parallel 16-bit external parallel bus with 16-bit command word size Point-to-point asynchronous serial Multi-drop asynchronous serial CAN bus 2.0B, protocol co-exists with CANOpen, 11-bit identifier
Serial port baud rate range	1,200 baud to 460,800 baud
CAN port transmission rate range	10,000 baud to 1,000,000 baud
Profile modes	S-curve point-to-point Position, velocity, acceleration, deceleration, and jerk parameters Trapezoidal point-to-point Position, velocity, acceleration, and deceleration parameters Velocity-contouring Velocity, acceleration, and deceleration parameters Electronic Gear Encoder or trajectory position of one axis used to drive a second axis. Master and slave axes and gear ratio parameters.
Position range	-2,147,483,648 to +2,147,483,647 counts or steps
Velocity range	-32,768 to +32,767 counts or steps per cycle with a resolution of 1/65,536 counts or steps per cycle
Acceleration and deceleration ranges	0 to +32,767 counts or steps per cycle ² with a resolution of 1/65,536 counts or steps per cycle ²
Jerk range	0 to ½ counts or steps per cycle ³ with a resolution of 1/4,294,967,296 counts or steps per cycle ³
Electronic gear ratio range	-32,768 to +32,767 with a resolution of 1/65,536 (negative and positive direction)
Position error	32 bits

Position error tracking	Motion error windowAllows axis to be stopped upon exceeding programmable window Tracking windowAllows flag to be set if axis exceeds a programmable position window Axis settledAllows flag to be set if axis exceeds a programmable position window for a programmable amount of time after trajectory motion is complete
Motor output mode	Pulse and directionMC55x20: 4.98 Mpulses/sec maximum MC55110: 97.6 kpulses/sec maximum
Maximum encoder rate	Incremental (up to 8 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 μ sec)
Cycle timing range	51.2 microseconds to 1.048576 seconds
Minimum cycle time	51.2 microseconds
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 <i>AxisIn</i> signal per axis, 1 <i>AxisOut</i> signal per axis
Software-invertible signals	<i>Encoder A</i> , <i>Encoder B</i> , <i>Index</i> , <i>Home</i> , <i>AxisIn</i> , <i>AxisOut</i> , <i>PositiveLimit</i> , <i>NegativeLimit</i> , <i>Pulse</i> , <i>Direction</i>
Analog input	8 10-bit analog inputs
User defined discrete I/O	256 16-bit width 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
Maximum number of trace variables	4
Number of traceable variables	31

2.2 Physical Characteristics and Mounting Dimensions

Figure 2-1:
CP chip (all
dimensions in
millimeters)

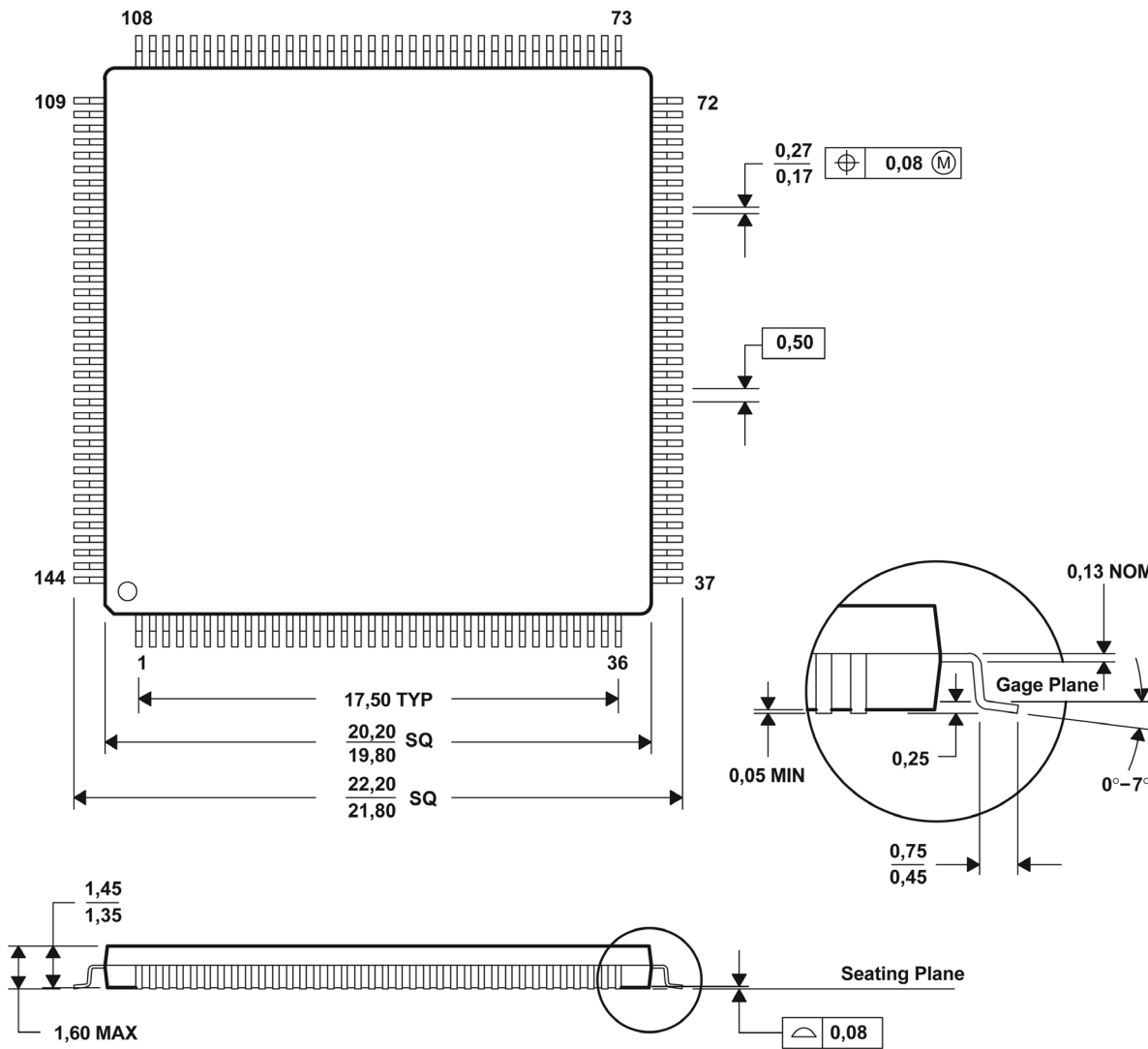
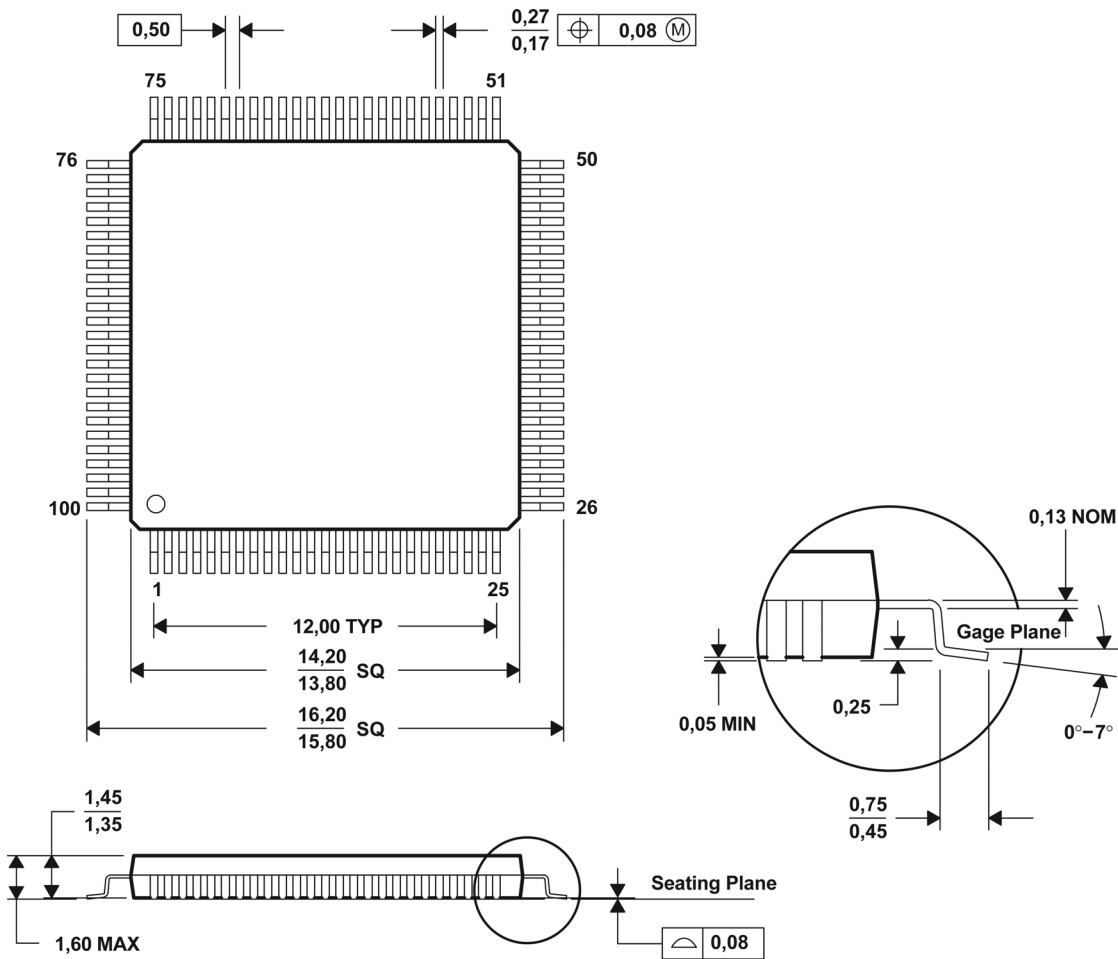


Figure 2-2:
IO Chip (all
dimensions in
millimeters)



2.3 .Absolute Maximum Environmental and Electrical Ratings

2.3.1 CP 55110, 55x20

Supply Voltage (Vcc)	-0.3V to +4.6V
Vcc5 range	-0.3V to +5.5V
Input voltage (Vi)	-0.3V to +4.6V
Package thermal impedance (θ_{JA})	32°C/W
Junction temperature range (Tj)	-40°C to 150°C
Storage Temperature (Ts)	-65°C to 150°C
Nominal Clock Frequency (Fclk)	20.0 MHz

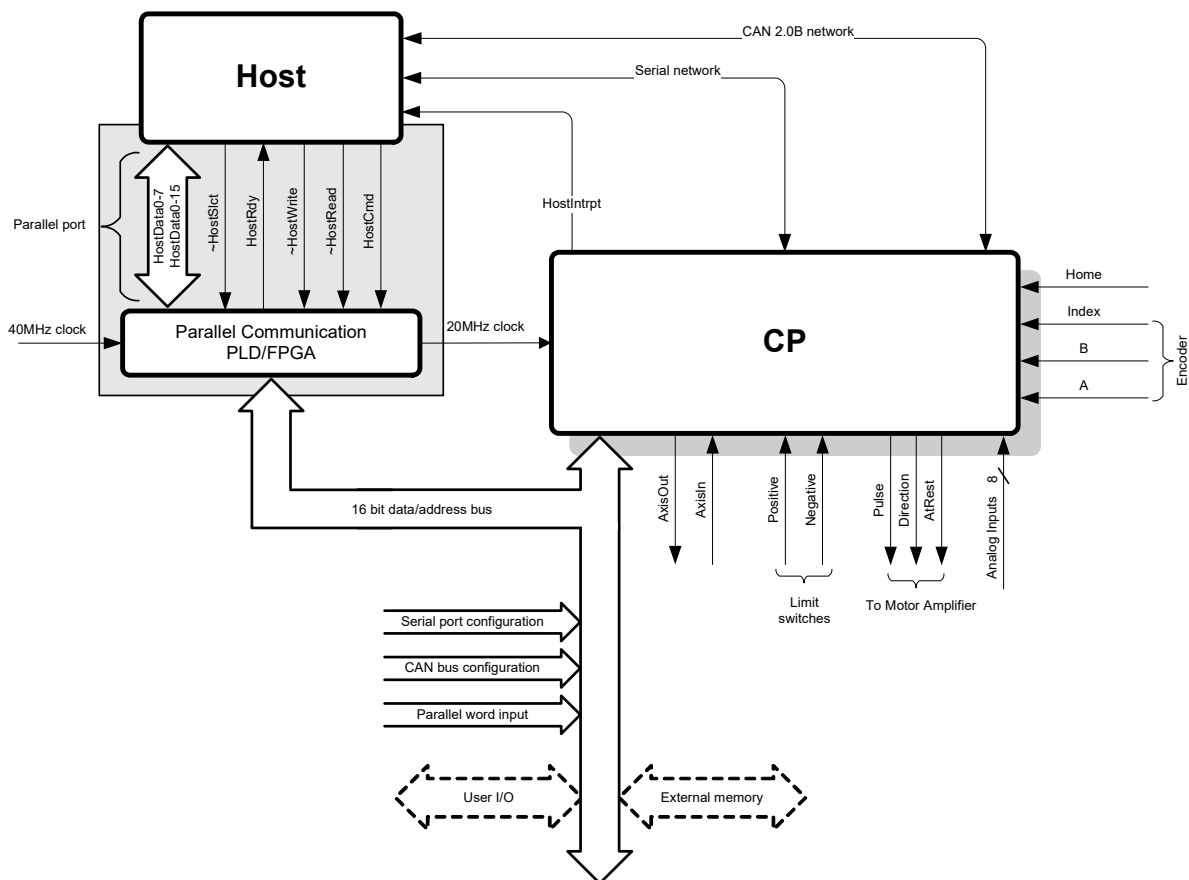
2.3.2 IO 55x20

Supply Voltage (Vcc)	-0.5V to +3.6V
Input voltage (Vi)	-0.5V to Vcc +0.5V
Package thermal impedance (θ_{JA})	39.7°C/W
Junction temperature range (Tj)	-40°C to 150°C
Storage Temperature (Ts)	-65°C to 150°C
Nominal Clock Frequency (Fclk)	40.0 MHz

2.4 MC55110 System Configuration — Single Chip, 1 Axis Control

The following figure shows the principal control and data paths in an MC55110 system.

Figure 2-3:
MC55110
control and
data paths



The CP chip is a self-contained motion control IC. In addition to handling all system functions, the CP chip contains the profile generator, which calculates position, velocity, acceleration, and values for a trajectory. Then, the CP chip generates pulse and direction signals. Optional axis position information returns to the motion control IC in the form of encoder feedback using either the incremental encoder input signals, or via the bus as parallel word input.

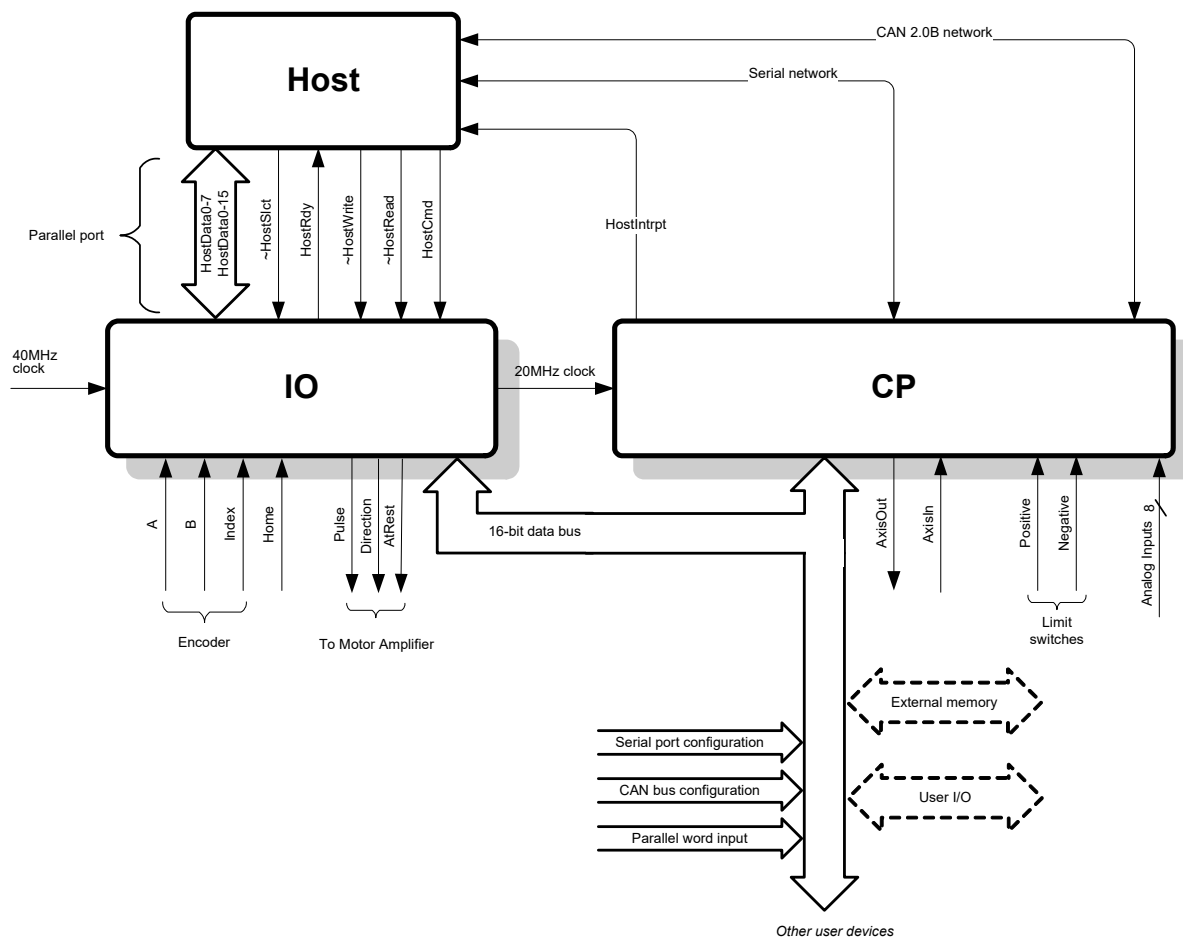
The MC55110 can co-exist in a CANOpen network as a slave device. It is CAN 2.0B compliant.

The shaded area shows the PLD/FPGA that must be provided by the designer if parallel communication is required. For a description and an example of the necessary logic (in schematic format) contact PMD.

2.5 MC55x20 System Configuration — Two Chip, 1 to 4 Axis Control

The following figure shows the principal control and data paths in an MC55x20 system.

Figure 2-4:
MC55x20
control and
data paths



The IO chip contains the parallel host interface, the incremental encoder input along with the pulse and direction motor output signals.

The CP chip contains the profile generator, which calculates position, velocity, acceleration, and values for a trajectory and communicates the results to the IO chip for output. Optional axis position information returns to the motion control IC in the form of encoder feedback using either the incremental encoder input signals, or via the bus as parallel word input.

The MC55x20 can co-exist in a CANOpen network as a slave device. It is CAN 2.0B compliant.

3. Electrical Characteristics

In This Chapter

- ▶ DC Characteristics for 55110, 55x20 CP
- ▶ DC Characteristics for 55x20 IO
- ▶ AC Characteristics

3.1 DC Characteristics for 55110, 55x20 CP

(V_{cc} and T_a per operating ratings, F_{clk} = 20.0 MHz)

Symbol	Parameter	Minimum	Maximum	Conditions
V _{cc}	Supply Voltage	3.0V	3.6V	
I _{dd}	Supply Current		120 mA	All I/O pins are floating
T _a	Operating free-air temperature	-40°C	85°C	
Input Voltages				
V _{ih}	Logic 1 input voltage	2.0V	V _{cc} + 0.3V	
V _{il}	Logic 0 input voltage	0	0.8V	
Output Voltages				
V _{oh}	Logic 1 Output Voltage	2.4V		I _o = -2 mA
V _{ol}	Logic 0 Output Voltage		0.4V	I _o = 2 mA
Other				
I _{out}	Tri-State output leakage current	-2 μA	2 μA	V _{in} = 0 or V _{cc}
I _{in}	Input current	-30 μA	30 μA	
C _{io}	Input/Output capacitance		2/3 pF	typical
Analog Input				
Z _{ai}	Analog input source impedance		1.4 kΩ	
I _a	Analog supply current		22 mA	
I _{refhi}	V _{refhi} input current		1.5 mA	
C _{ai}	Analog input capacitance		30 pF	typical
E _{zo}	Zero-offset error		±2 LSB	typical
E _{dnl}	Differential nonlinearity error. Difference between the step width and the ideal value.		±2 LSB	
E _{inl}	Integral nonlinearity error. Maximum deviation from the best straight line through the ADC transfer characteristics, excluding the quantization error.		±2 LSB	

3.2 DC Characteristics for 55x20 IO

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

Symbol	Parameter	Minimum	Maximum	Conditions
V _{cc}	Supply Voltage	3.0V	3.6V	
I _{dd}	Supply Current		24 mA	All I/O pins are floating
T _a	Operating free-air temperature	-40°C	85°C	
Input Voltages				
V _{ih}	Logic 1 input voltage	2.0V	V _{cc}	
V _{il}	Logic 0 input voltage	0	0.8V	
Output Voltages				
V _{oh}	Logic 1 Output Voltage	2.4V		I _o = -2 mA
V _{ol}	Logic 0 Output Voltage		0.4V	I _o = 6 mA
Other				
I _{out}	Tri-State output leakage current	-10 μA	10 μA	
I _{in}	Input current	-10 μA	10 μA	
C _{io}	Input/Output capacitance		7/7 pF	typical

3.3 AC Characteristics

See timing diagrams in [Chapter 4, “I/O Timing Diagrams”](#) for *T_n* numbers. The symbol “~” indicates active low signal.

Timing Interval	T _n	Minimum	Maximum
Clock			
IOClkIn Frequency (F _{clk}) ¹		8 MHz	40 MHz
IOClkIn pulse duration ³	T1a	0.4 T2a	0.6 T2a
IOClkIn Period	T2a	25 nsec	125 nsec
CPClkIn Frequency (F _{clk}) ¹		4 MHz	20 MHz
CPClkIn pulse duration ³	T1b	0.4 T2b	0.6 T2b
CPClkIn Period	T2b	50 nsec	250 nsec
CPClkIn rise/fall time	T58		5 nsec
Encoder			
Encoder Pulse Width	T3	200 nsec	
Dwell Time Per State	T4	100 nsec	
Index Setup and Hold (relative to Quad A and Quad B low)	T5	0 nsec	
Host IO			
~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 Hold Time	T13	40 nsec	70 nsec

Timing Interval	T _n	Minimum	Maximum
~HostWrite Pulse Width	T14	70 nsec	
Write Data Delay Time	T15		15 nsec
Write Data Hold Time	T16	0 nsec	
Read Recovery Time ²	T17	60 nsec	
Write Recovery Time ²	T18	60 nsec	
~HostRead Pulse Width	T19	70 nsec	
External Memory Read			
ClockOut low to control valid	T20		4 nsec
ClockOut low to address valid	T21		8 nsec
Address valid to ~ReadEnable low	T22	5.5 nsec	
ClockOut high to ~ReadEnable low	T23		5 nsec
ClockOut low to ~ReadEnable high	T23a	-8 nsec	1 nsec
Data access time from Address valid	T24		40 nsec
Data access time from ~ReadEnable low	T25		31 nsec
Data setup time before ~ReadEnable high	T25a	8 nsec	
Data hold time after ~ReadEnable high	T26	0 nsec	
~ReadEnable high to Address invalid	T26a	0 nsec	
ClockOut low to control inactive	T27		5 nsec
Address hold time after ClockOut low	T28	2 nsec	
ClockOut low to Strobe low	T29		5 nsec
ClockOut low to Strobe high	T30		6 nsec
W/~R low to R/~W rising delay time	T31		5 nsec
External Memory Write			
ClockOut high to control valid	T32		4 nsec
ClockOut high to address valid	T33		10 nsec
Address valid to ~WriteEnable low	T34	3.5 nsec	
ClockOut low to ~WriteEnable low	T35		6 nsec
ClockOut low to ~WriteEnable high	T35a		6 nsec
Data setup time before ~WriteEnable high	T36	33 nsec	
Data bus driven from ClockOut low	T37	-3 nsec	
Data hold time after ~WriteEnable high	T38	2 nsec	
ClockOut high to control inactive	T39		5 nsec
Address hold time after ClockOut low	T40	-5 nsec	
ClockOut low to Strobe low	T41		6 nsec
ClockOut low to Strobe high	T42		6 nsec
R/~W low to W/~R rising delay time	T43		5 nsec
ClockOut high to control valid	T44		6 nsec
ClockOut high to R/~W high	T44a		6 nsec
Peripheral Device Read			
ClockOut high to ClockOut low ⁴	T45	112.5 nsec	562.5 nsec
Data access time from Address valid	T46		65 nsec
Data access time from ~ReadEnable low	T47		56 nsec
Peripheral Device Write			
ClockOut low to ClockOut low ⁴	T48	125 nsec	625 nsec
Data setup time before ~WriteEnable high	T49	58 nsec	

Timing Interval	T_n	Minimum	Maximum
Device Reset⁵			
Reset low pulse width	T50	400 nsec	
Device Ready/ Outputs Initialized	T57		1.5 msec

1. Performance figures and timing information valid at Fclk = 40.0 MHz for the dual chip configuration and Fclk = 20.0 MHz for the single chip configurations only. For timing information and performance parameters at lower Fclk, see [Section 6.1.3, "Using a Non-standard System Clock Frequency."](#)
2. For 8/16 interface modes only.
3. The clock low/high split has an allowable range of 40 - 60%.
4. The minimum and maximum values correspond to a 50 nsec and 250 nsec CPClkIn clock periods, or 25 nsec and 125 nsec IOClkIn clock periods, respectively.
5. For additional important information on Reset signal management and timing please see [Section 6.4.6, "Reset Signal."](#)

4. I/O Timing Diagrams

In This Chapter

- ▶ Clock
- ▶ Quadrature Encoder Input
- ▶ Reset
- ▶ Host Interface, 8/16 Mode
- ▶ Host Interface, 16/16 Mode
- ▶ External Memory Timing
- ▶ Peripheral Device Timing

For the values of T_n , please refer to the table in [Section 3.3, “AC Characteristics.”](#)

4.1 Clock

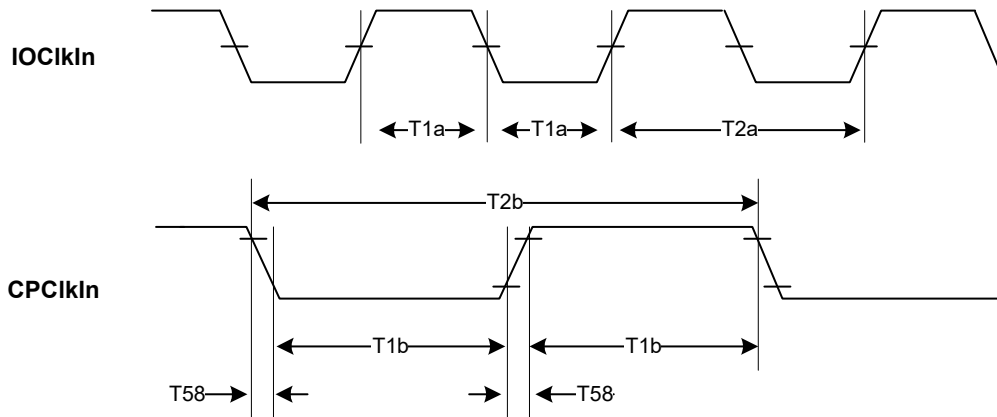
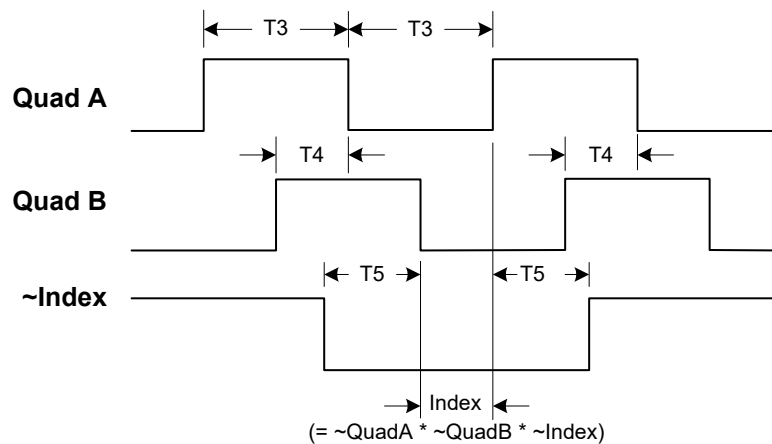


Figure 4-1:
Clock timing

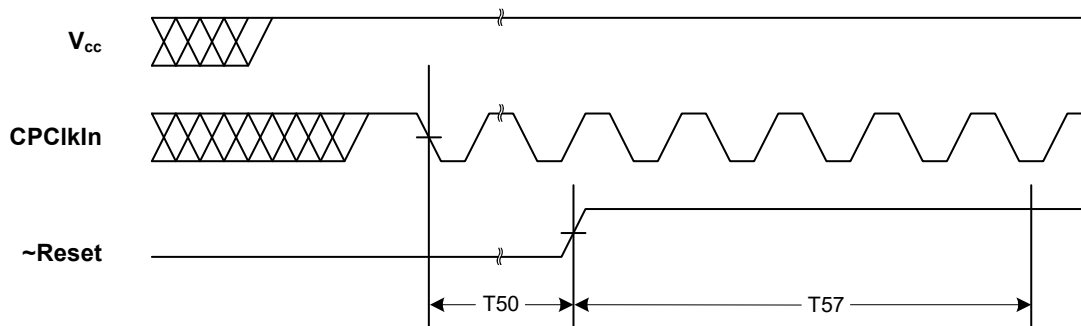
4.2 Quadrature Encoder Input

Figure 4-2:
Quad encoder
timing



4.3 Reset

Figure 4-3:
Reset timing



NOTE: The device must be reset after power on.

NOTE: For additional important information on Reset signal management and timing please see [Section 6.4.6, "Reset Signal."](#)

4.4 Host Interface, 8/16 Mode

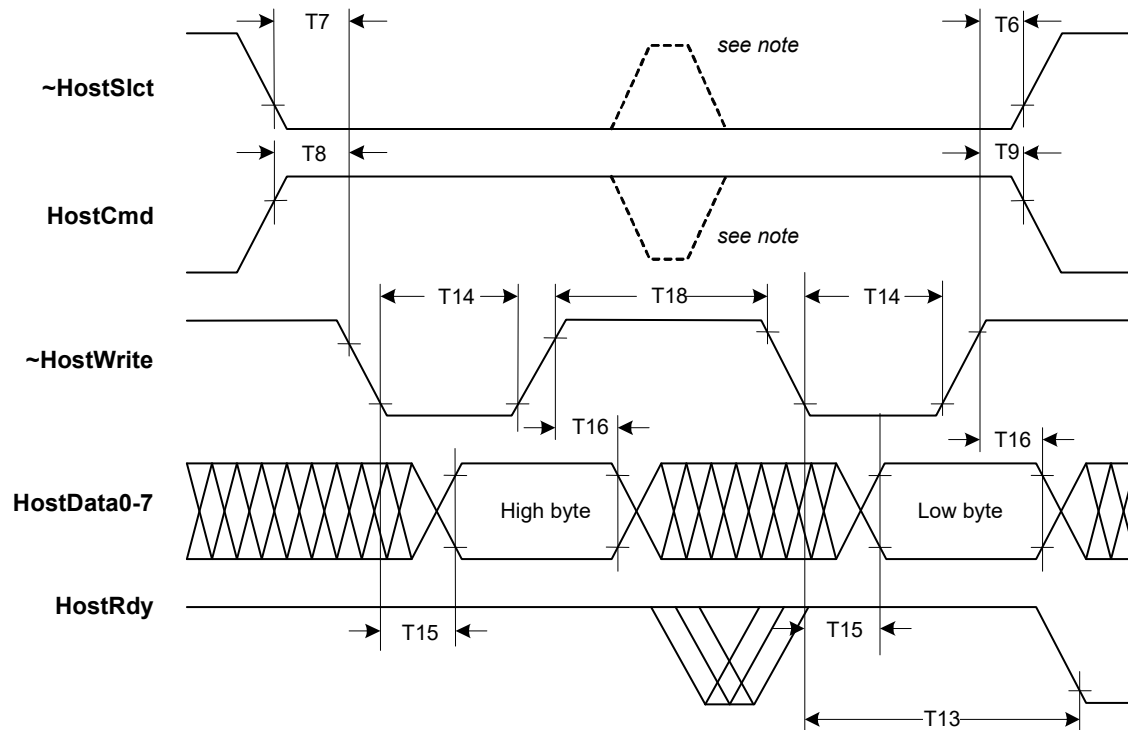


Figure 4-4:
Instruction
write, 8/16
mode

NOTE: If setup and hold times are met, \sim HostSlect and HostCmd may be de-asserted at this point.

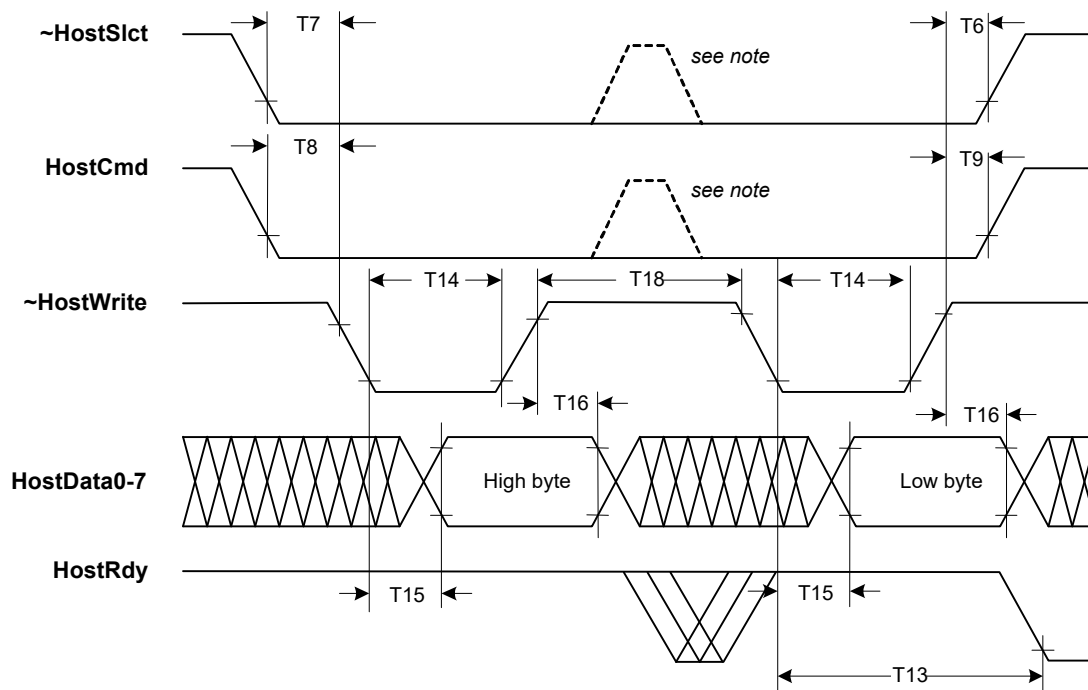
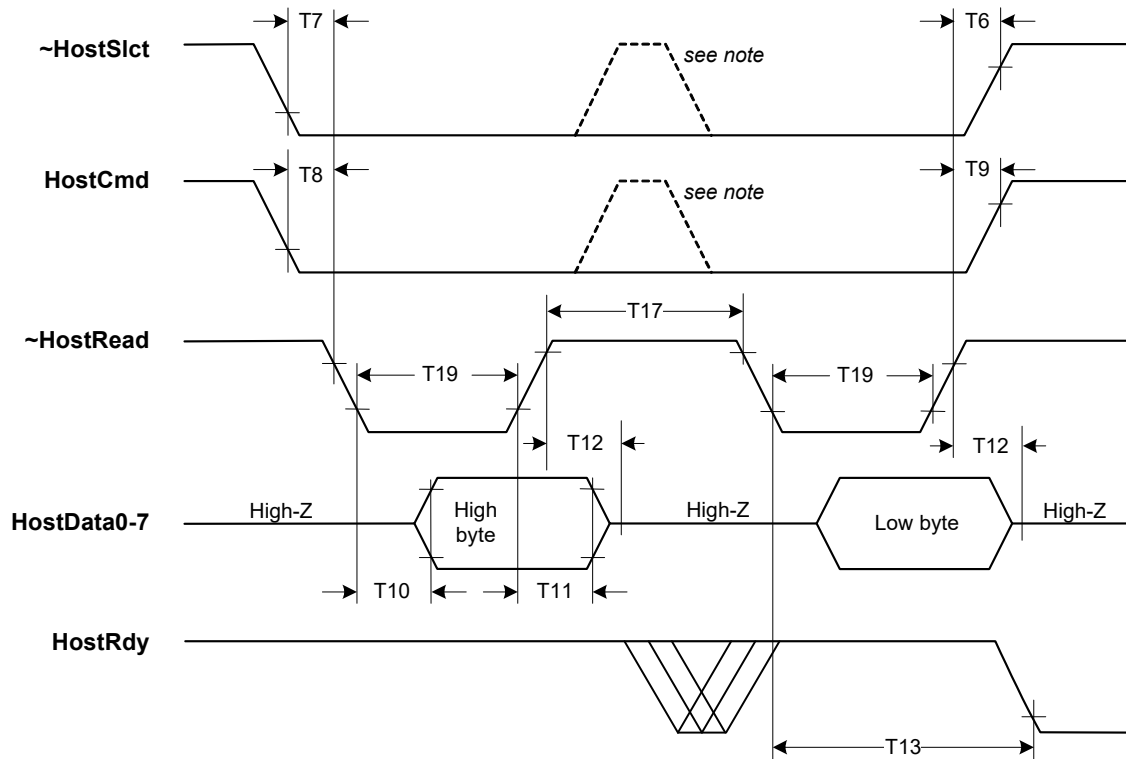


Figure 4-5:
Data write, 8/
16 mode

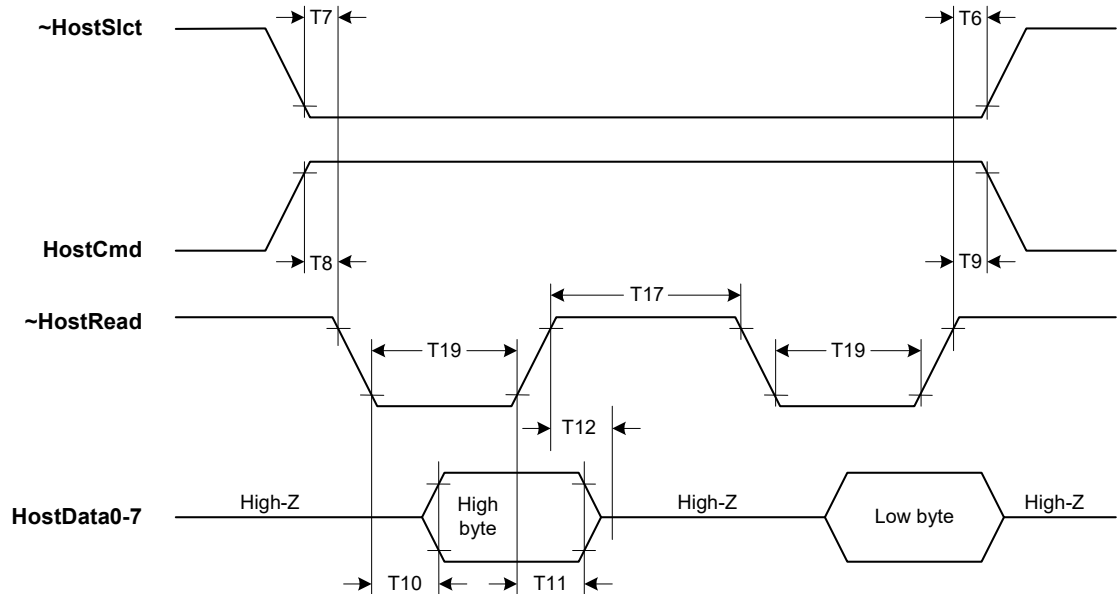
NOTE: If setup and hold times are met, \sim HostSlect and HostCmd may be de-asserted at this point.

Figure 4-6:
Data read, 8/16
mode



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

Figure 4-7:
Status read, 8/
16 mode



4.5 Host Interface, 16/16 Mode

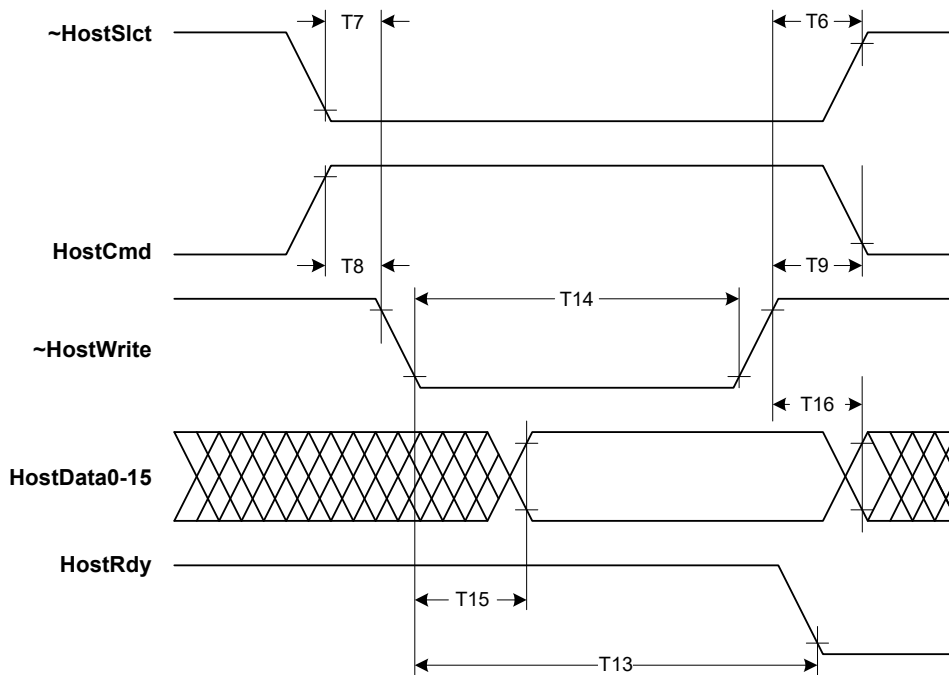


Figure 4-8:
Instruction
write, 16/16
mode

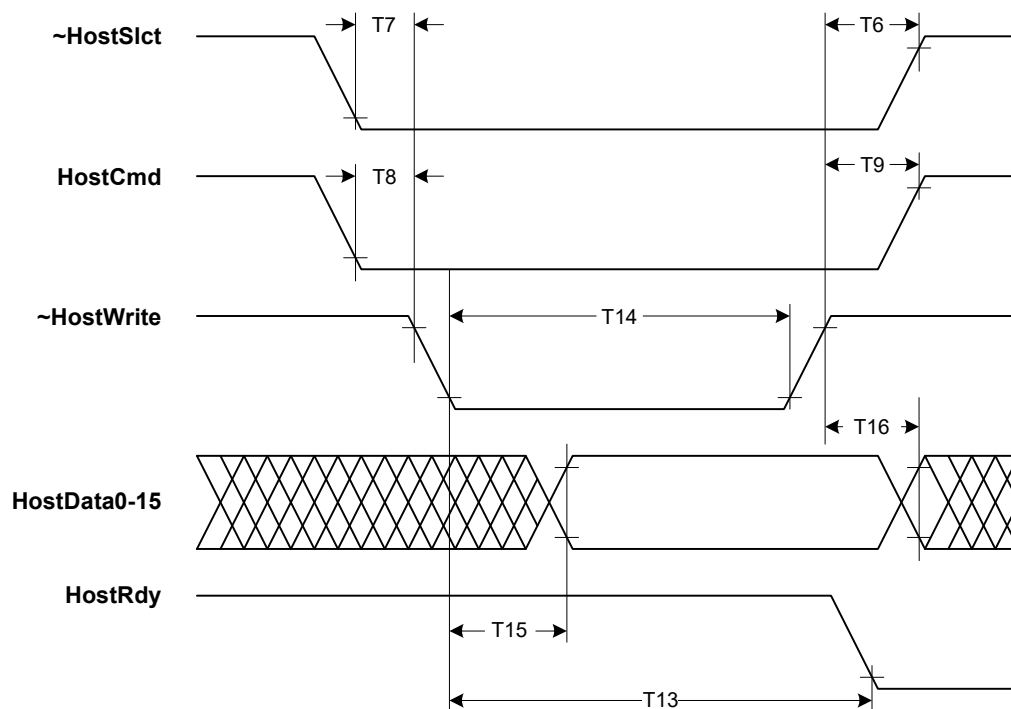


Figure 4-9:
Data write, 16/
16 mode

Figure 4-10:
Data read, 16/
16 mode

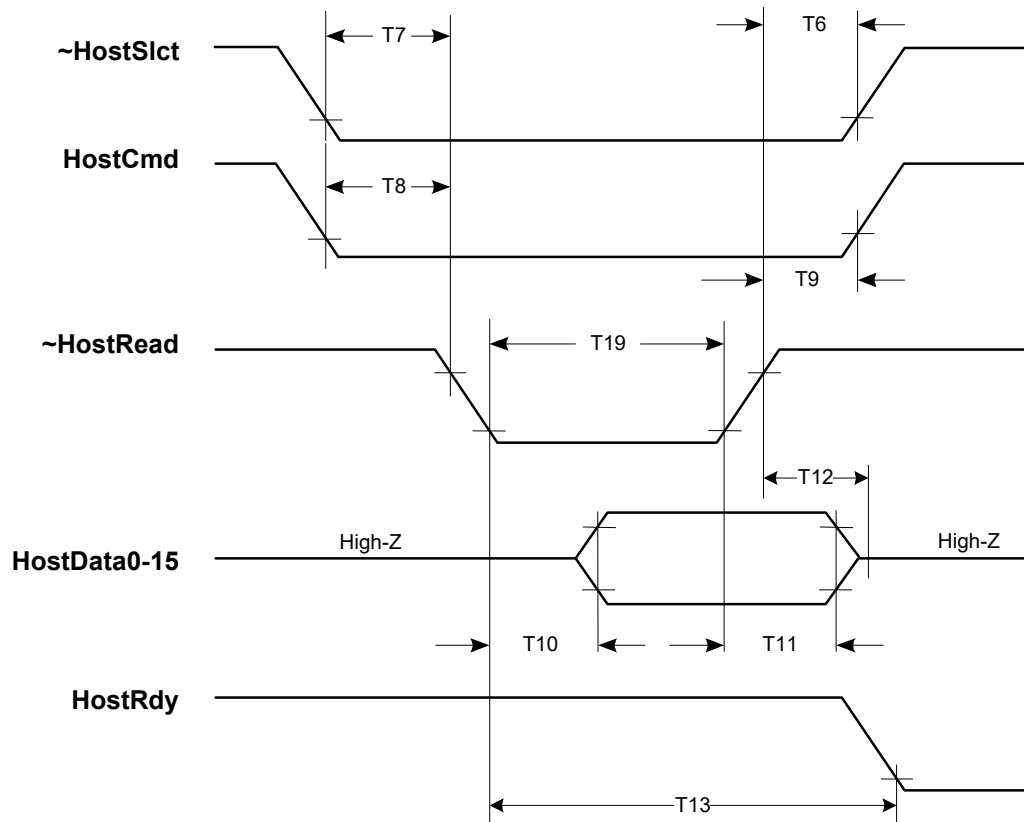
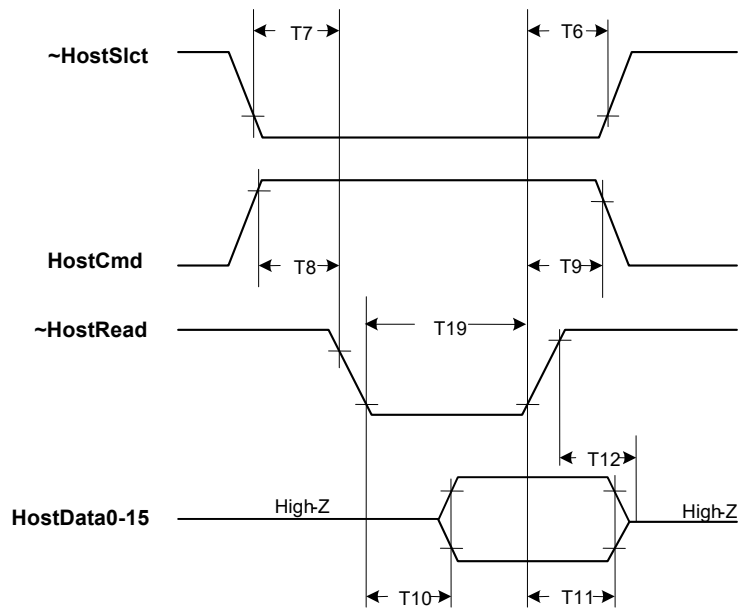


Figure 4-11:
Status read,
16/16 mode



4.6 External Memory Timing

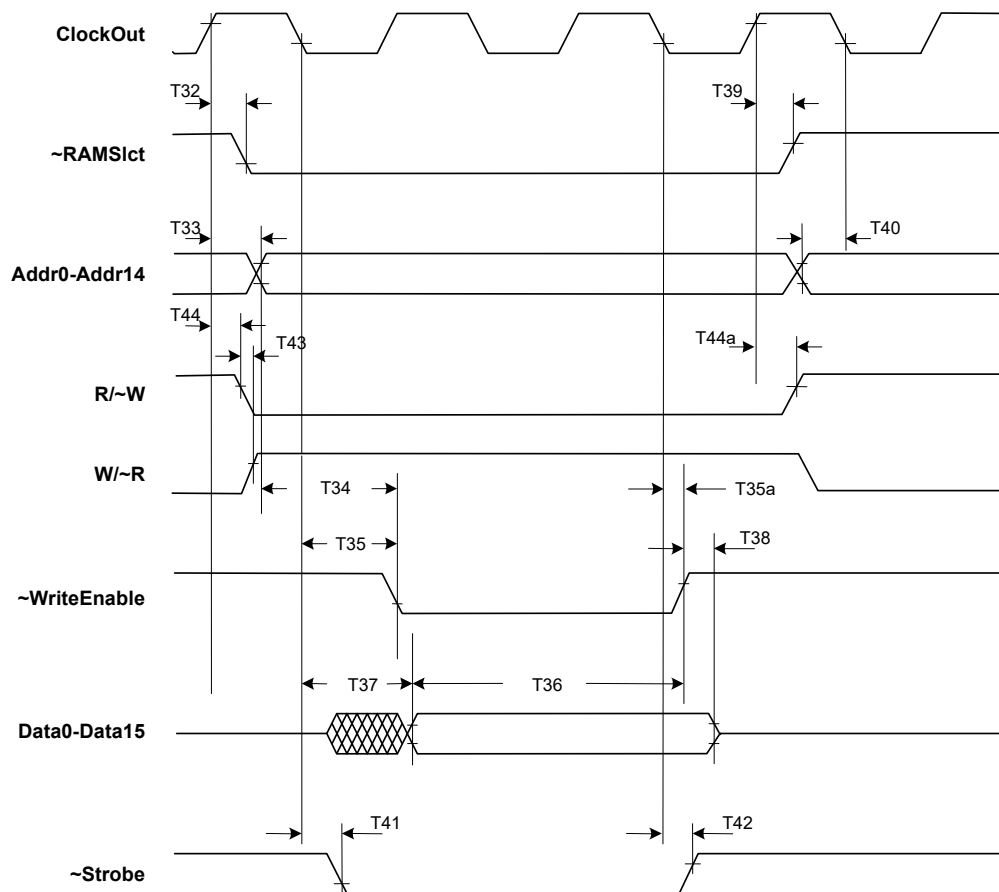
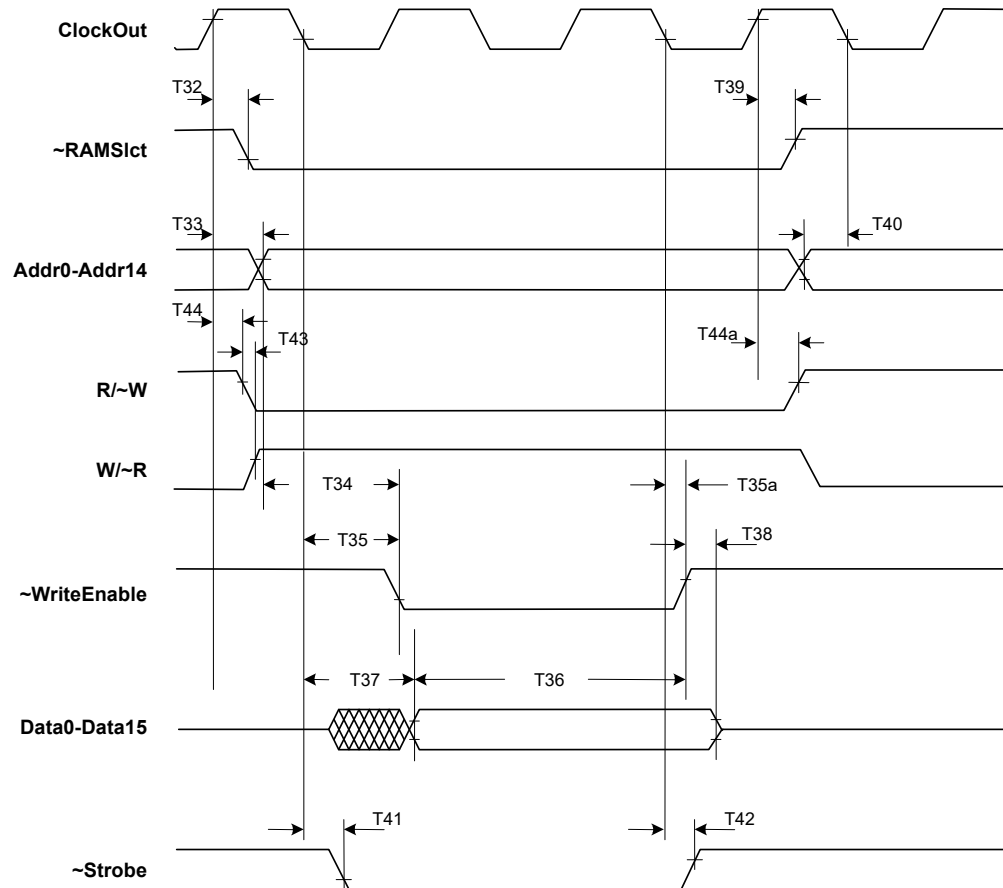


Figure 4-12:
External
memory read

Figure 4-13:
External
memory write



4.7 Peripheral Device Timing

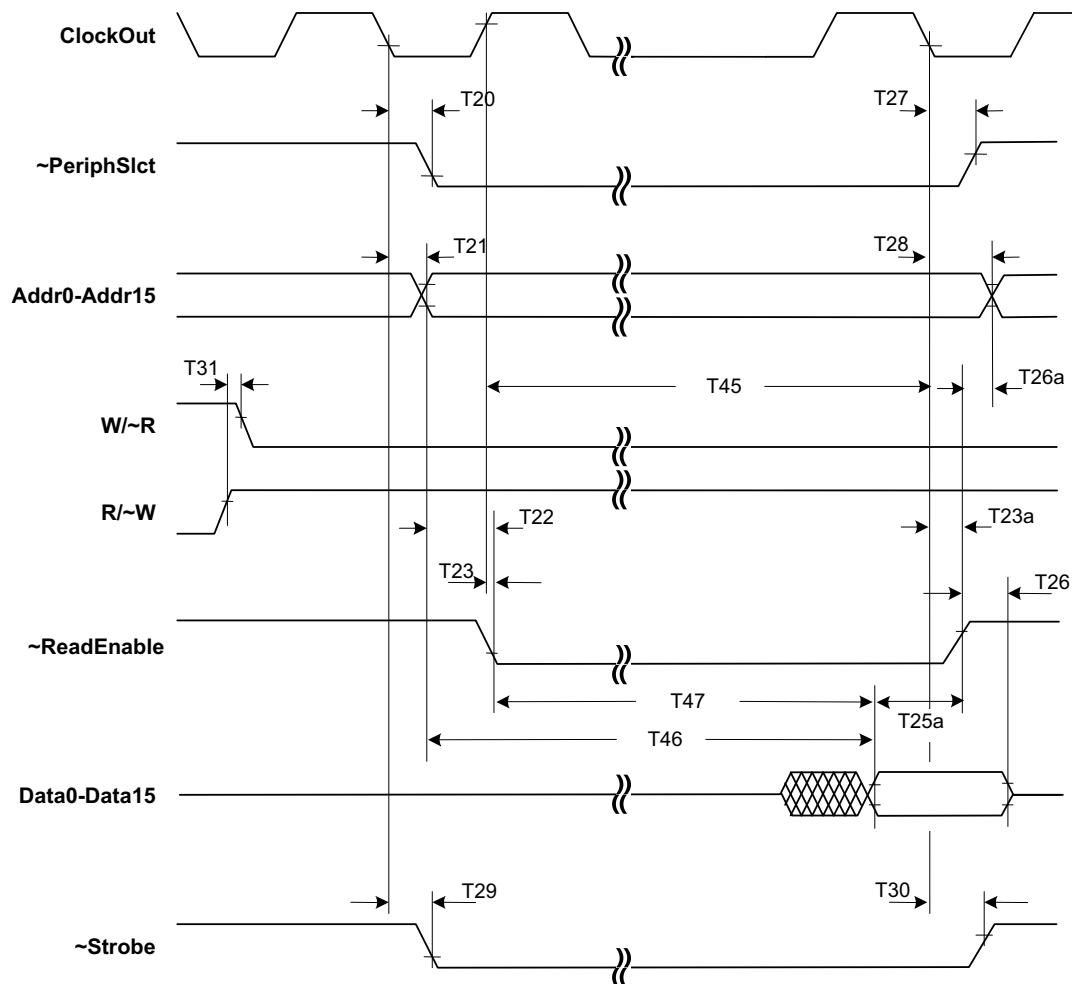
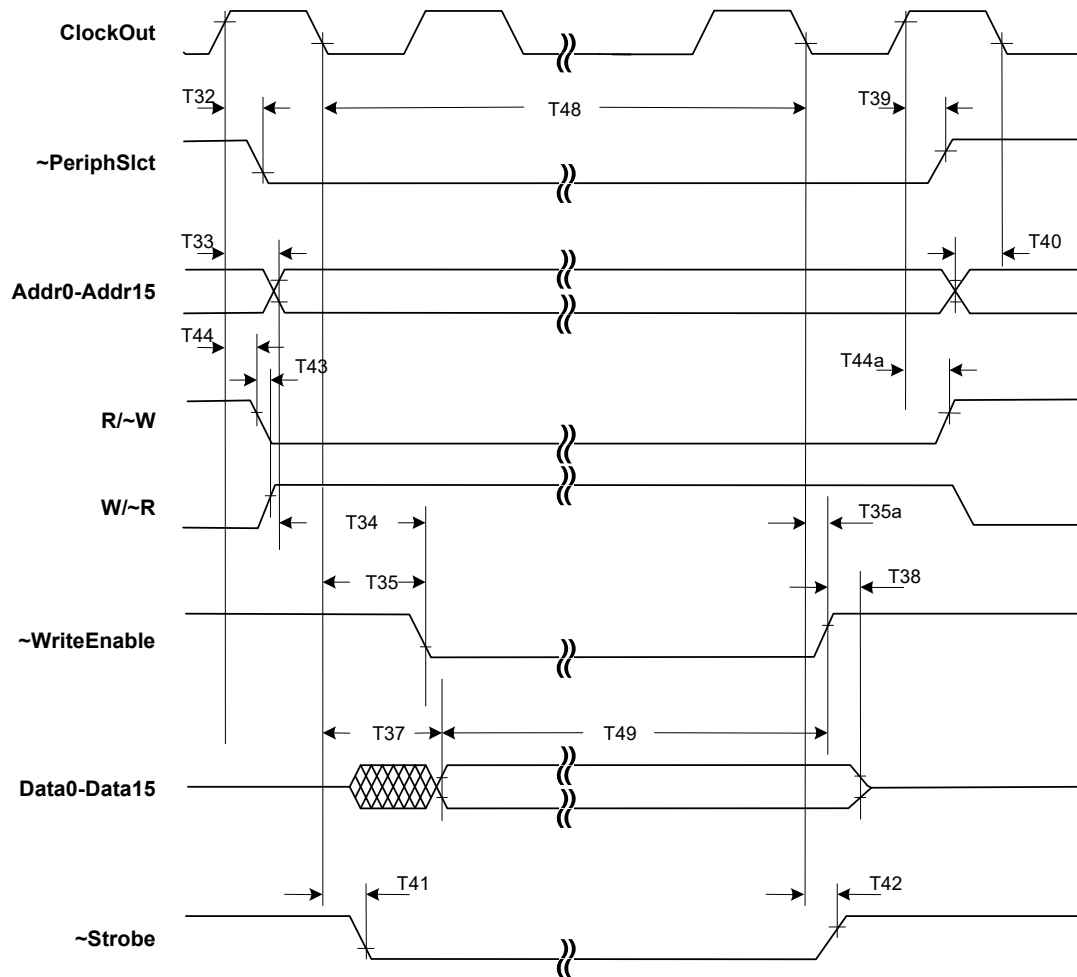


Figure 4-14:
Peripheral
device read

Figure 4-15:
Peripheral
device write



5. Pinouts and Pin Descriptions

In This Chapter

- ▶ Pinouts for the MC55110
- ▶ MC55110 Pin Descriptions
- ▶ Pinouts for the MC55x20
- ▶ MC55x20 Pin Descriptions

5.1 Pinouts for the MC55110

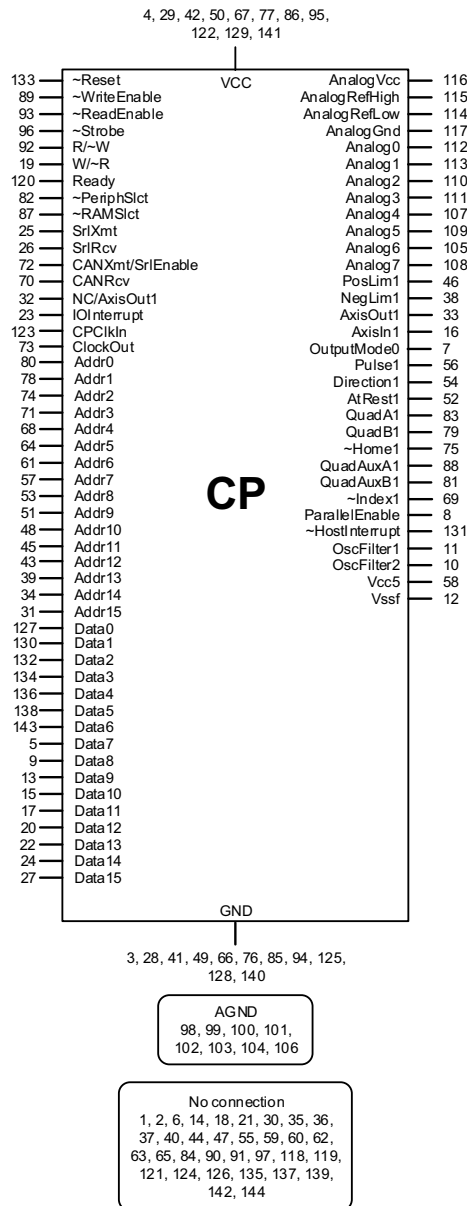


Figure 5-1:
MC55110
pinouts

5.2 MC55110 Pin Descriptions

55110 CP			
Pin Name and Number		Direction	Description
\sim Reset	133	input/output	This is the master reset signal. This pin must be brought <i>low</i> to reset the chipset to its initial condition. NOTE: A software reset will momentarily drive this pin <i>low</i> . NOTE: For additional important information on Reset signal management and timing please see Section 6.4.6, "Reset Signal."
\sim WriteEnable	89	output	This signal is the write-enable strobe. When <i>low</i> , this signal indicates that data is being written to the bus.
\sim ReadEnable	93	output	This signal is the read-enable strobe. When <i>low</i> , this signal indicates that data is being read from the bus.
\sim Strobe	96	output	This signal is <i>low</i> when the data and address are valid during CP communications.
R/ \sim W	92	output	This signal is <i>high</i> when the CP chip is performing a read, and <i>low</i> when it is performing a write.
W/ \sim R	19	output	This signal is the inverse of R/ \sim W; it is <i>high</i> when R/ \sim W is <i>low</i> , and vice versa. For some decode circuits and devices this is more convenient than R/ \sim W.
Ready	120	input	<i>Ready</i> can be pulled <i>low</i> to add wait states for external accesses. <i>Ready</i> indicates that an external device is prepared for a bus transaction to be completed. If the device is not ready, it pulls the <i>Ready</i> pin <i>low</i> . The motion control IC then waits one cycle and checks <i>Ready</i> again. For a timing diagram and example schematic using the <i>Ready</i> signal refer to Section 6.8.1, "Slow Asynchronous SRAM." If used, this signal is typically asserted during RAM Read/Write or Peripheral Read/Write operations. However another use of this signal is to hold off on configuration reads done at startup. Keeping <i>Ready</i> asserted at the time of <i>Reset</i> release and beyond allows synchronization with FPGAs other external logic that may not yet be ready to receive configuration Peripheral reads. This signal may remain unconnected if it is not used.
\sim PeriphSlct	82	output	This signal is <i>low</i> when peripheral devices on the data bus are being addressed.
\sim RAMSlct	87	output	This signal is <i>low</i> when external memory is being accessed.
SrIXmt	25	output	This pin outputs serial data from the asynchronous serial port.
SrIRcv	26	input	This pin inputs serial data to the asynchronous serial port. If not used, this pin should be tied to Vcc.
CANXmt/ SrIEnable	72	output	When the CAN host interface is used, this pin transmits serial data to the CAN transceiver. When the multi-drop serial interface is used, this pin sets the serial port enable line and the <i>CANXmt</i> function is not available. <i>SrIEnable</i> is <i>high</i> during transmission for the multi-drop protocol and always <i>high</i> during point-to-point mode.
CANRcv	70	input	This pin receives serial data from the CAN transceiver. If not used, this pin should be tied to Vcc.
NC/AxisOutI	32	input or output	If <i>OutputMode0</i> is <i>low</i> this pin should be left unconnected. If <i>OutputMode0</i> is left floating at powerup this pin provides the <i>AxisOutI</i> output. <i>AxisOutI</i> can be programmed to track the state of any bit in the status registers. If this pin is not used, it may remain unconnected.
IOInterrupt	23	input	This interrupt signal is used for IO to CP communication. This signal may remain unconnected if it is not used.
CPClkIn	123	input	This is the clock signal for the motion control IC. It is driven at a nominal 20 MHz.
ClockOut	73	output	This signal is the reference output clock. Its frequency is twice the frequency of the input clock (which is normally 20 MHz), resulting in a nominal output frequency of 40 MHz. <i>ClockOut</i> will not be active when \sim Reset is active.

55110 CP

Pin Name and Number		Direction	Description
Addr0	80	output	Multi-purpose address lines. These pins comprise the CP chip's external address bus, which is used to select devices for communication over the data bus. Other address pins may be used for DAC output, parallel word input, external memory, or user-defined I/O operations. See Section 6.2, "Peripheral Device Access." for a complete memory map.
Addr1	78		
Addr2	74		
Addr3	71		
Addr4	68		
Addr5	64		
Addr6	61		
Addr7	57		
Addr8	53		
Addr9	51		
Addr10	48		
Addr11	45		
Addr12	43		
Addr13	39		
Addr14	34		
Addr15	31		
Data0	127	bi-directional	Multi-purpose data lines. These pins comprise the CP chip's external data bus, which is used for all communications with peripheral devices such as external memory or DACs. They may also be used for parallel-word input and for user-defined I/O operations.
Data1	130		
Data2	132		
Data3	134		
Data4	136		
Data5	138		
Data6	143		
Data7	5		
Data8	9		
Data9	13		
Data10	15		
Data11	17		
Data12	20		
Data13	22		
Data14	24		
Data15	27		
AnalogVcc	116	input	Analog input V_{CC} . This pin should be connected to the analog input supply voltage, which must be in the range of 3.0V to 3.6V. If the analog input circuitry is not used, this pin should be tied to V_{CC} .
AnalogRefHigh	115	input	Analog high voltage reference for A/D input. The allowed range is <i>AnalogRefLow</i> to <i>AnalogVcc</i> . If the analog input circuitry is not used, this pin should be tied to V_{CC} .
AnalogRefLow	114	input	Analog low voltage reference for A/D input. The allowed range is <i>AnalogGND</i> to <i>AnalogRefHigh</i> . If the analog input circuitry is not used, this pin should be tied to <i>GND</i> .
AnalogGND	117	input	Analog input ground. This pin should be connected to the analog input power supply return. If the analog input circuitry is not used, this pin should be tied to <i>GND</i> .
Analog0	112	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 signal input range is <i>AnalogRefLow</i> to <i>AnalogRefHigh</i> . Any unused pins should be tied to <i>AnalogGND</i> . If the analog input circuitry is not used, these pins should be tied to <i>GND</i> .
Analog1	113		
Analog2	110		
Analog3	111		
Analog4	107		
Analog5	109		
Analog6	105		
Analog7	108		

55110 CP

Pin Name and Number		Direction	Description
PosLim I	46	input	This signal provides input from the positive-side (forward) travel limit switch. On power-up or after reset, this signal defaults to active <i>low</i> interpretation, but the interpretation can be set to active <i>high</i> interpretation using the SetSignalSense instruction. If this pin is not used, it may remain unconnected.
NegLim I	38	input	This signal provides input from the negative-side (reverse) travel limit switch. On power-up or after reset, this signal defaults to active <i>low</i> interpretation, but the interpretation can be set to active <i>high</i> interpretation using the SetSignalSense instruction. If this pin is not used, it may remain unconnected.
AxisOut I	33	output	For Magellan ICs revision 3.0 or higher this pin provides the AxisOut I output. AxisOut I can be programmed to track the state of any bit in the status registers.
AxisIn I	16	input	This pin is a general-purpose input which can also be used as a breakpoint input. If this pin is not used, it may remain unconnected.
OutputMode0	7	input	OutputMode0 should be tied low with Magellan ICs revision 3.0 or higher. For Magellan ICs lower than revision 3.0 this pin should be left floating. The state of this pin is only checked during power up.
Pulse I	56	output	This pin provides the pulse (step) signal to the motor. A step occurs when the signal transitions from a <i>high</i> to a <i>low</i> state. This default behavior can be changed to a <i>low</i> to <i>high</i> state transition using the command SetSignalSense . If this pin is not used, it may remain unconnected.
Direction I	54	output	This pin indicates the direction of motion, and works in conjunction with the pulse signal. A <i>high</i> level on this signal indicates a positive direction move, and a <i>low</i> level indicates a negative direction move.
AtRest I	52	output	This signal indicates that the axis is at rest and the step motor can be switched to low power or standby mode. A <i>high</i> level on this signal indicates the axis is at rest while a <i>low</i> signal indicates the axis is in motion.
QuadA I QuadB I	83 79	input	These pins should be connected to the A and B quadrature signals from the incremental encoder. When the axis is moving in the positive (forward) direction, signal A leads signal B by 90°. NOTE: Some encoders require a pull-up resistor to 3.3V on each signal to establish a proper high signal. Check your encoder's electrical specification. If these pins are not used, they may remain unconnected.
~Home I	75	input	This pin provides the home signal; a general-purpose input to the position capture mechanism. A valid home signal is recognized by the motion control IC when ~Home transitions from <i>high</i> to <i>low</i> . If this pin is not used, it may remain unconnected.
QuadAuxA I QuadAuxB I ~Index I	88 81 69	input	If index capture is required, the encoder A and B signals connected to QuadA I and QuadB I signals must also be connected to QuadAuxA I and QuadAuxB I. The index pin should be connected to the index signal from the incremental encoder. A valid index pulse is recognized by the motion control IC when it meets the criteria shown in Figure 4-2 . If these pins are not used, they may remain unconnected. WARNING! There is no internal gating of the index signal with the encoder A and B inputs. This must be performed externally if desired.

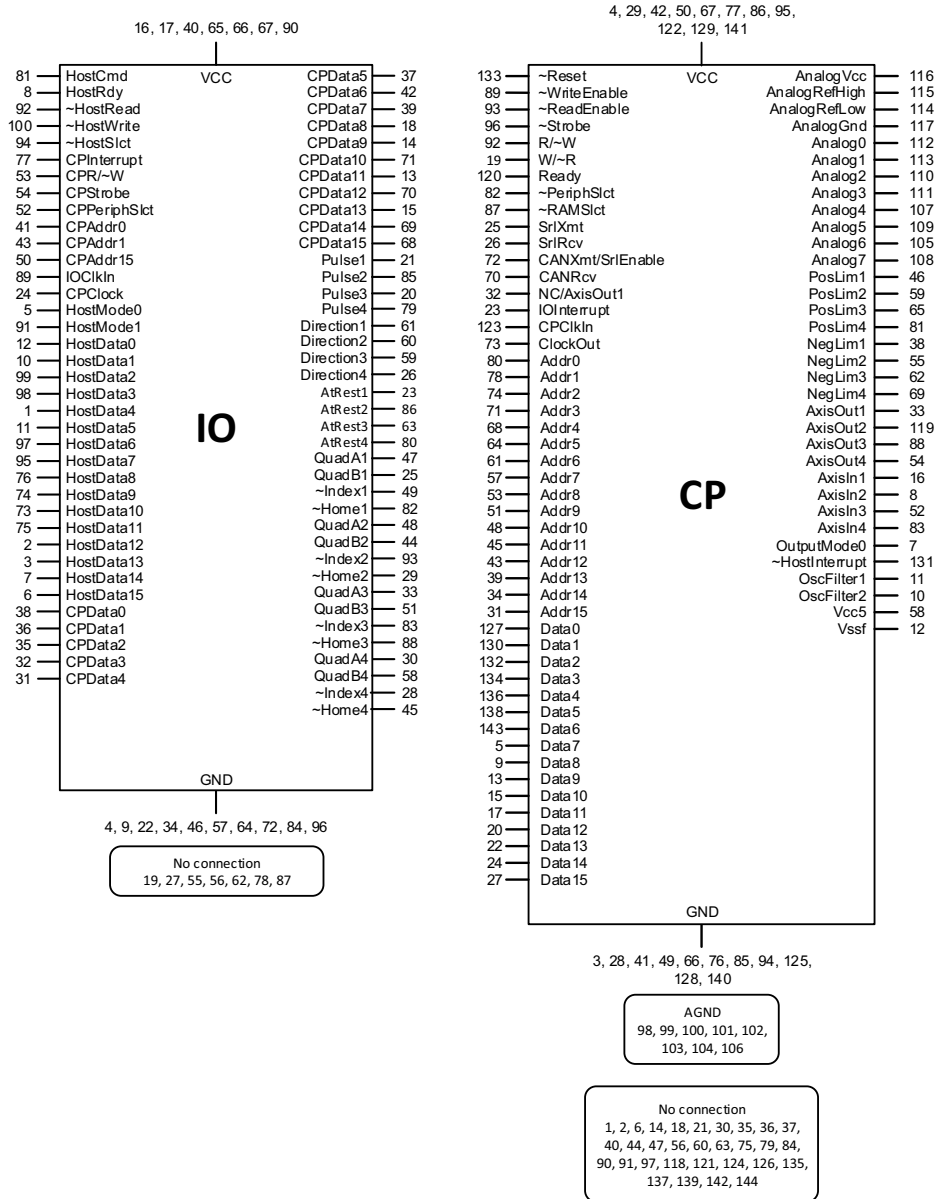
55110 CP

Pin Name and Number	Direction	Description
ParallelEnable 8	input	This signal enables/disables the parallel communication with the host. If this signal is tied <i>high</i> , the parallel interface is enabled. If this signal is tied <i>low</i> , the parallel interface is disabled. Contact PMD for more information on parallel communication. WARNING! This signal should only be tied high if an external logic device which implements the parallel communication logic is included in the design.
~HostInterrupt 131	output	When <i>low</i> , this signal causes an interrupt to be sent to the host processor.
OscFilter1 11		These signals connect to the external oscillator filter circuitry. Section 6.4.5, "External Oscillator Filter," details the required filter circuitry.
OscFilter2 10		
V _{cc5} 58		This signal can be tied to a 5V supply if available. If 5V is not available this signal must be tied to GND. Being tied to GND will not adversely affect the device performance.
V _{ssf} 12		This signal must be tied to V _{cc} . It must also be tied to pin 28 via a bypass capacitor. A ceramic capacitor with a value between 0.1 μ F and 0.01 μ F should be used.
V _{cc} 4, 29, 42, 50, 67, 77, 86, 95, 122, 129, 141		CP digital supply voltage. All of these pins must be connected to the supply voltage. V _{cc} must be in the range of 3.0V to 3.6V.
GND 3, 28, 41, 49, 66, 76, 85, 94, 125, 128, 140		CP digital supply ground. All of these pins must be connected to the digital power supply return.
AGND 98, 99, 100, 101, 102, 103, 104, 106		These signals must be tied to <i>AnalogGND</i> . If the analog input circuitry is not used, these pins must be tied to <i>GND</i> .
No connection 1, 2, 6, 14, 18, 21, 30, 35, 36, 37, 40, 44, 47, 55, 59, 60, 62, 63, 65, 84, 90, 91, 97, 118, 119, 121, 124, 126, 135, 137, 139, 142, 144		These signals must remain unconnected.

5.3 Pinouts for the MC55x20

5.3.1 MC55420 Pinouts

Figure 5-2:
MC55420
pinouts



5.3.2 MC55320 Pinouts

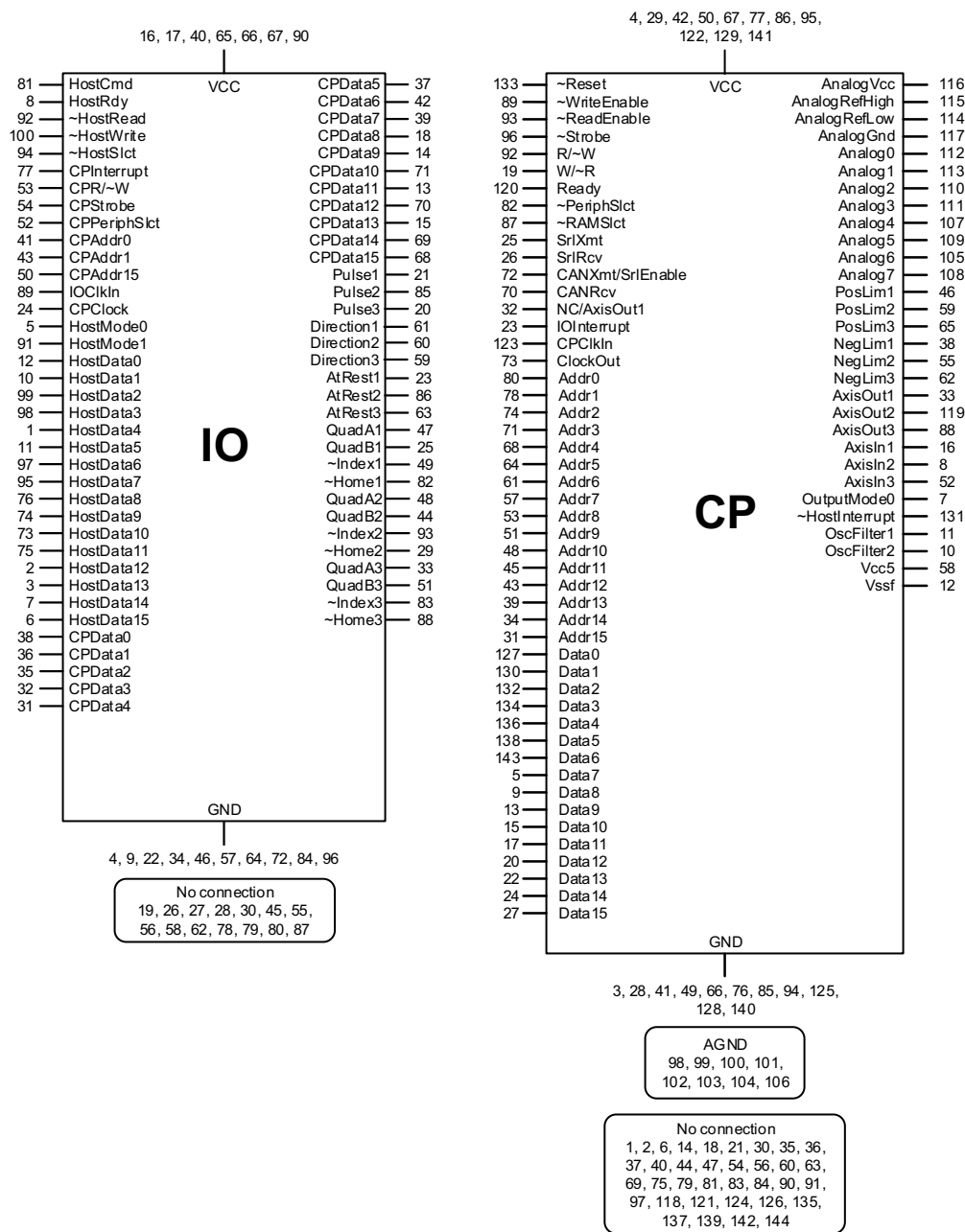
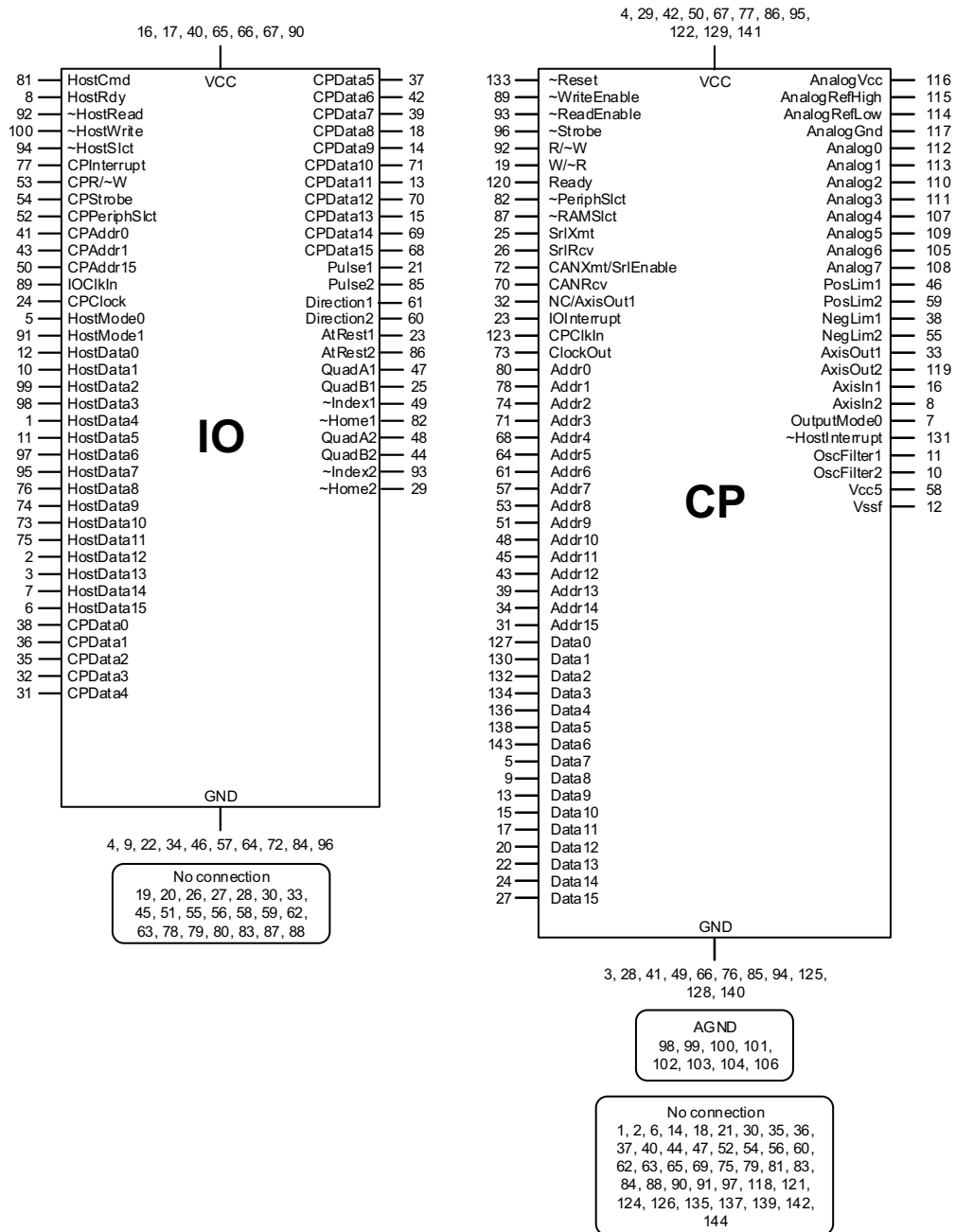


Figure 5-3:
MC55320
pinouts

5.3.3 MC55220 Pinouts

Figure 5-4:
MC55220
pinouts



5.3.4 MC55120 Pinouts

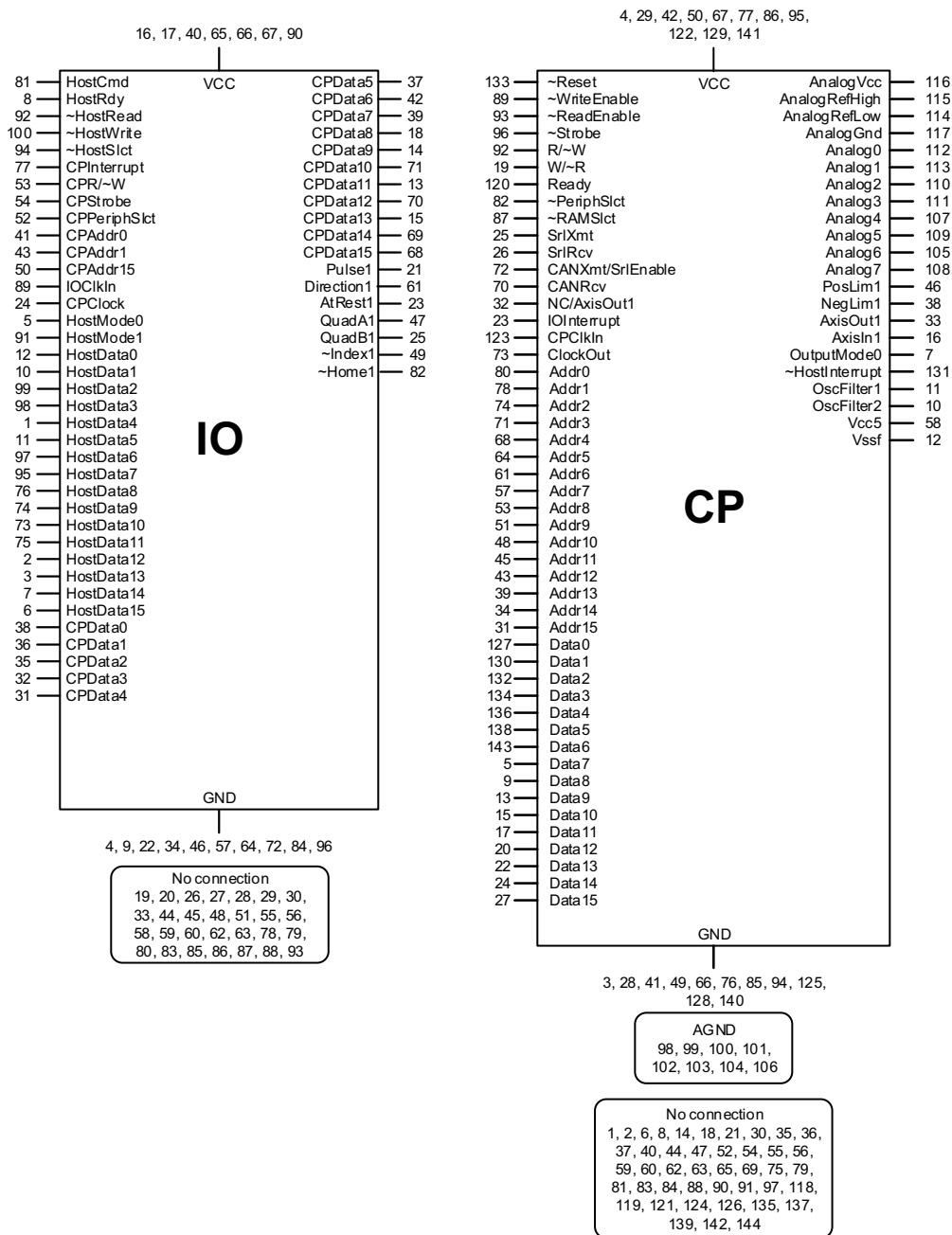


Figure 5-5: MC55120 pinouts

5.4 MC55x20 Pin Descriptions

5.4.1 MC55x20 I/O Chip

MC55x20 IO																		
Pin Name and Number	Direction	Description																
HostCmd	81	input	This signal is asserted <i>high</i> to write a host instruction to the motion control IC, or to read the status of the <i>HostRdy</i> and <i>HostInterrupt</i> signals. It is asserted <i>low</i> to read or write a data word.															
HostRdy	8	output	<p>This signal is used to synchronize communication between the motion control IC and the host. <i>HostRdy</i> (Host Ready) will go <i>low</i> indicating host port busy at the end of a read or write operation according to the interface mode in use, as follows:</p> <table border="0"> <tr> <td>Interface Mode</td> <td>HostRdy goes low</td> </tr> <tr> <td>8/16</td> <td>after the second byte of the instruction word after the second byte of each data word is transferred</td> </tr> <tr> <td>16/16</td> <td>after the 16-bit instruction word after each 16-bit data word</td> </tr> </table> <p><i>HostRdy</i> will go <i>high</i>, indicating that the host port is ready to transmit, when the last transmission has been processed. All host port communications must be made with <i>HostRdy high</i> (ready).</p> <p>A typical busy-to-ready cycle is 10 microseconds, but can be significantly longer for certain host command operations.</p>	Interface Mode	HostRdy goes low	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									
Interface Mode	HostRdy goes low																	
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																	
\sim HostRead	92	input	When \sim HostRead is <i>low</i> , a data word is read from the motion control IC.															
\sim HostWrite	100	input	When \sim HostWrite is <i>low</i> , a data word is written to the motion control IC.															
\sim HostSlct	94	input	When \sim HostSlct is <i>low</i> , the host port is selected for reading or writing operations.															
CPInterrupt	77	output	IO chip to CP chip interrupt. It should be connected to CP chip pin 23, <i>IOInterrupt</i> .															
CPR/ \sim W	53	input	This signal is <i>high</i> when the CP chip is reading data from the IO chip, and <i>low</i> when it is writing data. It should be connected to CP chip pin 92, <i>R/\simW</i> .															
CPStrobe	54	input	This signal goes <i>low</i> when the data and address become valid during motion control IC communication with peripheral devices on the data bus, such as external memory or a DAC. It should be connected to CP chip pin 96, \sim <i>Strobe</i> .															
CPPeriphSlct	52	input	This signal goes <i>low</i> when a peripheral device on the data bus is being addressed. It should be connected to CP chip pin 82, \sim <i>PeriphSlct</i> .															
CPAddr0	41	input	These signals can be <i>high</i> or <i>low</i> , and are used when the CP chip is communicating with the IO chip. They should be connected to CP chip pin 80 (<i>Addr0</i>), and pin 78 (<i>Addr1</i>).															
CPAddr1	43																	
CPAddr15	50	input	This signal is used by the CP chip when communicating with the IO chip. It should be connected to CP chip pin 31 (<i>Addr15</i>).															
IOClkIn	89	input	This is the master clock signal for the chip set. It is driven at a nominal 40 MHz.															
CPClock	24	output	This signal provides the clock pulse for the CP chip. Its frequency is half that of <i>IOClkIn</i> (pin 89), or 20 MHz nominal. It is connected directly to the CP chip <i>IOClock</i> signal (pin 123).															
HostMode0	5	input	<p>These two signals determine the host communications mode, as follows:</p> <table border="0"> <tr> <td><i>HostMode1</i></td> <td><i>HostMode0</i></td> <td></td> </tr> <tr> <td>0</td> <td>0</td> <td>16/16 parallel (16-bit bus, 16-bit instruction)</td> </tr> <tr> <td>0</td> <td>1</td> <td><i>not used</i></td> </tr> <tr> <td>1</td> <td>0</td> <td>8/16 parallel (8-bit bus, 16-bit instruction)</td> </tr> <tr> <td>1</td> <td>1</td> <td>Parallel disabled</td> </tr> </table>	<i>HostMode1</i>	<i>HostMode0</i>		0	0	16/16 parallel (16-bit bus, 16-bit instruction)	0	1	<i>not used</i>	1	0	8/16 parallel (8-bit bus, 16-bit instruction)	1	1	Parallel disabled
<i>HostMode1</i>	<i>HostMode0</i>																	
0	0			16/16 parallel (16-bit bus, 16-bit instruction)														
0	1			<i>not used</i>														
1	0			8/16 parallel (8-bit bus, 16-bit instruction)														
1	1	Parallel disabled																
HostMode1	91																	

MC55x20 IO

Pin Name and Number	Direction	Description
HostData0	12	bi-directional, tri-state These signals transmit data between the host and the motion control IC through the parallel port. Transmission is mediated by the control signals \sim HostSelect, \sim HostWrite, \sim 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 in which this port operates.
HostData1	10	
HostData2	99	
HostData3	98	
HostData4	1	
HostData5	11	
HostData6	97	
HostData7	95	
HostData8	76	
HostData9	74	
HostData10	73	
HostData11	75	
HostData12	2	
HostData13	3	
HostData14	7	
HostData15	6	
CPData0	38	bi-directional These signals transmit data between the IO chip and pins Data0-15 of the CP chip.
CPData1	36	
CPData2	35	
CPData3	32	
CPData4	31	
CPData5	37	
CPData6	42	
CPData7	39	
CPData8	18	
CPData9	14	
CPData10	71	
CPData11	13	
CPData12	70	
CPData13	15	
CPData14	69	
CPData15	68	
Pulse1	21	output These pins provide the pulse (step) 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 <i>high</i> state to a <i>low</i> state. This default behavior can be changed to a <i>low</i> to <i>high</i> state transition using the command SetSignalSense . The number of available axes determines which of these signals are valid. Invalid axis pins may remain unconnected.
Pulse2	85	
Pulse3	20	
Pulse4	79	
Direction1	61	output These pins indicate the direction of motion and work in conjunction with the pulse signal. A <i>high</i> level on this signal indicates a positive direction move and a <i>low</i> level indicates a negative direction move. The number of available axes determines which of these signals are valid. Invalid axis pins may remain unconnected.
Direction2	60	
Direction3	59	
Direction4	26	
AtRest1	23	output The AtRest signal indicates the axis is at rest and the step motor can be switched to low power or standby. A <i>high</i> level on this signal indicates the axis is at rest. A <i>low</i> signal indicates the axis is in motion. The number of available axes determines which of these signals are valid. Invalid axis pins may remain unconnected.
AtRest2	86	
AtRest3	63	
AtRest4	80	
QuadA1	47	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°. NOTE: Some encoders require a pull-up resistor to 3.3V on each signal to establish a proper high signal. Check your encoder's electrical specification. The number of available axes determines which of these signals are valid. WARNING! If a valid axis pin is not used, its signal should be tied high. Invalid axis pins may remain unconnected, or may be connected to ground.
QuadB1	25	
QuadA2	48	
QuadB2	44	
QuadA3	33	
QuadB3	51	
QuadA4	30	
QuadB4	58	

MC55x20 IO

Pin Name and Number	Direction	Description
~Index1 ~Index2 ~Index3 ~Index4	49 93 83 28	input
		<p>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 <i>low</i>.</p> <p>The number of available axes determines which of these signals are valid.</p> <p>WARNING! If a valid axis pin is not used, its signal should be tied high.</p> <p>Invalid axis pins may remain unconnected, or may be connected to ground.</p>
~Home1 ~Home2 ~Home3 ~Home4	82 29 88 45	input
		<p>These pins provide the home signals, which are the general-purpose inputs to the position-capture mechanism. A valid home signal is recognized by the chipset when ~Home_n goes <i>low</i>. These signals are similar to ~Index, but are not gated by the A and B encoder channels.</p> <p>The number of available axes determines which of these signals are valid.</p> <p>WARNING! If a valid axis pin is not used, its signal should be tied high.</p> <p>Invalid axis pins may remain unconnected, or may be connected to ground.</p>
Vcc	16, 17, 40, 65, 66, 67, 90	
		All of these pins must be connected to the IO chip digital supply voltage, which should be in the range of 3.0V to 3.6V.
GND	4, 9, 22, 34, 46, 57, 64, 72, 84, 96	
		IO chip ground. All of these pins must be connected to the digital power supply return.
Not connected	19, 27, 55, 56, 62, 78, 87	
		These pins must remain unconnected (floating).

5.4.2 CP Chip

MC55x20 CP			
Pin Name and Number	Direction	Description	
\sim Reset	133	input/output	This is the master reset signal. This pin must be brought <i>low</i> to reset the chipset to its initial conditions. NOTE: A software reset will momentarily drive this pin <i>low</i> . NOTE: For additional important information on Reset signal management and timing please see Section 6.4.6, "Reset Signal."
\sim WriteEnable	89	output	This signal is the write-enable strobe. When <i>low</i> , this signal indicates that data is being written to the bus.
\sim ReadEnable	93	output	This signal is the read-enable strobe. When <i>low</i> , this signal indicates that data is being read from the bus.
\sim Strobe	96	output	This signal is <i>low</i> when the data and address are valid during CP communications. It should be connected to IO chip pin 54, <i>CPStrobe</i> .
R/ \sim W	92	output	This signal is <i>high</i> when the CP chip is performing a read, and <i>low</i> when it is performing a write. It should be connected to IO chip pin 53, <i>CPR/\simW</i> .
W/ \sim R	19	output	This signal is the inverse of R/ \sim W; it is <i>high</i> when R/ \sim W is <i>low</i> , and vice-versa. For some decode circuits and devices, this is more convenient than R/ \sim W.
Ready	120	input	<i>Ready</i> can be pulled <i>low</i> to add wait states for external accesses. <i>Ready</i> indicates that an external device is prepared for a bus transaction to be completed. If the device is not ready, it pulls the <i>Ready</i> pin <i>low</i> . The motion control IC then waits one cycle and checks <i>Ready</i> again. or a timing diagram and example schematic using the <i>Ready</i> signal refer to Section 6.8.1, "Slow Asynchronous SRAM." If used, this signal is typically asserted during RAM Read/Write or Peripheral Read/Write operations. However another use of this signal is to hold off on configuration reads done at startup. Keeping <i>Ready</i> asserted at the time of Reset release and beyond allows synchronization with FPGAs other external logic that may not yet be ready to receive configuration Peripheral reads. This signal may remain unconnected if it is not used.
\sim PeriphSlect	82	output	This signal is <i>low</i> when peripheral devices on the data bus are being addressed. It should be connected to IO chip pin 52, <i>CPPeriphSlect</i> .
\sim RAMSlect	87	output	This signal is <i>low</i> when external memory is being accessed.
SrIXmt	25	output	This pin outputs serial data from the asynchronous serial port.
SrIRcv	26	input	This pin inputs serial data to the asynchronous serial port. If not used, this pin should be tied to Vcc.
CANXmt/ SrIEnable	72	output	When the CAN host interface is used, this pin transmits serial data to the CAN transceiver. When the multi-drop serial interface is used, this pin sets the serial port enable line, and the <i>CANXmt</i> function is not available. <i>SrIEnable</i> is <i>high</i> during transmission for the multi-drop protocol, and always <i>high</i> during point-to-point mode.
CANRcv	70	input	This pin receives serial data from the CAN transceiver. If not used, this pin should be tied to Vcc.
NC/AxisOutI	32	input or output	If <i>OutputMode0</i> is <i>low</i> this pin should be left unconnected. if <i>OutputMode0</i> is left floating at power up this pin provides the <i>AxisOutI</i> output. <i>AxisOutI</i> can be programmed to track the state of any bit in the status registers. If unused, this pin may be left unconnected.
IOInterrupt	23	input	This interrupt signal is used for IO to CP communication. It should be connected to IO chip pin 77, <i>CPInterrupt</i> .
CPClkIn	123	input	This is the CP chip clock signal. It should be connected to IO chip pin 24, <i>CPClock</i> .
ClockOut	73	output	This signal is the reference output clock. Its frequency is the same as the <i>CPClkIn</i> signal to the IO chip, nominally 40 MHz. <i>ClockOut</i> will not be active when \sim Reset is active.

MC55x20 CP			
Pin Name and Number		Direction	Description
Addr0	80	output	Multi-purpose address lines. These pins comprise the CP chip's external address bus, and are used to select devices for communication over the data bus. <i>Addr0</i> , <i>Addr1</i> , and <i>Addr15</i> are connected to the corresponding <i>CPAddr</i> pins on the IO chip, and are used to communicate between the CP and IO chips. Other address pins may be used for DAC output, parallel word input, external memory, or user-defined I/O operations. See Section 6.2, "Peripheral Device Access." for a complete memory map.
Addr1	78		
Addr2	74		
Addr3	71		
Addr4	68		
Addr5	64		
Addr6	61		
Addr7	57		
Addr8	53		
Addr9	51		
Addr10	48		
Addr11	45		
Addr12	43		
Addr13	39		
Addr14	34		
Addr15	31		
Data0	127	bi-directional	Multi-purpose data lines. These pins comprise the CP chip's external data bus, which is used for all communications with the IO 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.
Data1	130		
Data2	132		
Data3	134		
Data4	136		
Data5	138		
Data6	143		
Data7	5		
Data8	9		
Data9	13		
Data10	15		
Data11	17		
Data12	20		
Data13	22		
Data14	24		
Data15	27		
AnalogVcc	116	input	Analog input Vcc. This pin should be connected to the analog input supply voltage, which must be in the range of 3.0V to 3.6V. If the analog input circuitry is not used, this pin should be tied to V _{CC} .
AnalogRefHigh	115	input	Analog high voltage reference for A/D input. The allowed range is 2V to <i>AnalogVcc</i> . Furthermore, the difference between V _{CC} and <i>AnalogVcc</i> should not be larger than 0.3V. If the analog input circuitry is not used, this pin should be tied to V _{CC} .
AnalogRefLow	114	input	Analog low voltage reference for A/D input. The allowed range is <i>AnalogGND</i> to <i>AnalogRefHigh</i> . If the analog input circuitry is not used, this pin should be tied to GND.
AnalogGND	117	input	Analog input ground. This pin should be connected to the analog input power supply return. If the analog input circuitry is not used, this pin should be tied to GND.
Analog0	112	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 signal input range is <i>AnalogRefLow</i> to <i>AnalogRefHigh</i> . Any unused pins should be tied to <i>AnalogGND</i> . If the analog input circuitry is not used, these pins should be tied to GND.
Analog1	113		
Analog2	110		
Analog3	111		
Analog4	107		
Analog5	109		
Analog6	105		
Analog7	108		
PosLim1	46	input	These signals provide inputs from the positive-side (forward) travel limit switches. On power-up or after reset, these signals default to active <i>low</i> interpretation, but the interpretation can be set explicitly using the SetSignalSense instruction. The number of available axes determines which of these signals are valid. Invalid or unused pins may remain unconnected.
PosLim2	59		
PosLim3	65		
PosLim4	81		

MC55x20 CP			
Pin Name and Number	Direction	Description	
NegLim1	38	input	These signals provide inputs from the negative-side (reverse) travel limit switches. On power-up or after reset, these signals default to active <i>low</i> interpretation, but the interpretation can be set explicitly using the SetSignalSense instruction.
NegLim2	55		
NegLim3	62		
NegLim4	69		
			The number of available axes determines which of these signals are valid. Invalid or unused pins may remain unconnected.
AxisOut1	33	output	Each of these pins can be conditioned to track the state of any bit in the status registers associated with its axis.
AxisOut2	119		
AxisOut3	88		
AxisOut4	54		
			The number of available axes determines which of these signals are valid. Invalid or unused pins may remain unconnected.
AxisIn1	16	input	These are general-purpose inputs which can also be used as a breakpoint input.
AxisIn2	8		
AxisIn3	52		
AxisIn4	83		
			The number of available axes determines which of these signals are valid. Invalid or unused pins may remain unconnected.
OutputMode0	7		OutputMode0 should be tied low with Magellan ICs revision 3.0 or higher. For Magellan ICs lower than revision 3.0 this pin should be left floating.
~HostInterrupt	131	output	When <i>low</i> , this signal causes an interrupt to be sent to the host processor.
OscFilter1	11		These signals connect to the external oscillator filter circuitry. Section 6.4.5, "External Oscillator Filter," details the required filter circuitry.
OscFilter2	10		
V _{cc5}	58		This signal can be tied to a 5V supply if available. If 5V is not available this signal must be tied to GND. Being tied to GND will not adversely affect the device performance.
V _{ssf}	12		This signal must be tied to V _{cc} . It must also be tied to pin 28 via a bypass capacitor. A ceramic capacitor with a value between 0.1 μ F and 0.01 μ F should be used.
V _{cc}	4, 29, 42, 50, 67, 77, 86, 95, 122, 129, 141		CP digital supply voltage. All of these pins must be connected to the supply voltage. V _{cc} must be in the range of 3.0V to 3.6V.
GND	3, 28, 41, 49, 66, 76, 85, 94, 125, 128, 140		CP digital supply ground. All of these pins must be connected to the digital power supply return.
AGND	98, 99, 100, 101, 102, 103, 104, 106		These signals must be tied to <i>AnalogGND</i> . If the analog input circuitry is not used, these pins must be tied to <i>GND</i> .
No connection	1, 2, 6, 14, 18, 21, 30, 35, 36, 37, 40, 44, 47, 56, 60, 63, 75, 79, 84, 90, 91, 97, 118, 121, 124, 126, 135, 137, 139, 142, 144		These signals must remain unconnected.

6. Application Notes — MC55110 and MC55x20

6

In This Chapter

- ▶ General Design Notes
- ▶ Design Tips
- ▶ Peripheral Device Address Mapping
- ▶ Device Initialization
- ▶ Power Supplies
- ▶ Clock Generator, Grounding and Decoupling, and Device Reset
- ▶ Serial Communication Interface (SCI)
- ▶ CAN Communication Interface
- ▶ External Memory
- ▶ Asynchronous SRAM
- ▶ Using the On-chip ADC
- ▶ User I/O Space
- ▶ Parallel Communication Interface
- ▶ Overcurrent and Emergency Braking Circuits for Motor Drivers
- ▶ Pulse & Direction Mode Output Connected to Atlas
- ▶ Using the Allegro A3977 to Drive Microstepping Motors

6.1 General Design Notes

Logic functions presented in the example schematics are implemented by standard logic gates. In cases where specific parameters are of significance (propagation delay, voltage levels, etc...) a recommended part number is given.

One important point of note is that the single and dual chip configurations of Magellan share several signals with the same name that reside on physically different chips. For example, on the MC55x20, the pulse & direction signals are located on the IO chip, while on the MC55110, the pulse & direction signals are located on the CP chip. As such, care should be taken to ensure that during the initial schematic layout that the correct CP chip is selected.

The schematic designs presented in this chapter are accurate to the best of PMD's knowledge. They are intended for reference only and have not all been tested in hardware implementations.



6.1.1 Interfacing to Other Logic Families

When integrating different logic families, consideration should be given to timing, logic level compatibility, and output drive capabilities. The Magellan CP and IO chips are 3.3V CMOS input/output compatible and cannot be directly interfaced to 5V CMOS components. In order to drive a 5V CMOS device, level shifters from the 5V CMOS AHCT

(or the slower HCT) families can be used. When using a 5V CMOS component to drive the CP, a voltage divider may be used or a member from the CMOS 3.3V LVT family may serve as a level shifter.

6.1.2 Serial Interface

The serial interface is a convenient interface which 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, and the serial interface is used for debugging as previously mentioned, the CP data bus should be tied high. This places the serial interface in a default configuration of 57,600, n, 8, 1 after power on or reset.

6.1.3 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 MC59000 ICs, it is possible to use a clock below the standard value of 40 MHz. In this case, all system frequencies will be reduced as a fraction of the input clock versus the standard 40 MHz clock. The following list details the affected system parameters.

- Serial baud rate
- Cycle time

For example, if an input clock of 34 MHz is used with a serial baud rate of 9600, the following timing changes will result.

- Serial baud rate decreases to $9600 \text{ bps} * 34/40 = 8160 \text{ bps}$
- Total cycle time increases by a factor of $40/34$

6.2 Peripheral Device Access

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

Address	Device	Description
0100h	Motor type configuration	Contains the configuration data for the per axis motor type selection
0200h	Serial port configuration	Contains the configuration data (transmission rate, parity, stop bits, etc.) for the asynchronous serial port
0400h	CAN port configuration	Contains the configuration data (baud rate and node ID) for the CAN controller
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
8000h	<i>reserved</i>	

6.2.1 Device Initialization and Configuration

Following a hardware or software reset, the motion control IC reads from three external configuration registers to determine the desired settings for serial communication and CAN communication. These reads take place sequentially using the peripheral address read. The timing for this read is shown in [Figure 4-15](#).

6.2.1.1 Serial Port Configuration

When the serial configuration is read, the 16-bit word is interpreted according to the following table.

Bit Number	Name	Instance	Encoding
0-3	transmission rate	1200 baud	0
		2400	1
		9600	2
		19200	3
		57600	4
		115200	5
		230400	6
4-5	parity	460800	7
		none	0
		odd	1
6	stop bits	even	2
		1	0
6	stop bits	2	1
		Point-to-point	0
7-8	protocol	Multi-drop using idle-line detection	1
		reserved	2
		reserved	3
		reserved	3
11-15	multi-drop address	Address 0	0
		Address 1	1
	
		Address 31	31

6.2.1.2 CAN Port Configuration

When the CAN configuration is read, the 16-bit word is interpreted according to the following table.

Bit Number	Name	Instance	Encoding
0-6	nodeID	Address 0	0
		Address 1	1
	
		Address 127	127
7-12	reserved	reserved	reserved
13-15	transmission rate	1,000,000 baud	0
		800,000	1
		500,000	2
		250,000	3
		125,000	4
		50,000	5
		20,000	6
		10,000	7

As an alternative to decoding each configuration address, a special condition occurs when the device powers up and the external bus is pulled high. In this case, the device will read the contents of each configuration register as containing the value 0xffff. When this occurs, the device will configure the serial port as 57,600, n, 8, 1; and the CAN port as 20,000 bps with a NodeID of zero.

If the serial or CAN port is not required, the circuitry for decoding the relevant addresses can be omitted, and the *CANRcv* and *SrIRcv* signals can remain disconnected to prevent the chip from responding to either of these communication inputs.



Since CANbus cannot be used when serial multi-drop mode is selected, if using CANbus the serial port configuration register, described in [Section 6.2.1.2, “CAN Port Configuration,”](#) must have bits 7 and 8 tied low (selecting point to point serial communications).

6.2.2 Parallel-Word Encoder Input

When the parallel-word encoder value is read the word interpretation is as detailed in the table below:

Address	Word
0x810	Upper 16-bits of Axis 1 word
0x811	Lower 16-bits of Axis 1 word
0x812	Upper 16-bits of Axis 2 word
0x813	Lower 16-bits of Axis 2 word
0x814	Upper 16-bits of Axis 3 word
0x815	Lower 16-bits of Axis 3 word
0x816	Upper 16-bits of Axis 4 word
0x817	Lower 16-bits of Axis 4 word

6.3 Power Supplies

In the schematic shown in [Figure 6-1](#), the design is powered by an external 5V DC power source. The MC55000 device requires a 3.3V supply and an optional 5V input. The 5V input to the motion control IC can be omitted if 5V is not required elsewhere in the design. The 3.3V digital supply, VCC, is generated by an LT1086-3.3, a 1.5Amp fixed 3.3V low-dropout voltage regulator. Components with a larger power capacity are also available, such as the LT1085-3.3.

If the CP's analog-to-digital converter (ADC) is used, it should be supplied with a filtered 3.3V supply. The +3.3Vs supply is a filtered version of the VCC supply, which is used to supply the ADC and its related conditioning circuitry. The extra filtering is used to provide additional decoupling of the analog elements from the digital elements in the circuitry.

The following is the list of supplies which are referenced in the example schematics:

- +5Vs: a filtered version of 5VCC. This is used for analog components requiring +5V supplies. The extra filtering is used to reduce the voltage ripple, and to generate additional decoupling of the analog elements from the digital elements in the circuitry.
- ± 15 Vs: ± 15 V supplies, used for analog components dealing with large input or output voltage swings; usually when interfacing to motors or sensors. The Callex 5D15.033 is a 1W ± 15 V DC/DC converter which delivers ± 33 mA. Depending on the current load of the final design, a larger power capacity DC/DC converter may be required. An LC filter is used to reduce the voltage ripple.

Notes:

- The schematic in [Figure 6-1](#) should be used for reference only. The actual supplies used should be designed according to the stability and precision requirements of the application. The power supplies presented here are only designed to meet the requirements of the example schematics.

- Power supplies for the motor drivers are not shown. Care should be taken when designing these power supplies, as they should be capable of sinking high switching currents.

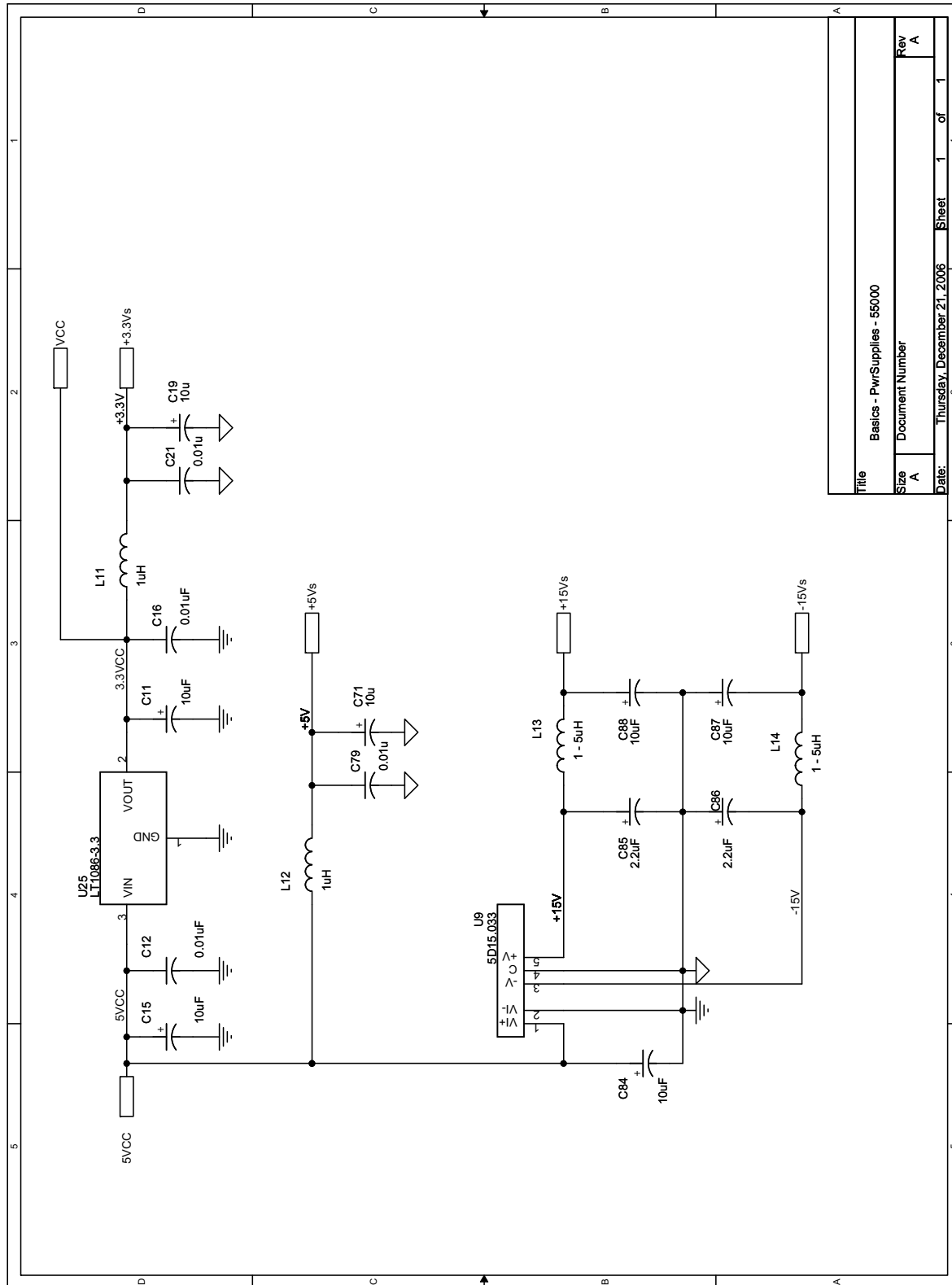


Figure 6-1:
Basics, power
supplies,
55000

6.4 Clock Generator, Grounding and Decoupling, and Device Reset

6.4.1 Clock Generator — MC55110

The nominal clock frequency of the MC55110 CP is 20 MHz. A separate 20 MHz clock may be generated for the device and peripherals or a pre-existing derivative of a clock generated on the board may be used. If an existing clock is to be used, ensure that the input voltages and timing requirements of the MC55110 are met and that the correct frequency is generated.

For any frequency in the range, the bypass capacitor (labeled C3 in figures [Figure 6-2](#) and [Figure 6-3](#)) should be between 0.1 and 0.01 μF , ceramic, and it should have private and as short as possible traces to the pins. This method will reduce noise and jitter, and increase isolation.

6.4.2 Clock Generator — MC55x20

The nominal clock frequency of the MC55x20 IO is 40 MHz. The IO chip generates a nominal 20 MHz clock signal for the CP chip by dividing the input frequency by two. When applying a lower clock frequency to the IO chip, the CP external oscillator filter circuit must adhere to the values listed in [Section 6.4.5, “External Oscillator Filter.”](#)

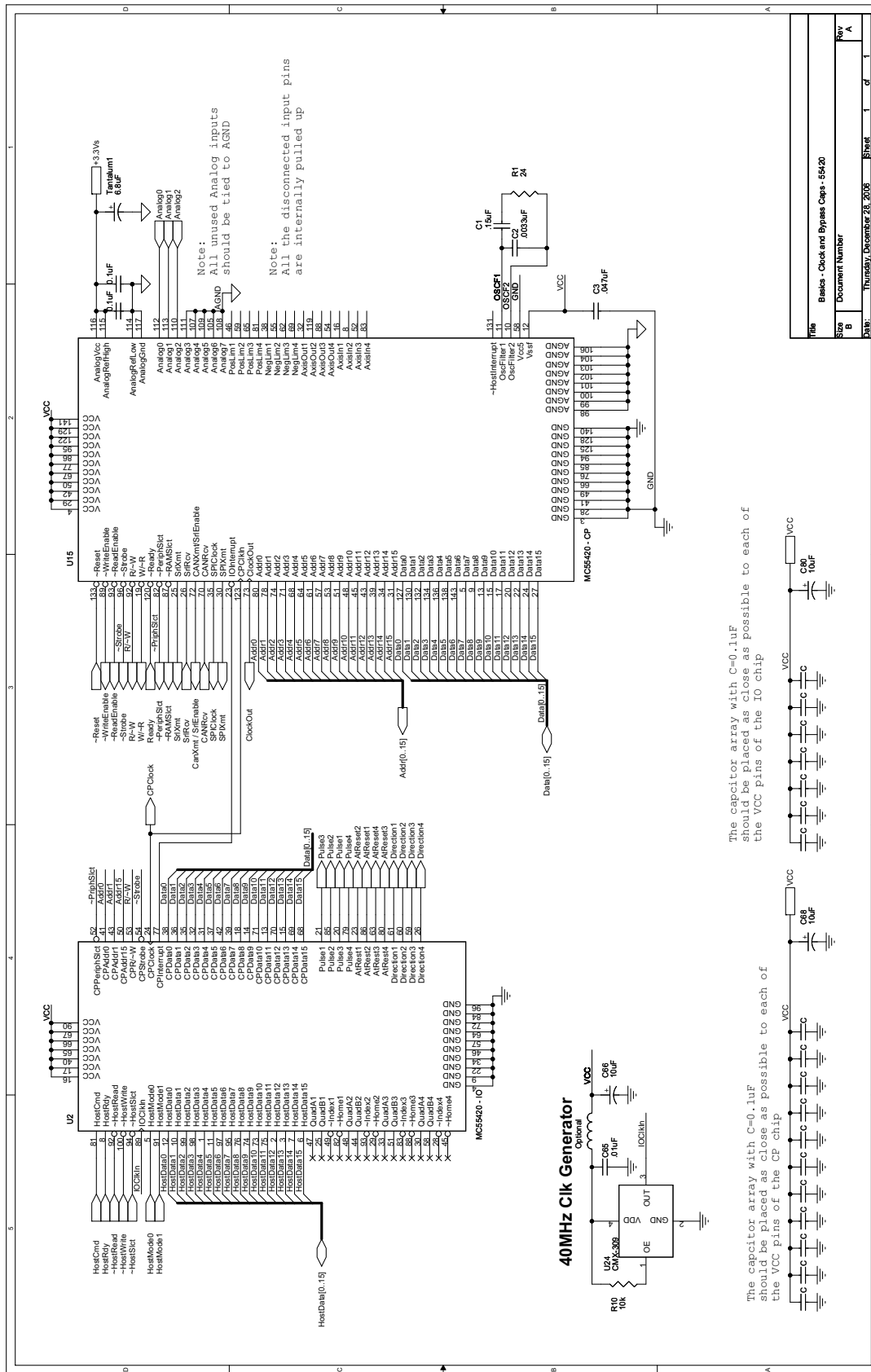
6.4.3 Grounding and Decoupling

Each component should be decoupled with the use of large capacitors, usually tantalum 6.7-10 μF in parallel, with a set of 10-100 nF ceramic capacitors placed as close as possible between each one of the power supply pins and ground. This general rule applies to all analog and digital components, although in some of the schematics that follow these capacitors are not shown for reasons of brevity. In some cases, especially in analog parts, it may be beneficial to run a separate power line from the power supply to the component in order to prevent power supply fluctuations from impacting low-level signal components.

The same points should be considered when designing the ground. The schematics in figures [Figure 6-2](#) and [Figure 6-3](#) show a star connection at one point in the power supply. Care should be taken to ensure that voltage differences do not accumulate between the grounds, especially in mixed signal components such as DACs and ADCs.

Additional isolation, for example ferrite beads, may be inserted between the analog and digital grounds to suppress high frequency ground noise. Some components, such as motor drivers, require special grounding. The system designer should refer to the component data sheets of selected components in order to ensure correct usage of the grounding methods.

Figure 6-3: Basics, clock and bypass caps, 55420



6.4.4 Decoupling of the On-chip ADC

The voltage supply to the ADC should be decoupled with the use of a 2.2-6.8 μF tantalum capacitor in parallel with a 0.01-0.1 μF ceramic capacitor placed as close as possible to the power supply and ground pins. For additional isolation purposes, an additional 0.01-0.1 μF ceramic capacitor should be placed across AnalogRefLow and AnalogRefHigh.

6.4.5 External Oscillator Filter

The circuit in [Figure 6-4](#) shows the recommended configuration and suggested values for the filter which must be connected to the OscFilter1 and OscFilter2 pins of the CP chip. The resistor tolerance is $\pm 5\%$, and the capacitor tolerance is $\pm 20\%$.

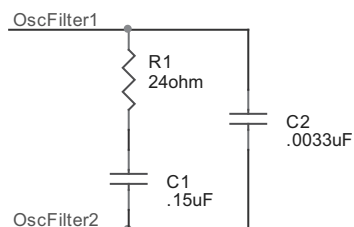


Figure 6-4:
Oscillator filter circuit

When applying a different clock frequency, the PLL's external loop filter circuit (capacitors C1 and C2, and resistor R1) should be varied as a function of the clock frequency. These reference values are detailed in the following table. C1 and C2 capacitors must be non-polarized.

CPClkIn [MHz]	R1 [Ω] ($\pm 5\%$)	C1 [μF] ($\pm 20\%$)	C2 [μF] ($\pm 20\%$)
5	5.6	2.7	0.056
10	11	0.68	0.015
15	16	0.33	0.0068
20	24	0.15	0.0033

6.4.6 Reset Signal

The CP accepts a reset signal, $\sim\text{Reset}$, which should go low after power-up or when an external reset event occurs. From the rising edge of this signal, the CP begins an initialization procedure, which is concluded within 1.5 milliseconds. During this period, the outputs of the CP and IO chips will be in an unknown state. In order to prevent signals in an arbitrary state from driving the motors, a disabling signal, $\sim\text{ResetHold}$, is generated. The $\sim\text{ResetHold}$ signal is a ~ 2.2 msec extension to the active low period of the $\sim\text{Reset}$ signal, and is used to disable the motor drivers during the initialization period. [Figure 6-5](#) shows a circuit for generating the $\sim\text{ResetHold}$ signal.

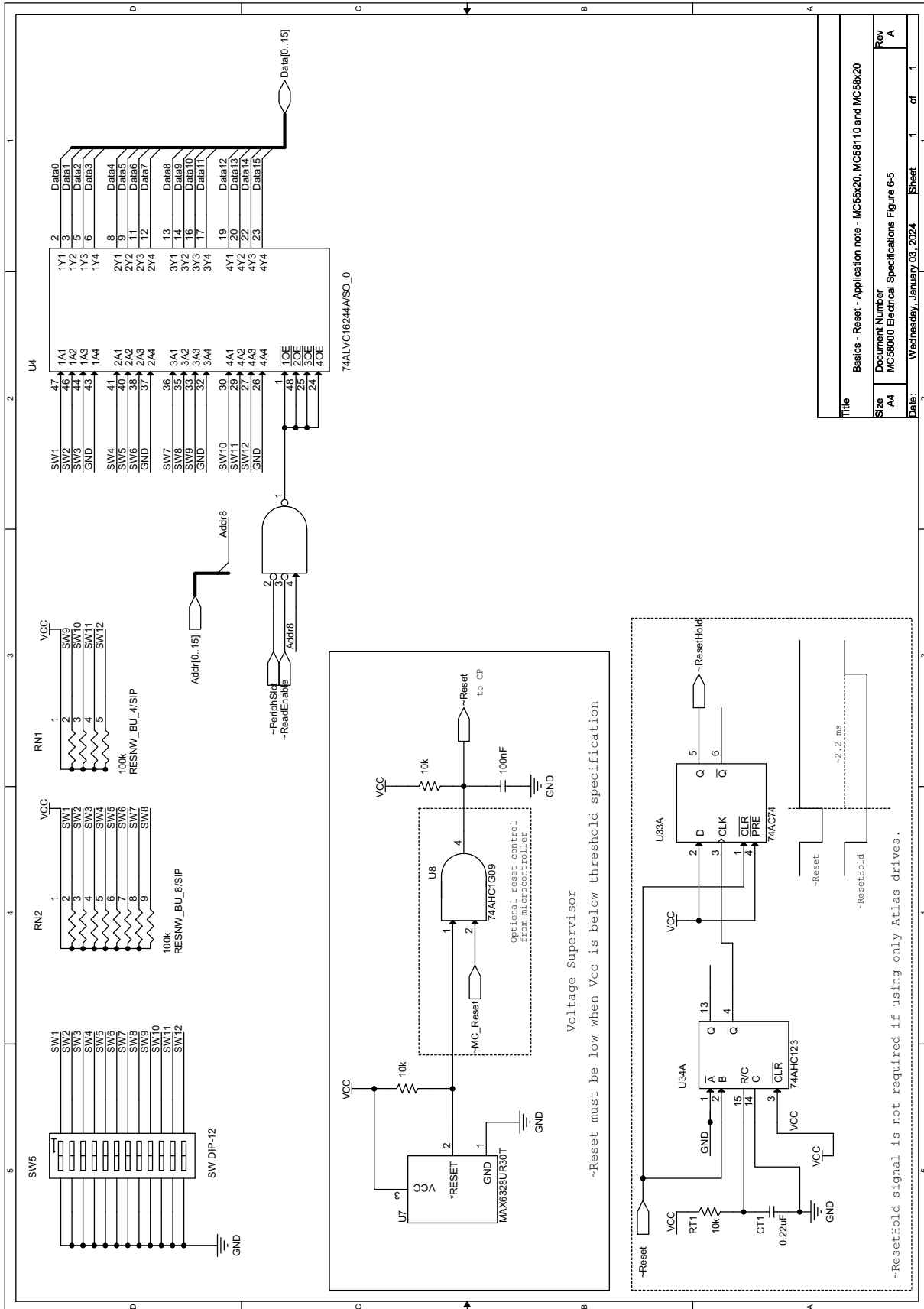
In addition to the power up delay, the $\sim\text{Reset}$ signal must stay low (0V) anytime V_{cc} is below its minimum specification. This is true at all times including power on and power off.

The typical solution implemented to meet this requirement involves the use of a voltage supervisor IC. This IC monitors the V_{cc} line and forces the $\sim\text{Reset}$ pin to zero any time V_{cc} is below specification. [Section 3.1, "DC Characteristics for 55110, 55x20 CP."](#) provides details on the specifications for V_{cc} .

In the schematic shown an optional AND gate is used to allow a microprocessor to control the $\sim\text{Reset}$ signal when the voltage supervisor is not actively driving it low.

During the initialization period, the CP reads the two external configuration registers to determine the configuration for serial and CAN communication. Refer to sections [Section 6.5.2, “Interfacing to Off-board Hosts Through Asynchronous Serial Communications,”](#) and [Section 6.6, “CAN Communication Interface,”](#) for more information.

Figure 6-5: Basics, reset



Title	Basics - Reset - Application note - MC55x20, MC58110 and MC58x20
Size	A4
Document Number	MC58000 Electrical Specifications Figure 6-5
Rev	A
Date:	Wednesday, January 03, 2024
Sheet	1 of 1

6.5 Serial Communication Interface (SCI)

In this section, the serial communication interface to the host is described. [Figure 6-6](#) shows circuitry used to configure the SCI port on power-up. This circuitry may be omitted if the default configuration values are suitable.

Subsequent sections demonstrate the use of RS-232, RS-422 and RS-485 line-drivers for interfacing to a remote host.

6.5.1 SCI Configuration During Power-up or Reset

On power-up or after a reset, the CP configures the SCI according to the 16-bit value residing at the peripheral address 200h. If a value of FFFFh is read, then the SCI is configured to its default configuration: 57,600 baud, no parity, one stop bit, point-to-point mode. Since the data bus inputs are internally pulled-up, the pins may remain disconnected and the default configuration will take effect at power-up or reset. If a non-default SCI configuration is required the circuitry presented in the reference schematic may be used.

Note that after communication has been established, the SCI configuration may be altered via the SetSerialPortMode command.

The following should be observed when designing the power-up/reset SCI circuitry:

- 1 The MC55000 peripheral address map is arranged so that Addr9 is dedicated for SCI configuration.
- 2 The following logic condition for presenting the setup word on the data bus should be used:

$$\sim\text{SCISetupDataEnable} = \sim\text{ReadEnable} + \sim\text{PeriphSlct} + \sim\text{Addr9}$$

Where:

$\sim\text{SCISetupDataEnable}$	When high the tri-state buffer outputs are placed in a high-impedance state.
$\sim\text{ReadEnable}$	When low the bus is in a read cycle.
$\sim\text{PeriphSlct}$	When low the peripheral address space is being addressed.

The logic may be implemented in a PLD, and its propagation delay should not exceed 20 nsec; assuming an enable time for the tri-state buffer of less than 10 nsec.

- 3 The DIPswitch resistors of $\sim 100\text{K}$ ensure sufficient V_{IH} level. In case of a zero input, a current of $\sim 33\ \mu\text{A}$ will be flowing between VCC and GND. This may result in a worst-case scenario of $\sim 0.55\ \text{mA}$ when the all-zero word is encoded.

6

Direct connection to on-board host's SCI ports

Title		Host Communications - SCI	
Size	Document Number	Rev	
A		A	

Date: Tuesday, December 12, 2006 Sheet 1 of 1

Figure 6-6:
Host communication, SCI

MC55000 Electrical Specifications

63

6.5.2 Interfacing to Off-board Hosts Through Asynchronous Serial Communications

When the host and motion control IC are located on the same physical board it is most likely that simply wiring the transmit and receive lines directly between the host and CP chip is all that is required (assuming they are both 3.3V CMOS devices). When the host is remote and the interface requires longer communication lines, achieving reliable communication is more involved.

TIA/EIA standards provide reliable communication over varying cable lengths and communication rates. The most commonly used standards are RS-232, RS-422 and RS-485. These standards are separated into two categories: single-ended and differential. RS-232 is a single-ended standard allowing for moderate communication rates over relatively short cables. RS-422 and RS-485 are differential, offering higher data rates and longer cable runs.

Line drivers and receivers (transceivers) are commonly used in order to mediate between the cable interface and the digital circuitry signal levels. Although RS-485 transceivers also support the RS-422 electrical specification (the reverse is not true), there are several design considerations that should be taken into account when deciding which of these two communication methods is the best fit for an application.

- Full-duplex vs. half-duplex

The terms full-duplex and half-duplex are used to distinguish between a system having two separate physical communications lines from one having one common line for transmission and reception.

- Line contention

This problem can occur in half-duplex systems. Most line-drivers supply physical protection against such conditions but there is no automatic recovery of lost data in these levels. When interfacing the Magellan to a half-duplex communication system the designer should note that the turn-around time for command processing and response is at least 1 byte at the current baud rate. As a result the host should release the communication line before this time elapses so that contention can be avoided.

- Termination impedance

Long cables and/or high data rates require termination resistors if the transceiver is located at the end of the transmission lines. One way to determine if termination is required is if the propagation delay across the cable is larger than ten times the signaling transition time. If this condition is satisfied, then termination is required. The RS485 standard specifies the signaling transition time to be less than 0.3 times the signaling period, thus imposing an upper limit on the maximum cable length for a specified baud rate.

The termination resistor should match the characteristic impedance of the cable with 20% tolerance. Resistors with a value of 80-120Ω are typically used. For RS-422, only the receiver end should use a termination resistor, due to the communication line being unidirectional (full duplex). Note that if the transceiver is not placed at the ends of the cable, no termination resistors are required. However, the stubs should be kept as short as possible to prevent reflections.

The schematic in [Figure 6-7](#) employs the ADM3202 and ADM3491 transceivers as an example of RS232 and RS485/422 interfaces respectively. Other RS232 transceivers may be used, such as Maxim's MAX3321E. The ADM3491 circuitry can be configured for both full-duplex and half-duplex communications, and may include termination resistors. As an alternative, transceivers from the MAX307xE family may be used.

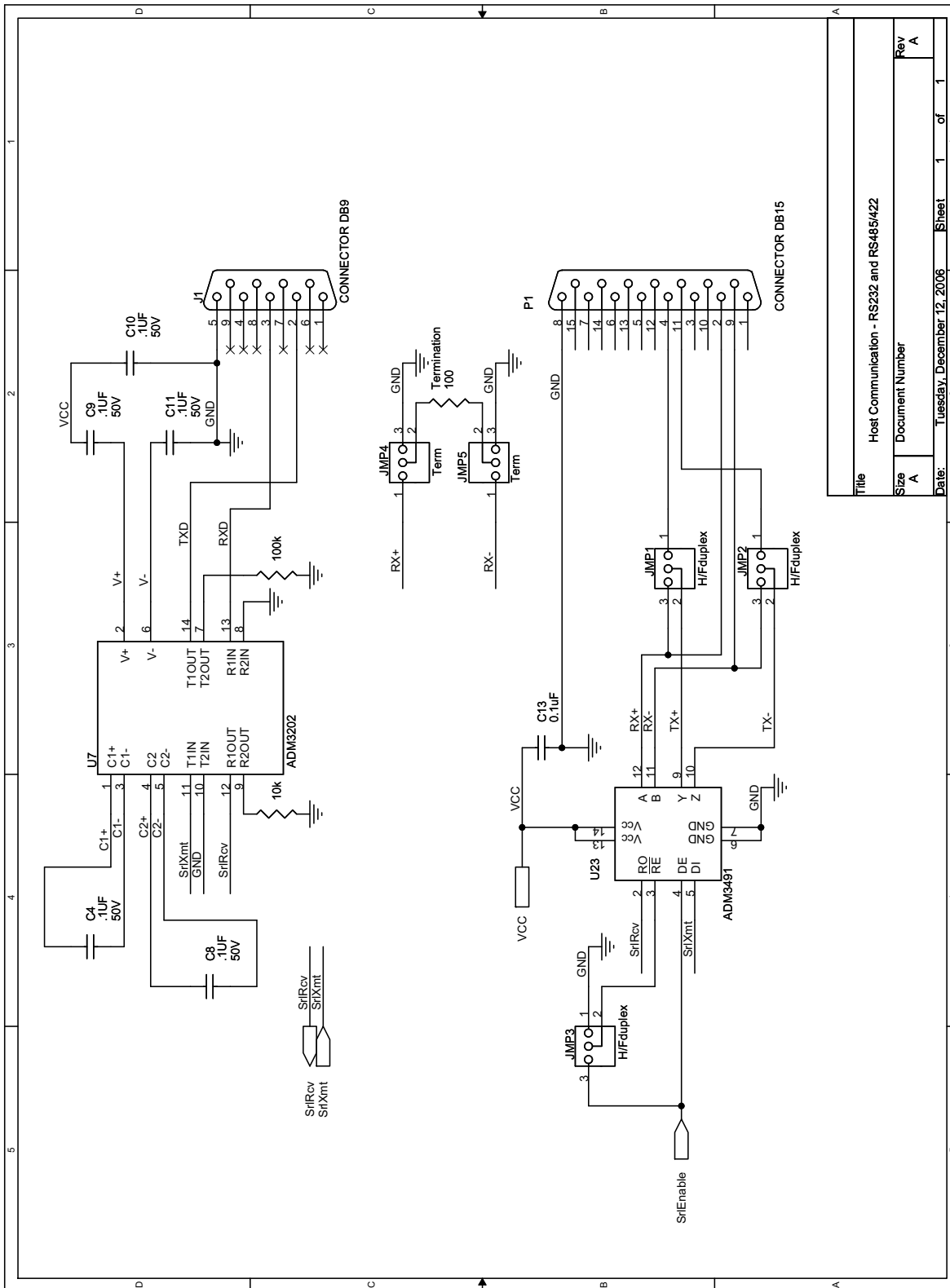
The following table shows configuration options for the RS-485/422 circuitry of [Figure 6-7](#).

Configuration	Jumper Position	Application
Half Duplex ¹	JMP1/2/3 in 2-3	RS-485 in multipoint system
Full Duplex	JMP1/2/3 in 1-2	RS-422 or RS-485 in point to point system

Configuration	Jumper Position	Application
Termination on ²	JMP4/5 in 1-2	Both RS-485 and RS-422. For high transmission rates and/or long cable. Only when placed at the end of the cable.
Termination off	JMP4/5 in 2-3	Both RS-485 and RS-422. For low transmission rates and short cable. Or when placed at the middle of the cable.

1. JMP3 should only be placed be in the half duplex state (2-3) if multi-point communication is being used.
2. Note that the reference circuitry does not support resistance termination on the transmitting side when operated in full duplex because it is assumed that RS 485 will only be used in the half-duplex configuration.

Figure 6-7:
Host communication, RS232
and RS485/
422



Title		Host Communication - RS232 and RS485/422	
Size	A	Document Number	
Date:	Tuesday, December 12, 2006	Sheet	1 of 1
Rev	A		

6.6 CAN Communication Interface

The following example illustrates an interface to a CAN backbone using of TI's SN65HVD232 transceiver, which supports ISO 11898 standard. Generally the CAN high-speed standard ISO 11898 provides a single line structure as network topology. The bus line is terminated at both ends with a single termination resistor of ~120ohms. However in practice some deviation from that topology may be needed to accommodate appropriate drop cable lengths and particular applications. Consult CAN ISO 11898 standard for more information on termination schemes and EMC considerations.

6.6.1 CAN Configuration During Power-up or Reset

On power-up or after reset, the CP configures the CAN controller according to the 16-bit value residing at the peripheral address 400h. If a value of FFFFh is read, then the CAN controller is configured to its default configuration: 20 kbps with a NodeID of 0. Since the data bus inputs are internally pulled-up, the pins may remain disconnected and the default configuration will take effect at power-up or reset. If a non-default CAN configuration is required the circuitry presented in the reference schematic ([Figure 6-8](#)) may be used.

Note that after communication has been established, the CAN configuration may be altered via the SetCANMode command.

More advanced CAN bus drivers such as the SN65HVD230 supply a programmable input pin which may be used to adjust the rise and fall times of the transmitter. This may be important in unshielded, low-cost systems in order to reduce electromagnetic interference. The pin may be hard-wired through a resistor to ground (refer to the component data sheet for calculating the resistor's value), or the host may control this pin by introducing additional circuitry attached to the I/O user space of the CP for a more flexible and tunable design.

The following should be observed when designing the power-up/reset CAN circuitry.

- 1 The MC55000 peripheral address map is arranged so that Addr10 is dedicated for CAN configuration.
- 2 The following logic condition for presenting the setup word on the data bus should be used.

$$\sim\text{CANSetupDataEnable} = \sim\text{ReadEnable} + \sim\text{PeriphSlct} + \sim\text{Addr10}$$

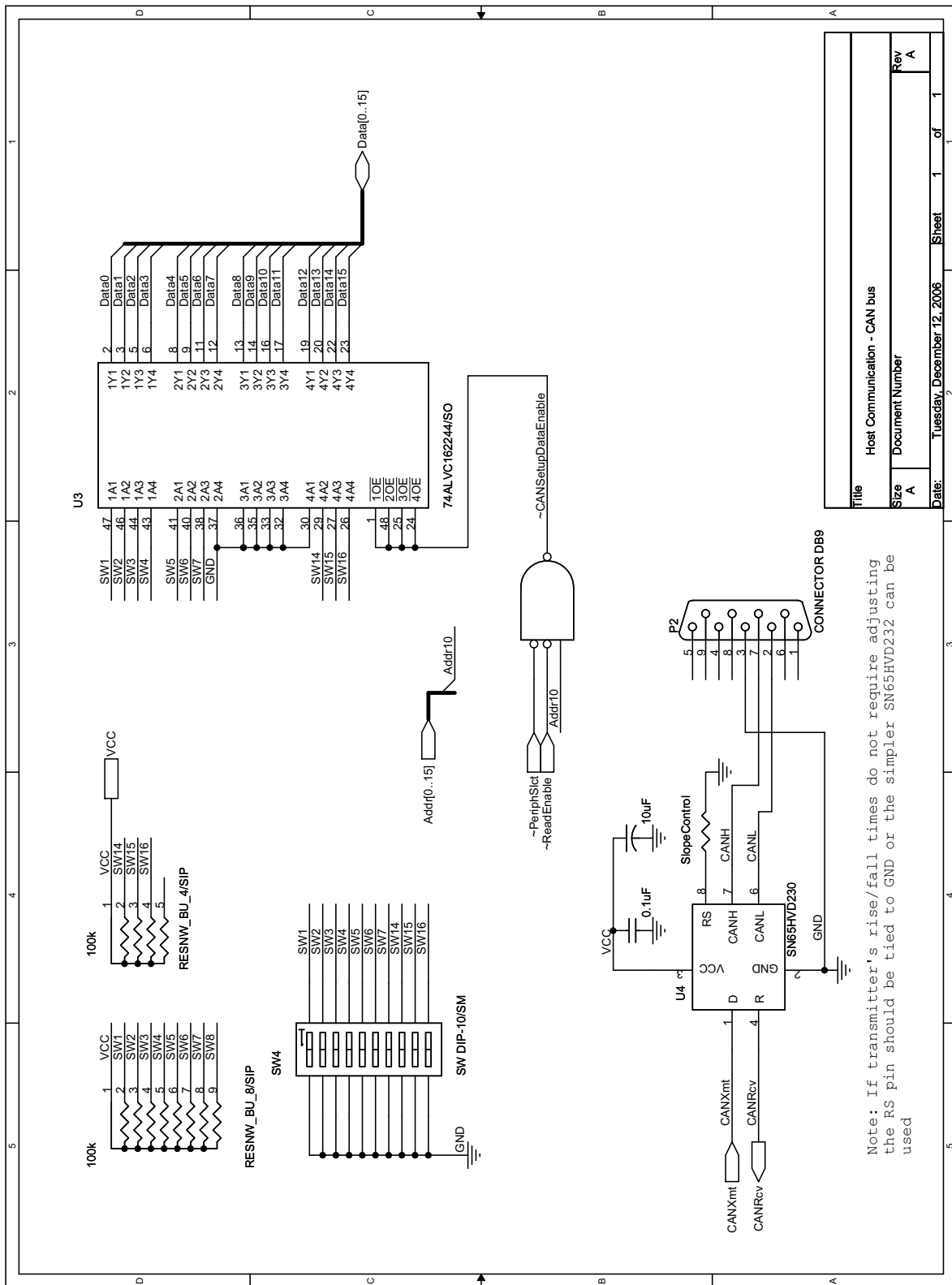
Where:

$\sim\text{CANSetupDataEnable}$	When high the tri-state buffer outputs are placed in a high-impedance state.
$\sim\text{ReadEnable}$	When low, the bus is in a read cycle.
$\sim\text{PeriphSlct}$	When low, the peripheral address space is being addressed.

The logic may be implemented in a PLD, and its propagation delay should not exceed 20 nsec; assuming an enable time for the tri-state buffer of less than 10 nsec.

- 3 The DIPswitch resistors of ~100K ensure sufficient VIH level. In case of a zero input, a current of ~33 μA will be flowing between VCC and GND. This may result in a worst-case scenario of ~0.55 mA when the all-zero word is encoded.

Figure 6-8:
Host communi-
cation, CAN
bus



Note: If transmitter's rise/fall times do not require adjusting the RS pin should be tied to GND or the simpler SN65HVD232 can be used

Title		Host Communication - CAN bus	
Size	Document Number	Rev	A
Date:	Tuesday, December 12, 2006	Sheet	1 of 1

6.7 External Memory

Utilizing its external bus, the Magellan Motion Control IC can interface with two types of external memory: asynchronous SRAM and synchronous dual port RAM (DPRAM). External memory is used for trace data storage and is optional. SRAM is typically used in designs that do not require real-time access to the data. DPRAM permits high speed downloading of trace data and is most applicable in applications where the data is being downloaded and analyzed on a real-time basis.

6.7.1 CP External Memory Interface

The MC55000 external bus is comprised of the *Addr[0..15]* and *Data[0..15]* signals. The signals *~WriteEnable*, *~ReadEnable*, *~RAMSct*, *W/~R*, *R/~W* and *~Strobe* are used in conjunction with the address bus signals for controlling access to the attached memory device. The *Ready* input signal may also be used to insert wait-states for accessing slower memory devices. Signal timing information is given in chapters 3 and 4 of this manual.

All signals are time referenced to the *ClockOut* signal, which has a nominal 25 nsec period. The MC55000 can directly access 32Kx16 bits of external memory and uses the 15 least significant bits of the address bus. *Addr15* is not used. Larger external memories may be used by adding a page register, as detailed in the following section.

6.8 Asynchronous SRAM

The following schematic ([Figure 6-9](#)) illustrates a pair of IDT71V424SA15 512Kx8 SRAMs with a 15 ns access time interfaced to the MC55000, resulting in a total of 16 pages of storage. Expansion to 32 pages is easily achieved with four IDT71V428 1024Kx8 SRAMs. Memory blocks are accessed with the use of a page register. The IDT71V424SA15 is an asynchronous SRAM which is controlled by three input signals: chip select (*~CS*), output enable (*~OE*), and write enable (*~WE*). The SRAM is interfaced with the MC55000 output signals as shown in the following table.

Device	Signal Name		
MC55000	<i>~RAMSct</i>	<i>~ReadEnable</i>	<i>~WriteEnable</i>
IDT71V424SA15	<i>~CS</i>	<i>~OE</i>	<i>~WE</i>

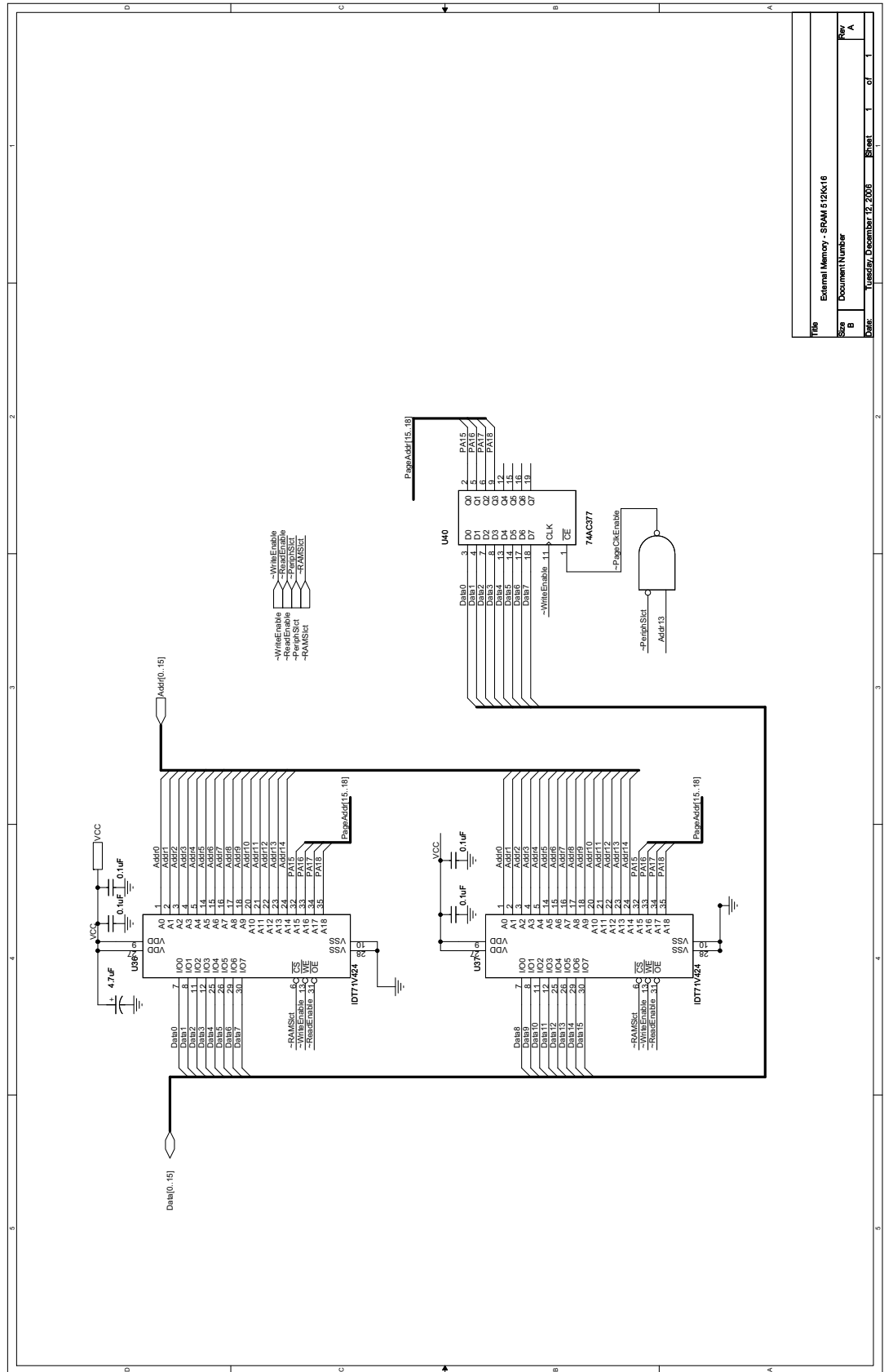
Note that the selected SRAM device should meet the timing requirements of the MC55000 output signals. Usually, asynchronous SRAMs with cycle times of less than 1.5 *ClockOut* cycles will meet this requirement. One example is the CY7C1020CV33-15 32Kx16 SRAM which has a 15 nsec access time. This device may be used to provide one page of storage.

If larger external memory is required, several pages may be addressed (up to 64K pages) by using a page register. The page register may be accessed at the peripheral address 2000h and the *Addr13* signal can be used as a chip-select. The page register operates the extra address lines required to interface with larger external memory devices. Before the external memory write or read cycle, the CP performs a write to the page register to select the required page.

The use of larger SRAM chips is recommended. If the capacity of one SRAM is not adequate, multiple chips may be cascaded. The two common methods for cascading SRAM chips are:

- Using high capacity, lower organization (x8 or x4) chips. In this configuration SRAMs share the same address bus and each SRAM is wired to a different portion of the data bus.
- Using the SRAM's chip-select input(s) as an additional address line. This option requires a decoder to map the address to the appropriate chip select signal. The propagation delay of the decoder must be below 0.5 of the *ClockOut* period. In addition the total access time should not exceed 1.5 *ClockOut* cycles including the SRAM access time.

Figure 6-9:
External memory, SRAM
512Kx16



Title	External Memory - SRAM 512Kx16		
Rev	B	Document Number	Rev
Page	1	of	1
Date	Thursday, December 12, 2008	Sheet	1

6.8.1 Slow Asynchronous SRAM

If the SRAM does not meet the timing requirements, it may still be connected to the MC55000 by adding wait states. In order to generate the wait-states, the **Ready** signal must be activated during read/write memory accesses. As long as the **Ready** signal is kept low during the rising edge of the **ClockOut** signal, the end of the current read/write cycle will be deferred to the next **ClockOut** rising edge.

The following schematic (Figure 6-10) contains a circuit and timing diagram for generating one wait state. Expanding to two or more wait states is similar. Note that adding wait states slows the operation of the MC55000 and therefore the number of wait states should be kept as low as possible if the device is expected to maintain normal operation. Contact PMD to determine if the use of wait states will affect device operation in your application.

The following timing restrictions apply when the device is operating with the standard 40 MHz **ClockOut** frequency:-

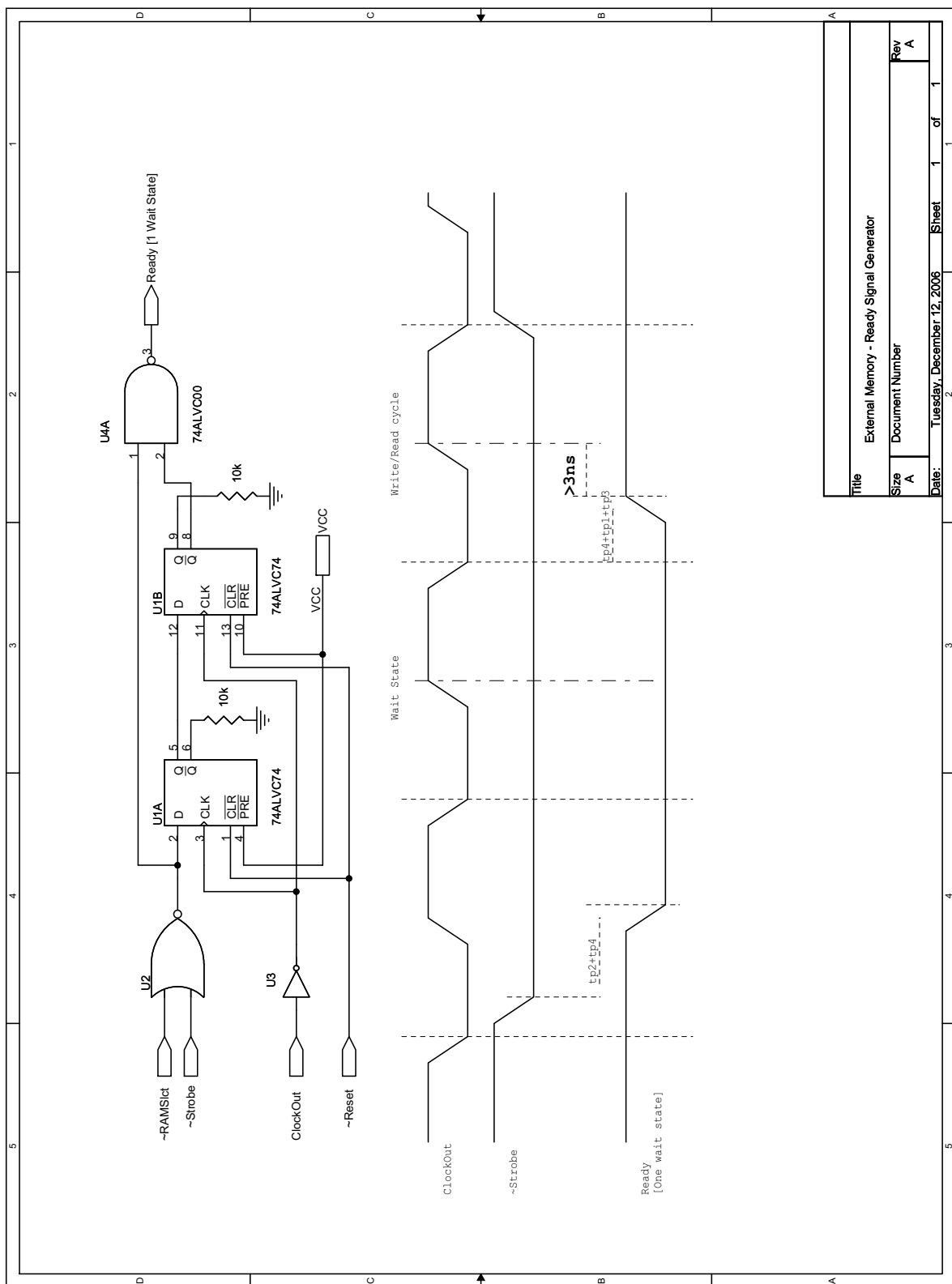
- 1 $tp4 + tp2 < 22 \text{ ns}$
- 2 $tp2 + ts1 < 19 \text{ ns}$
- 3 $tp1 + tp4 + tp3 < 9.5 \text{ ns}$

Where $tp1$ and $ts1$ are the propagation delay and setup time of the D flip-flop. TPx is the propagation delay of logic gate Ux .

Notes:

- 1 In order to meet the above timing requirements high-speed gates may be used or the logic may be implemented in a fast PLD. Timing restriction 3 may be relaxed by the use of fast negative edge JK-FF, such as the 74LCX112, resulting in a very tight constraint on $tp4$.
- 2 If read and write cycles do not require the same number of wait states, then either $\sim WriteEnable$ or $\sim ReadEnable$ may replace the $\sim Strobe$ signal. If $\sim ReadEnable$ is used, then restriction 2 becomes more stringent: $tp2 + ts1 < 7.5 \text{ ns}$.
- 3 If there is no need to add wait-states the **Ready** input pin may be left disconnected as it is internally pulled up.

Figure 6-10:
External memory, Ready
signal generator



Title		External Memory - Ready Signal Generator	
Size	A	Document Number	
Rev	A	Date:	Tuesday, December 12, 2006
		Sheet	1 of 1

6.9 Using the On-chip ADC

In this section two types of conditioning circuits which interface to the on-chip analog-to-digital converter are demonstrated. The first circuit interfaces to a single-ended voltage signal, and the second circuit to a differential voltage signal. The conditioning circuits should be adjusted appropriately in order to meet the system's requirements.

The MC55000 is equipped with an eight-channel 10-bit ADC. The sampling rate of each channel is 57.8K samples per second, and the sample-and-hold time per channel is 1.6 μ sec. The sampling capacitor is 30 pF, and the sampling resistor is in the range of 100 - 200 Ω . In order to meet the timing requirements, the output impedance of the conditioning circuitry, as seen by the ADC's inputs, should not exceed 6.1 k Ω .

The digital value derived from the input analog voltage is determined using the following formula.

$$\text{Digital value} = 1023 \times (\text{input voltage} - V_{\text{REFLO}}) / (V_{\text{REFHI}} - V_{\text{REFLO}}) \quad (1)$$

Where V_{REFLO} and V_{REFHI} are the voltages applied at *AnalogRefLow* and *AnalogRefHigh* pins, respectively.

The ADC's performance is guaranteed when $V_{\text{REFLO}} = \text{AGND}$ and $V_{\text{REFHI}} = \text{AVCC}$. Not adhering to these values may result in performance degradation.

The ADC power supply should be decoupled with the use of a 2.2-6.8 μ F tantalum capacitor in parallel with a 0.01-0.1 μ F ceramic capacitor placed as closely as possible to the power supply and ground pins. An additional 0.01-0.1 μ F ceramic capacitor should be placed across *AnalogRefLow* and *AnalogRefHigh*.

6.9.1 Single-ended Interface

The following schematic (Figure 6-12) is a single-ended conditioning circuit that may be used for interfacing an on-board temperature sensor, the RTI ACW-027 (refer to application notes). The input signal, V_T , is a single-ended voltage signal with a range of 0.45 - 2.9V and it is assumed to be varying slowly, at no greater than 100 Hz.

The goal of the conditioning circuitry is to match the analog signal to the ADC's voltage range and supply it with the required power. The conditioning circuit should be kept as simple as possible and make use of a single +3.3V supply.

6.9.1.1 Conditioning Circuitry and Op-amp Selection

Because the input is a voltage signal, an inverting amplifier is used to ensure a large input impedance. The operational amplifier should have rail-to-rail inputs/outputs with a unipolar supply. The TLV2471 is recommended as it can swing to within 180 mV of each supply rail while driving a 10 mA load.

The functionality of the circuitry at DC is depicted in equation (2).

$$V_{out} = V_T \left(1 + \frac{R_f}{R_g + R_3 \parallel R_2} \right) - V_S \cdot \frac{R_2}{R_2 + R_3} \cdot \frac{R_f}{R_g + R_3 \parallel R_2} \quad (2)$$

The gain of the circuitry is calculated in this manner so as to accommodate the full output swing of the op-amp, and to match it to the input swing of V_T . This is shown in the following equation.

$$\left(1 + \frac{R_f}{R_g + R_3 \parallel R_2} \right) = \frac{3.3 - 2 \cdot 0.18}{2.9 - 0.45} = 1.2 \quad (3)$$

Additionally, the circuitry should bias the output so that when V_T reaches the lowest value of interest, the op-amp also reaches its lowest output voltage. Applying (3) and calculating equation (2) at $V_{out} = 0.18$, and $V_T = 0.45$ results in the following.

$$\frac{R_2}{R_2 + R_3} = 0.5455 \quad (4)$$

Selecting $R_2 = 12\text{k}$ (1%), $R_3 = 10.0\text{k}$ (1%), $R_g = 19.6\text{k}$ (1%), $R_f = 4.99\text{k}$ (1%) satisfies equations (3) and (4), while maintaining load currents in the working range of the op-amp and ADC.

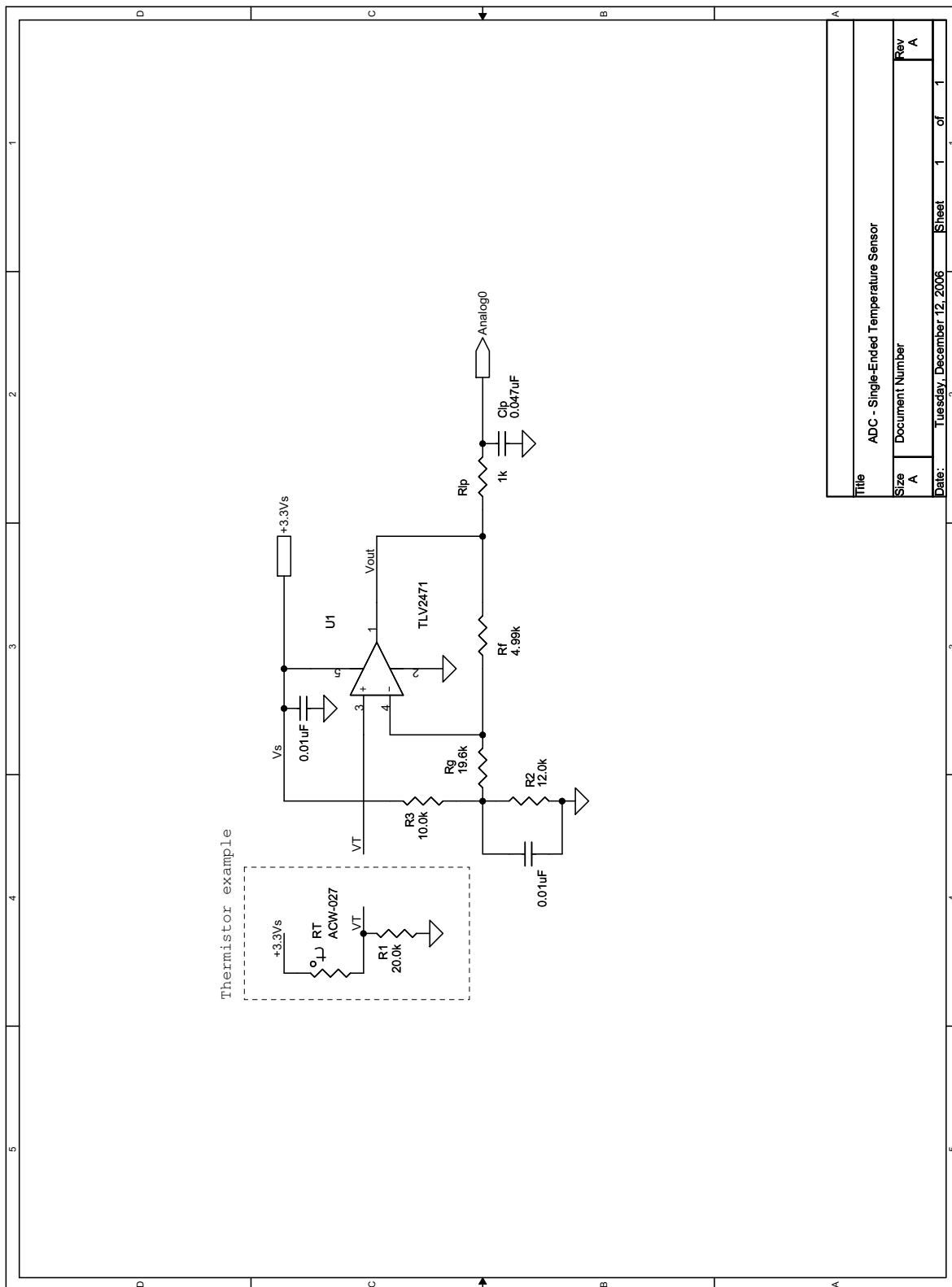
Note that if the input voltage V_T is linear within the supply voltage V_S , then the variation and sensitivity of the circuitry in V_S is relatively small since the same variations will affect the ADC. This will cancel out the variation's effects on the conditioning circuitry.

6.9.1.2 Rlp and Clp values

A low-pass RC filter is used to eliminate noise and prevent aliasing. Additionally, it is used to limit the load on the op-amp, which enables it to swing as close as possible to its rails.

Using $R_{lp} = 1\text{ k}\Omega$ and a ceramic $C_{lp} = 0.05\text{ }\mu\text{F}$ will result in a low-pass filter with a 3 dB point at $f_0 \sim 3\text{ kHz}$ (which is assumed to be at least one order larger than the signal's bandwidth). The capacitor should be placed as close as possible to the ADC input pin, as it partially drives the sample capacitor of the ADC.

Figure 6-12:
ADC, single-
ended
temperature
sensor



Title		ADC - Single-Ended Temperature Sensor	
Size	A	Document Number	Rev A
Date:	Tuesday, December 12, 2006	Sheet	1 of 1

6.9.2 Differential Interface

The input signal is assumed to be differential, V_{in+} and V_{in-} . The voltage signal is in the range of $(V_{in+} - V_{in-}) = [-3V, +3V]$, and slowly varying (not greater than 100 Hz).

The goal is to condition the differential input signal to fit the ADC's voltage range, and supply it with the required drive. For example, the circuitry may be used to interface to a resonator sensor rate such as the RRS75 from Inertial Science, Inc. Additional ADC channels may be used simultaneously in order to expand the dynamic range of the ADC.

6.9.2.1 Conditioning Circuitry

The purpose of this interface is to generate a signal with the following format.

$$\text{Analog0} = G(V_{in+} - V_{in-}) + V_{ref}, \text{ with nominal } G = 0.55 \text{ and } V_{ref} = 1.65.$$

The interface shown in [Figure 6-13](#) forms an instrumentation amplifier. The high input impedance of the instrumentation amplifier is highly desirable to eliminate voltage drops and CMRR concerns due to the signal source output impedance.

The following equation describes the functionality of the conditional circuitry at DC.

$$RO = (V_{in+}) \cdot G - (V_{in-}) \cdot m + V_{ref} \cdot [(R_2+R_1) / R_2] \cdot [R_4 / (R_3+R_4)] \quad (7)$$

where:

$$G = [R_1 / R_2] \cdot [(R_5+R_g) / R_g] + [R_6 / R_g] \cdot [R_3 / (R_3+R_4)] \cdot [(R_2+R_1) / R_2]$$

$$m = [(R_6+R_g) / R_g] \cdot [R_3 / (R_3+R_4)] \cdot [(R_2+R_1) / R_2] + [R_1 / R_2] \cdot [R_5 / R_g]$$

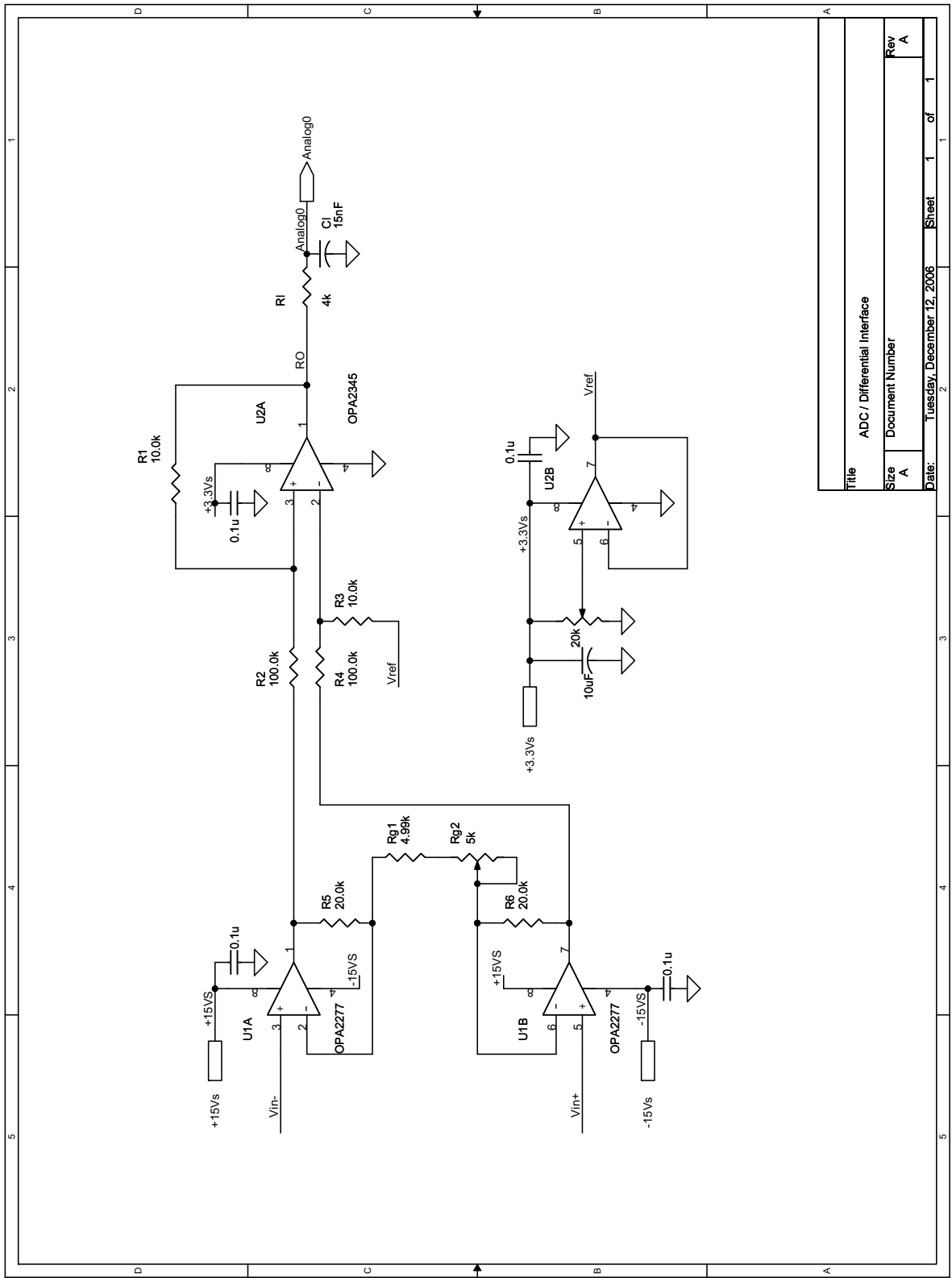
Selecting $R_3 = R_1$ and $R_4 = R_2$ will result in the following simplified version:

$$RO = (V_{in+} - V_{in-}) \cdot [R_1 / R_2] \cdot [1 + (R_5+R_g) / R_g] + V_{ref} \quad (7a)$$

Specifying resistors $R_3 = R_1 = 10.0 \text{ k}\Omega$ (1%), $R_4 = R_2 = 100.0 \text{ k}\Omega$ (1%), $R_5 = R_6 = 20.0 \text{ k}\Omega$ (1%), and nominal $R_g = 8.9 \text{ k}\Omega$, will result in the desired $G = 0.55$. The importance of having matching pairs of resistors should be evident from equation (7). If matching is not done common mode voltage will be introduced.

The OPA2345 is an input/output rail-to-rail operational amplifier with low voltage bias, and high CMRR. It tolerates input common voltages of $\pm 0.3V$ from its rails. As a protection measure, the addition of Schottky diodes with 0.3V forward voltage, such as 20L15T, is recommended (but not shown). The output swing of the op-amp is closely related to the load current. In order to make this current as low as possible, a resistor is added at the output of the op-amp. Adding a capacitor forms a LPF, with a 3 dB cut-off at $\sim 3 \text{ kHz}$. The capacitor should be placed as close as possible to the ADC input pins, and is partially used to drive the sampling capacitor.

Figure 6-13:
ADC,
differential
interface



Title		ADC / Differential Interface	
Size	Document Number	Rev	A
Date:	Tuesday, December 12, 2006	Sheet	1 of 1

6.10 User I/O Space

In the following schematic ([Figure 6-14](#)), the User I/O space is used to control four LEDs. The MC55000 User I/O accessible address space located from address 1000h to 10FFh on the external bus. The Addr12 bit is reserved in order to serve as a chip select, while the least significant eight bits serve as the active address. In this example, it is assumed that the active I/O space consists of eight registers; using only the three least significant bits of the address word. Additionally, the register to control the LEDs is assumed to reside at address offset 0x7h.

The simplest way to add an LED is to connect it to a high sink/source current port. In this example, a 74AC377 is used to buffer the data and to drive the LEDs. The MV8141 super bright red LEDs have been used, with 1.5V/1.7V/2.4V minimum/typical/maximum forward voltages, respectively, at 20 mA. $R = 150\Omega$ ensures that the output current doesn't exceed 20 mA; with a typical current of 8 mA (assuming a supply of $V_{CC} = 3.3V \pm 5\%$). It also ensures that a minimum of 2 mA current will flow through the LED. Note that the variation in the actual current is relatively large and will result in large variations in the luminance.

The 74AC377 was chosen due to the simplicity with which it interfaces to the MC55000. The 74AC377 is not equipped with a master reset and therefore on power-up the LEDs may be in an arbitrary state until the first valid write is received. The master reset version, the 74AC273, may be used providing that logic for generating the clock signal to it is added. The 74ACTQ823 may also be used with 5V supplies and features both clock enable and master reset.

6

Figure 6-14:
User I/O space,
red LED

The diagram illustrates the circuit for the User I/O space, featuring a 74AC377 decoder (U11) and four red LEDs (D0-D3). The decoder's data inputs (Data0-Data3) are connected to Data[0..15]. The decoder's clock input (CLK) is connected to ~WriteEnable. The decoder's chip enable input (CE) is connected to ~WriteStct. The decoder's address inputs (Addr0-Addr2) are connected to Data[0..15]. The decoder's outputs (Q0-Q7) are connected to LEDs D0-D3. The decoder is also connected to ~PeriphStct, ~CSled, and ~ResetHold signals. The decoder's output Q0 is connected to LED D0, Q1 to LED D1, Q2 to LED D2, and Q3 to LED D3. Each LED is connected to ground through a resistor (R).

Title	
User I/O Space - Red LED	
Size	Rev
A	A
Date:	Sheet
Tuesday, December 12, 2006	1 of 1

80

MC55000 Electrical Specifications

6.11 Parallel Communication Interface

Parallel communication supports the highest throughput of any of the communication interfaces. It is most often used when the host processor and MC55000 reside on the same circuit board. In the dual chip configuration (MC55x20) the IO chip provides the parallel interface to the host and care should be taken to ensure that the timing requirements specified in chapters 3 and 4 are observed. In the single chip configuration (MC55x10) if no external logic is providing the parallel interface the *ParallelEnable* input pin should be tied low to indicate that parallel communication is disabled.

In sections [6.11.1](#) and [6.11.2](#), the 16/16 (16-bit bus, 16-bit data) and 8/16 (8-bit bus, 16-bit data) host interfaces are demonstrated.

6.11.1 16/16 Host Interface

In this example, the IO chip is interfaced to the Motorola MCF5282 ColdFire microprocessor, as shown in [Figure 6-15](#). The MCF5282's external interface module is used for the interface, which includes data and address buses as well as additional control signals such as *R/~W*, *~TS*, *~OE* and *~CS*. For a detailed description of this device's functionality and timing specifications, refer to the MCF5282 data sheet. The following design notes focus on the interface between the MCF5282 and the IO chip.

6.11.1.1 Write Cycle

The host should be able to generate valid data at less than T_{15} (refer to [Section 3.3, "AC Characteristics"](#)) from the latest falling edge of either *R/~W* or *~CS* signals. Since both *R/~W* and *~CS* become active as much as half of the MCF5282's bus clock cycle prior to the data, the *~TS* (Transfer Start) signal is ANDed with the inverted *R/~W* signal. For the write cycle this achieves a one bus clock cycle delay in the incoming *IR/~W* signal to the IO chip. In this manner, a maximum of 10 nsec is guaranteed between the falling edge of *IR/~W* and valid data.

6.11.1.2 Read Cycle and Wait States

The host should add wait states in order to meet the timing requirements of the IO chip. The following formula may be used in order to calculate the number of required wait states as a function of the host's bus clock period, t_{CYC} :

$$N_{WS} = \lceil 70/t_{CYC} \rceil - 1$$

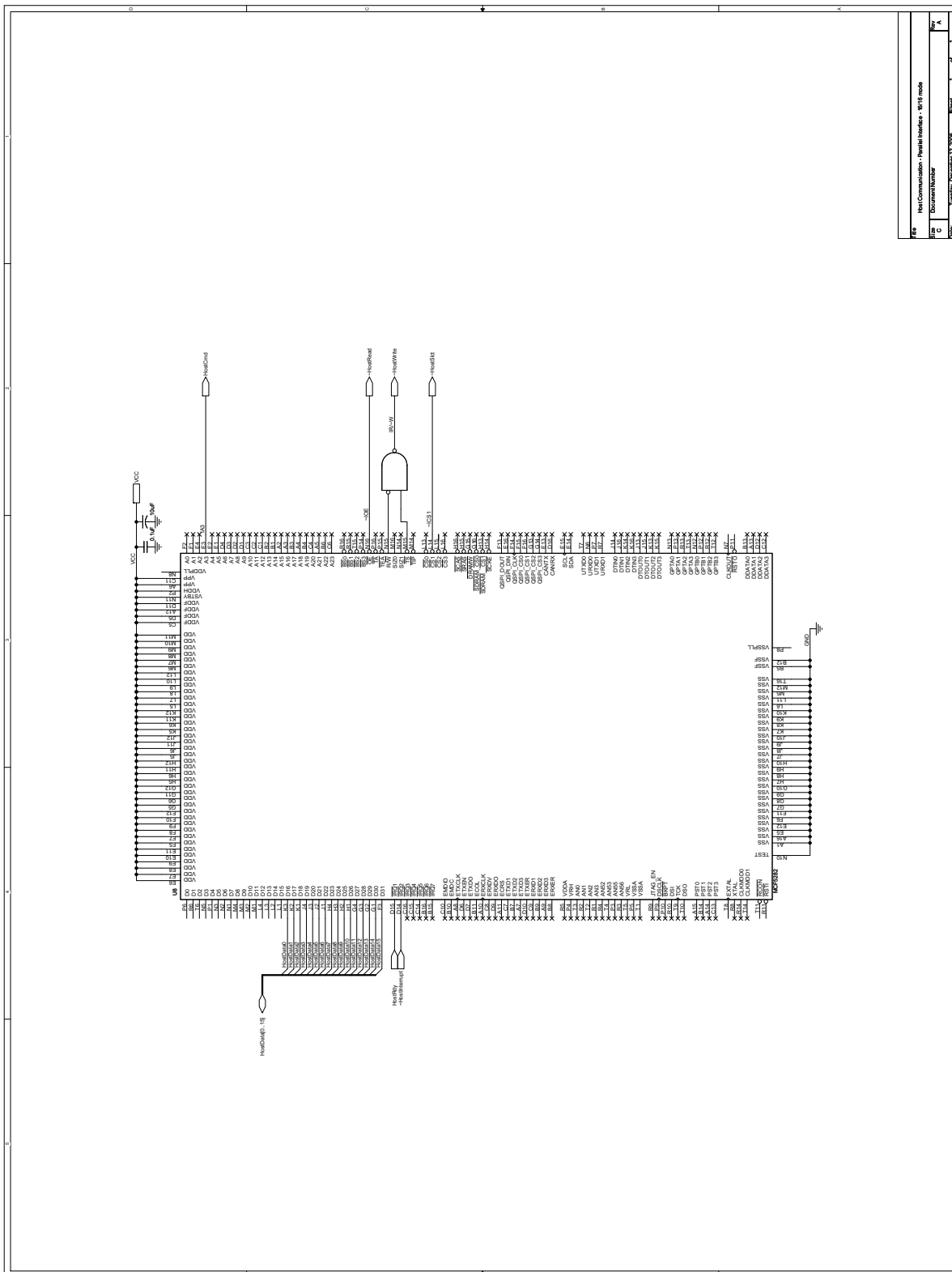
The operator $\lceil \cdot \rceil$ indicates rounding towards the largest integer. N_{WS} is the number of wait states that are required. The selected MC5282 has a 66 MHz input clock resulting in a t_{CYC} of ~ 15 nsec and thus four wait states are required.

6.11.1.3 Other Control Signals

In the example, address bit 3 is used for signaling to the IO chip whether a command or data word is being written. For a read cycle, this bit may be used for requesting either data or the status word.

HostRdy is used to interrupt the MCF5282. This can be a low priority interrupt used to invoke a communication ISR in the MCF5282. According to conditions that are programmable by the host the MC55000 can also activate the *~HostInterrupt* signal.

Figure 6-15:
Host communication, parallel
interface, 16/
16 mode



Rev	Host Communication - Parallel Interface - 16/16 mode
Doc	Document Number
Doc	MC55000, MC55000C, MC55000D, MC55000E, MC55000F, MC55000G, MC55000H, MC55000I, MC55000J, MC55000K, MC55000L, MC55000M, MC55000N, MC55000O, MC55000P, MC55000Q, MC55000R, MC55000S, MC55000T, MC55000U, MC55000V, MC55000W, MC55000X, MC55000Y, MC55000Z
Rev	1.0
Doc	1.0

6.11.2 8/16 Host Interface

In this example, a PIC microcontroller with limited I/O pins is interfaced with the IO chip. The minimum number of I/O pins required for the parallel 8/16 communications mode is eight bi-directional pins for the data, and five additional pins for the control signals (four outputs and one input). These signals are shown in [Figure 6-16](#).

The PIC16F648 features:

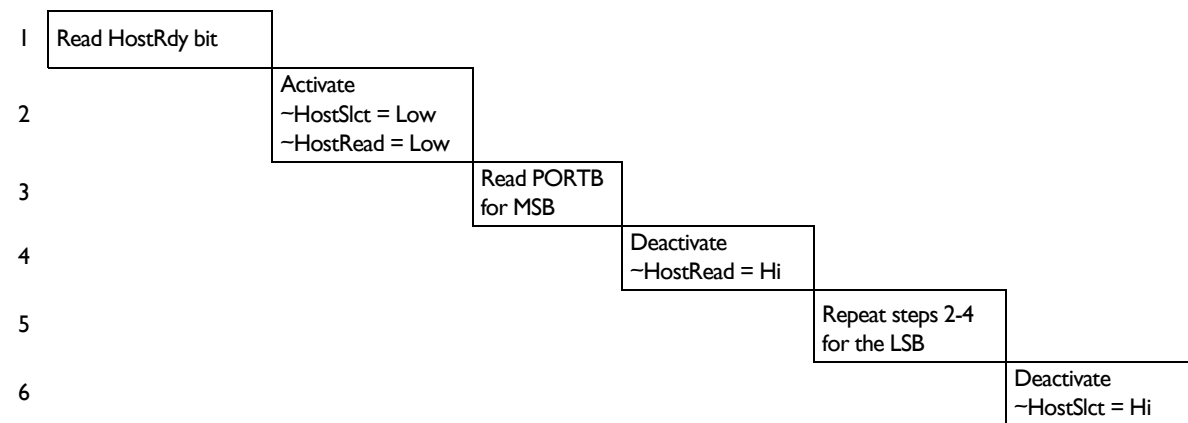
- An 8-bit microcontroller core
- Up to 10 MHz clock at 3.3V voltage supply
- 16 I/O pins divided into two ports, with a high impedance state and weak internal pull-up.

The eight I/O pins of the PORTB are used to connect to the IO chip's *HostData* bus (pins 0 through 7). The five pins of the PORTA are reserved for the control signals, as shown in the following table.

IO Chip Signal	PIC16F648 Signal	Dir	Comments
<i>HostData</i> 0-7	PORTB RB0-RB7	I/O	Should be pulled up (Bit 7 of the OPTION register). Should be kept in high impedance state unless written to.
\sim <i>HostSlct</i>	PORTA RA0	O	
<i>HostCmd</i>	PORTA RA1	O	
\sim <i>HostWrite</i>	PORTA RA2	O	
\sim <i>HostRead</i>	PORTA RA3	O	
<i>HostRdy</i>	PORTA RA6	I	

Shown below is a typical sequence of events for performing the host read and write cycle.

6.11.2.1 Typical Data / Status Read Sequence



Where:

Step 1: May be performed using the BTFSS instruction. This step must loop until *HostRdy* is high.

Step 2: Write a byte into PORTA with the lowest four bits set to either 0x4 (data) or 0x6 (status) using the MOVLW and MOVWF instructions.

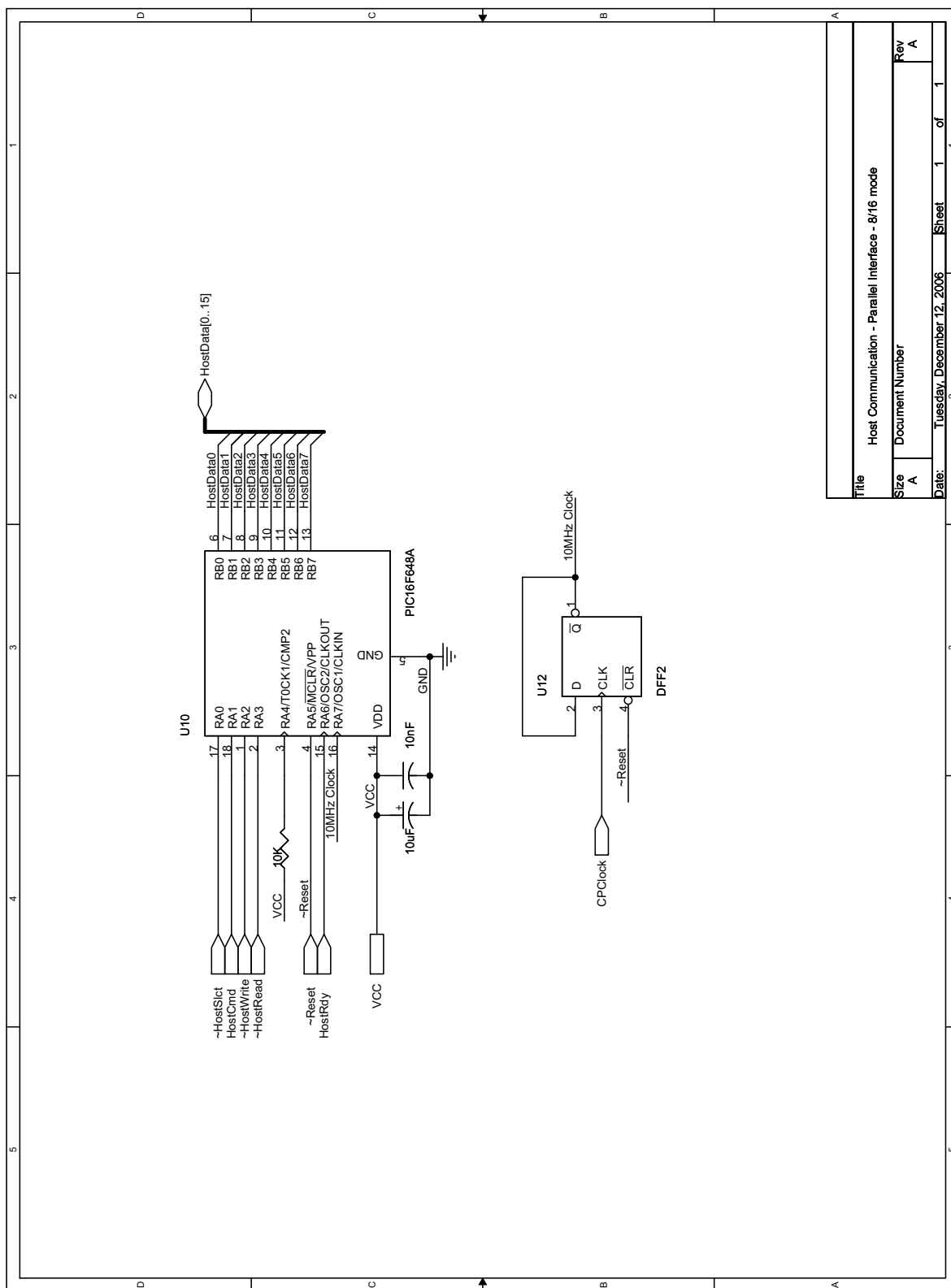
Step 3: Read Port B and store the result.

Step 4: Write a byte into PORTA with the lowest four bits set to either 0xC or 0xE to deactivate \sim HostRead.

Step 5: Repeat steps 2 - 4 for the LSB.

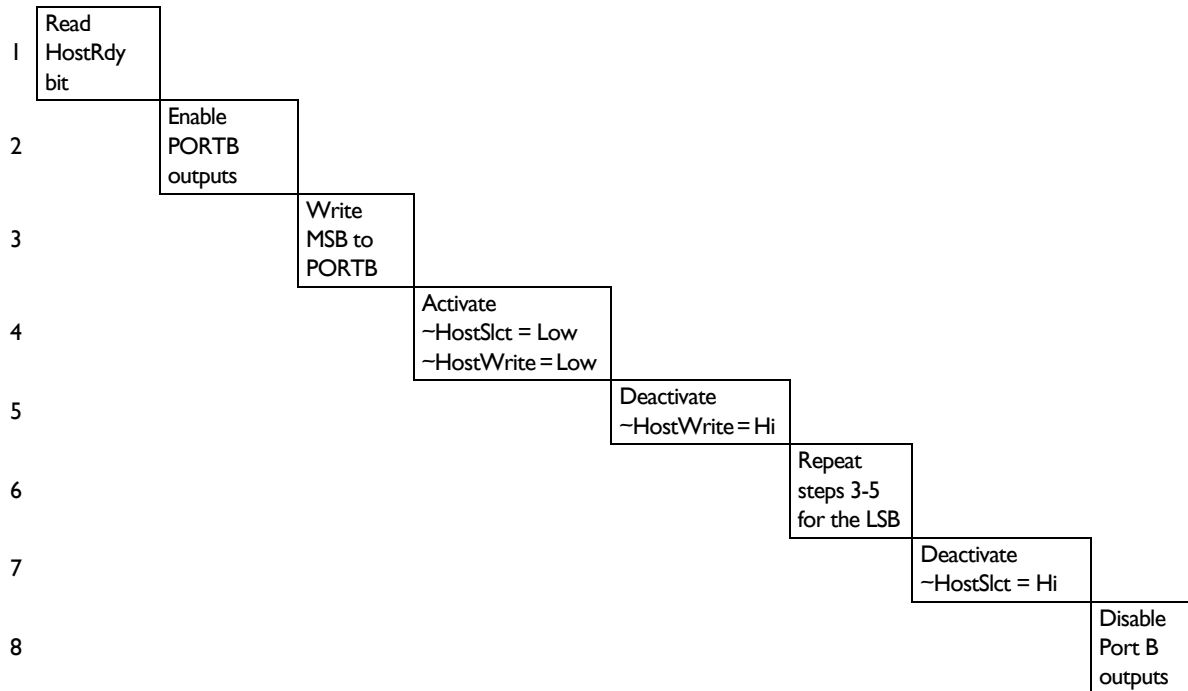
Step 6: Write a byte into PORTA with the lowest four bits set to 0xF to deactivate \sim HostSlct.

Figure 6-16:
Host communication, parallel
interface, 8/16 mode



Title		Host Communication - Parallel Interface - 8/16 mode	
Size	A	Document Number	Rev A
Date:	Tuesday, December 12, 2006	Sheet	1 of 1

6.11.2.2 Typical Data/Instruction Write Sequence



Where:

Step 1: May be performed using the BTFSS instruction. This step must loop until *HostRdy* is high.

Step 2: Enable PORTB outputs by writing the all-zero word to the TRISB register.

Step 3: Write the MSB into PORTB.

Step 4: Write a byte into PORTA, with the lowest 4 bits set to either 0x8(data) or 0xA(instruction) using the MOVLW and MOVWF instructions.

Step 5: Write a byte into PORTA, with the lowest 4 bits set to either 0xC or 0xE to deactivate \sim HostWrite.

Step 6: Repeat steps 3 - 5 for the LSB.

Step 7: Write a byte into PORTA with the lowest four bits set to 0xF to deactivate \sim HostSlct.

Step 8: Disable PORT B outputs by writing 0xFF to the TRISB register.

Note: Since each step takes one or multiple execution cycles (400 nsec) there are no practical timing constraints. For the write cycle, the data should be present on the data bus prior to enabling the write operation by setting \sim HostWrite to active low.

6.12 Pulse & Direction Mode Output Connected to Atlas

The following schematic shows Atlas operated in pulse & direction mode controlled by a single axis Magellan. Note that any source of pulse & direction signals, such as a microprocessor or other dedicated motion control IC, may be substituted for the Magellan in this schematic.

6.12.1 Atlas power input and motor outputs

Atlas is powered through pin pairs HV and Pwr_Gnd, and the power source is a transformer-isolated DC power supply.

For step motors pins MotorA, MotorB, MotorC and MotorD are wired to motor windings A+, A-, B+ and B-, respectively.

6.12.2 Atlas Pulse & Direction Interface

When in pulse & direction signal mode, Atlas receives pulse, direction and AtRest signals as shown in the schematic. When operated in pulse & direction signal mode SPI communications are not available.

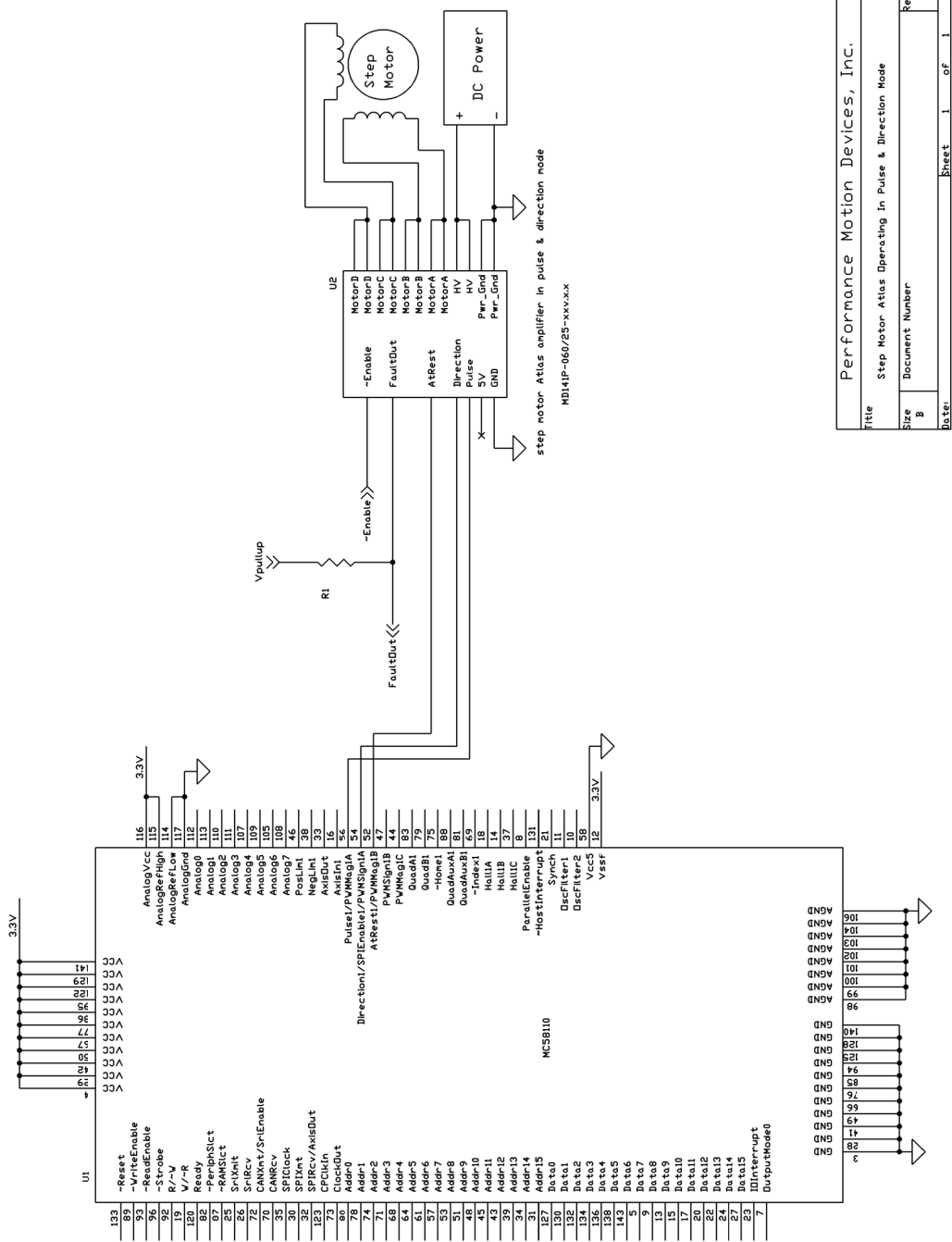
6.12.3 Atlas ~Enable and FaultOut Signals

Atlas has one dedicated input signal, ~Enable, which must be pulled low for the Atlas output stage to be active.

FaultOut is a dedicated output. During normal operation it outputs low. When a fault occurs it will go into a high impedance state. In this example, FaultOut is pulled up by Vpullup through resistor R1. Vpullup can be up to 24V to meet the system requirement. For example, if the fault signal is wired to a 5V TTL input, Vpullup can be 5V.

6.12.4 Magellan MC58110 configuration

In this schematic the SPI master is a single-axis Magellan MC58110 configured for pulse & direction signal output. Only the connections with Atlas are shown. For complete Magellan wiring, please refer to the MC581100 electrical specifications.



Performance Motion Devices, Inc.	
Title	Step Motor Atlas Operating In Pulse & Direction Mode
Size	Document Number
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Date	Sheet 1 of 1

Figure 6-17: Step Motor Atlas Operating In Pulse & Direction Mode

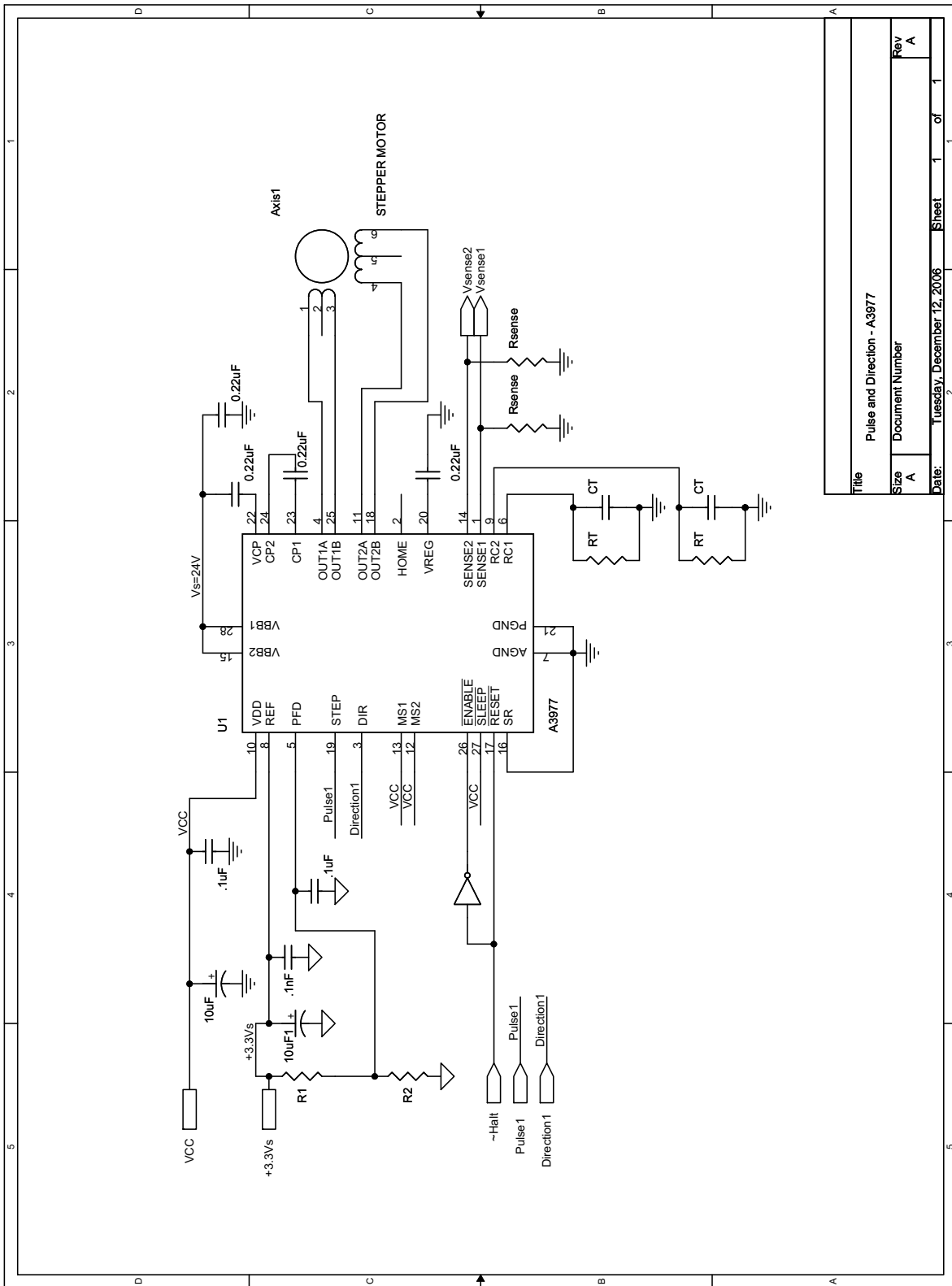
6.13 Using the Allegro A3977 to Drive Microstepping Motors

The A3977 is a complete microstepping motor driver with a built-in translator. The translator is capable of driving bipolar stepper motors in full-, half-, quad-, and eighth-step modes. When the step input transitions from low to high, the A3977 will advance the motor one full-, half-, quad-, or eighth-step according to the configuration of the MS1 and MS2 pins. In the example the driver is configured for eighth-step resolution.

The A3977 operation can be tuned with the use of external components. CT is used to determine the blanking period of the current sense comparator circuitry. The product of RT and CT is used to determine the PWM constant off period. $R1$ and $R2$, along with RT and CT , determine the percentage of the fast decay in mixed decay mode. The sense resistors, R_{sense} , should be selected according to the maximum current and voltage restrictions of the driver. Refer to the device data sheet for further information.

For a direct interface of the pulse signal to the step input, the polarity of the pulse signal must be inverted using the **SetSignalSense** command. This is required because the A3977 recognizes a step during a low-to-high transition of the step input signal, whereas the non-inverted behavior of the MC55000 is to generate a step on a high-to-low transition. The pulse and direction outputs will satisfy the A3977 timing requirements if operated at a step rate of 155.625 kHz or less. This can be set using the **SetStepRange** command. The MC55110 has a maximum step rate of 97.6 kHz.

The schematic in [Figure 6-18](#) uses the sense outputs to detect a malfunction by sensing the current through the motor windings. To generate the \sim *Halt* signal, the over-current circuitry should be configured with an $R_{sense} = 0.15\Omega$ power resistor for a rated 2A motor.



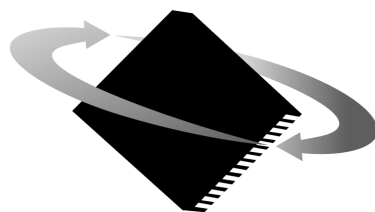
Title	Pulse and Direction - A3977
Size	Document Number
Rev	A
Date:	Tuesday, December 12, 2006
Sheet	1 of 1

Figure 6-18:
Pulse and
direction,
A3977

For additional information, or for technical assistance,
please contact PMD at (978) 266-1210.

You may also e-mail your request to support@pmdcorp.com

Visit our website at <https://www.pmdcorp.com>



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