Software

Model 5000

Software Developer's Guide V1.1

KEITHLEY

81840 Rev. B / 6-98

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Model 5000
Software Developer's Guide

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Cleveland, Ohio, U.S.A.
First Printing, June 1998
Document Number: 81840 Rev. B

Manual Print History

The print history shown below lists the printing dates of all Revisions and Addenda created for this manual. The Revision Level letter increases alphabetically as the manual undergoes subsequent updates. Addenda, which are released between Revisions, contain important change information that the user should incorporate immediately into the manual. Addenda are numbered sequentially. When a new Revision is created, all Addenda associated with the previous Revision of the manual are incorporated into the new Revision of the manual. Each new Revision includes a revised copy of this print history page.

Revision A (Document Number 81840) .... August 1996
Revision B (Document Number 81840) .... June 1998

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About this manual

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If you have comments or suggestions about how to make this (or other) manuals easier to understand, or if you find an error or an omission, please fill out and mail the reader response card at the end of this manual (postage is prepaid).

Conventions

Procedural

Keithley Instruments uses various conventions throughout this manual. You should become familiar with these conventions as they are used to draw attention to items of importance and items that will generally assist you in understanding a particular area.

WARNING **A warning is used to indicate that an action must be done with great care. Otherwise, personal injury may result.**

CAUTION **A caution is used to indicate that an action may cause minor equipment damage or the loss of data if not performed carefully.**

NOTE *A note is used to indicate important information needed to perform an action or information that is nice-to-know.*

When referring to pin numbering, pin 1 is always associated with a square solder pad on the actual component footprint.

Notational

A forward slash (/) preceding a signal name denotes an active LOW signal. This is a standard Intel convention.

Caret brackets (<>) denote keystrokes. For instance <Enter> represents carriage-return-with-line-feed keystroke, and <Esc> represents an escape keystroke.

Driver routine declarations are shown for C and BASIC (where applicable).

Hungarian notation is used for software parameters. In other words, the parameter type is denoted by a one or two letter lower case prefix:

c	character, signed or unsigned
s	short integer, signed
w	short integer, unsigned
l	long integer, signed
dw	long integer, unsigned

For example, wBoardAddr would be an unsigned short integer parameter.

An additional p prefix before the type prefix indicates that the parameter is being passed by reference instead of by value. (A pointer to the variable is being passed instead of the variable itself).

For example, pwErr would be an unsigned short integer parameter passed by reference.

This notation is also used in BASIC although no distinction between signed and unsigned variables exists.

In BASIC, all parameters also have a type suffix:

$	character, signed or unsigned
%	integer, signed or unsigned
&	long integer, signed or unsigned

Routine names are printed in bold font when they appear outside of function declarations, e.g., ReadStatus.

Parameter names are printed in italics when they appear outside of function declarations, e.g. sControls.

Constants are defined with all caps, e.g., ALL_AXES. Underscores {_} must be replaced by periods {.} for use with BASIC.

Combinational logic and hexadecimal notation is in C convention in many cases. For example, the hexadecimal number 7Ch is shown as 0x7C.

C relational operators for OR and AND functions — "| |" and "&&" — are used to minimize the confusion associated with grammar.

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1
Programming Overview

Installing the 5000 software

The 5000 driver includes the batch file, INSTALL.BAT, to install the software. The batch file takes one argument, which is the path where you will install the software. For example, to install the software on the C drive into a subdirectory called 5000, enter on the command line:

```
install c:000
```

Use the same path for the installation of all drivers. This puts all include files, examples, etc., together. This is especially important when using QuickBASIC, where you will have to combine many libraries into a quick library.

A BASIC subdirectory, a C subdirectory, and a Pascal subdirectory will be created off the directory you specify, and you may delete any unneeded subdirectories to save disk space.

Compiling and linking

The following paragraphs describe how to compile a program using the 5000 driver with the various supported compilers. It is assumed that the source file is named DEMO.C for C, DEMO.BAS for BASIC, and DEMO.PAS for Pascal.

Microsoft C or Microsoft QuickC

To compile and link on the command line, enter the following:

```
cl /Ax /Gs demo.c te5000x.lib        (C)
qcl /Ax /Gs demo.c te5000x.lib       (QuickC)
```

where x is:

s	small model
m	medium model
c	compact model
l	large model

Turn stack-checking off with the /Gs switch (option) if you use interrupts. For CodeView compatibility, include the /Zi switch.

To use the 5000 driver in the QuickC environment, perform the following steps:

1. In the Make menu, select the Set Program List option.
2. After naming the Make file, select Edit Program List, and enter the names of the source file (DEMO.C) and the appropriate library (e.g., te5000s.lib for small model).
3. In the Options/Make menu, select the Compiler Flags option and set the appropriate memory model (this model must match the library in the make list). If you use interrupts, turn stack-checking off.

Borland or Turbo C/C++

To compile and link on the command line, enter the following:

```
tcc -mx demo.c te5000x.lib          (Turbo C)
bcc -mx demo.c te5000x.lib          (Borland C)
```

where x is:

s	small model
m	medium model
c	compact model
l	large model

For Turbo Debugger compatibility, include the -v option.

To use the 5000 driver in the Borland environment, perform the following steps:

1. In the Project/Open Project menu, enter in the name of the project file you want to create.
2. In the Project/Add Item menu, enter the names of the source file (DEMO.C) and the appropriate library (e.g., te5000s.lib for small model).
3. In the Options/Compiler/Code Generation menu, set the appropriate memory model (this model must match the library in the Make list). If you use interrupts, turn stack-checking off.

Microsoft QuickBASIC

If you use compiled BASIC exclusively and never program in the QuickBASIC environment, you can link the library te5000b.lib into your application.

```
bc demo.bas;
link demo.obj,,,te5000b.lib
```

To compile and link for CodeView compatibility, enter the following:

```
bc /Zi demo.bas;
link /CO demo.obj,,,te5000b.lib
```

If you use the QuickBASIC environment, you must first run the batch file, QLB5000.BAT. This batch file will need modification, depending on which QuickBASIC version you use. The necessary modifications are explained by the remarks in the batch file itself.

The batch file creates two files: te5000qb.qlb and te5000qb.lib. Library te5000qb.qlb is a quick library for use in the QuickBASIC environment, and te5000qb.lib is the command line equivalent. Therefore, you will develop your program with te5000qb.qlb and then in the final compilation, link with te5000qb.lib.

To use the 5000 driver in the QuickBASIC environment, enter the following:

```
qb demo.bas /lte5000qb.qlb
```

To compile on the command line:

```
bc demo.bas;
link demo.obj,,,te5000qb.lib
```

To compile and link for CodeView compatibility:

```
bc /Zi demo.bas;
link /CO demo.obj,,,te5000qb.lib
```

The libraries te5000b.lib and te5000qb.lib are similar but not identical. Library te5000b.lib calls two routines not contained in the library itself: MoveDone and InputAlert. These two routines must be be included in your source code if you need to link te5000b.lib into the application program. The file, INTR5000.BAS, contains stub versions of these routines that you can use as a guide, or you can compile and link the file itself into the application. Since te5000b.lib has unresolved references, it cannot be converted into a quick library.

The library te5000qb.lib is created by the batch file by compiling INTR5000.BAS and linking the resulting object file with te5000b.lib. It has no unresolved references and can be converted into the quick library te5000qb.qlb. A program developed in the QuickBASIC environment using te5000qb.qlb can be compiled on the command line and linked with te5000qb.lib without modifying the source code. See the information on using interrupts with BASIC.

Borland Turbo Pascal

To compile and link on the command line, enter the following:

```
tpc /$S- demo
```

If you use interrupts, be sure to turn stack-checking off. Turn off stack-checking by including /$S on the command line as shown or by including the line {$S-} in the program source code.

To compile for Turbo Debugger compatibility, include the /v option.

To use the 5000 driver in the Turbo Pascal environment, enter the following:

```
turbo demo
```

The source file must include the line: *uses te5000p*;. If you use interrupts, be sure to turn stack-checking off. Turn off stack-checking through the Options/Compiler menu or by including the line {$S-} in the program.

Programming fundamentals

To quickly write simple applications for the 5000, follow the structure of the example programs provided in Section 2. For C, include the te5000.h file. For BASIC, include the TE5000.BAS file. For Pascal, always specify the te5000p unit.

Call InitSw first to initialize the software. Then call InitBoard once for every 5000 board in the system. To use the other driver routines, you must be familiar with the concept of board and axis numbers.

Each board in the system will be sequentially assigned a number from 0 to 5, called the board number, used to identify the board in calls to other routines. Each time InitBoard is called, another board number is assigned. If only one board is installed in the system, calling InitBoard once assigns a board number of zero.

Likewise, each axis in the system will be sequentially assigned an axis number from 0 to 17, used to identify a particular axis in calls to other routines. Each time InitBoard is called, three more axis numbers are assigned.

2
Example Programs

Introduction

The following code segments show the steps needed to use the 5000 software. Examples of common applications are shown. The first example is shown in C, BASIC, and Pascal. The other examples are shown only in C, but the ideas extend to BASIC and Pascal. The values used in these examples for position, velocity, acceleration, etc., are arbitrary. The actual values depend upon your system requirements.

Trapezoidal point-to-point move

The following code illustrates the simplest of examples. Values for distance, velocity, and acceleration are specified, and a trapezoidal move is started. Interrupts are set up for demonstration only and serve no useful purpose in these examples.

Move program in C

This routine shows how to move the motor to a specified point.

```
#include <te5000.h>

static void MoveDone(unsigned short *pwAxis);
static void InputAlert(unsigned short *pwAxis);

main()
{
   unsigned short wBoardAddr = 0x300;
   unsigned short wAxisNum = 0, wBoardNum = 0, wIRQNum = 3;

   /* initialize the software */
   InitSw();

   /* initialize the board */
   InitBoard(wBoardAddr);
   InterruptHooks(MoveDone, InputAlert);

   /* enable interrupts */
   EnableIRQ(wBoardNum, wIRQNum);
   InputAlertOn(wAxisNum);
   /* load the parameters */
   Distance(wAxisNum, 10000);
   Multiplier(wAxisNum, 100);
   LowVelocity(wAxisNum, 1);
   Velocity1(wAxisNum, 1000);
   Acceleration(wAxisNum, 1000);
   Deceleration(wAxisNum, 1000);
   DownPoint(wAxisNum, 610);

   /* select preset mode and the move direction of "down" */
   ModeSelect(wAxisNum, POSMODE_DOWN);

   /* always reset move before starting up */
   StartStop(wAxisNum, RESET_MOVE */
```

```
    /* start move */
    StartStop(wAxisNum, START1_MOVE);

    /* wait for move to be complete */
    while(IsBusy(wAxisNum));

    /* disable interrupts before exiting the program */
    DisableIRQ();
}

void MoveDone(unsigned short *pwAxis)
{
    /* end-of-move interrupt handling goes here */
}

void InputAlert(unsigned short *pwAxis)
{
    /* input interrupt handling goes here */
}
```

Move program in BASIC

```
'$INCLUDE:  'TE5000.BAS'

CONST BOARD.ADDR  = &H300
CONST IRQ.NUM     = 3

AxisNum% = 0
BoardNum% = 0

'initialize the software
X% = InitSw

'initialize the board
X% = InitBoard(BOARD.ADDR)

'enable interrupts
X% = EnableIRQ(BoardNum%, IRQ.NUM)
X% = InputAlertOn(AxisNum%)

'load the parameters
X% = Distance(AxisNum%, 10000)
X% = Multiplier(AxisNum%, 100)
X% = LowVelocity(AxisNum%, 1)
X% = Velocity1(AxisNum%, 1000)
X% = Acceleration(AxisNum%, 1000)
X% = Deceleration(AxisNum%, 1000)
X% = DownPoint(AxisNum%, 610)

'select preset mode and the move direction of "down"
X% = ModeSelect(AxisNum%, POSMODE.DOWN)

'always reset move before starting up
X% = StartStop(AxisNum%, RESET.MOVE)
```

```
'start the move
X% = StartStop(AxisNum%, START1.MOVE)

' wait for move to be complete
do
loop while IsBusy(AxisNum%)

'disable interrupts before exiting the program
X% = DisableIRQ

'Interrupt Stub routines are supplied to satisfy the linker
SUB MoveDone (AxisNum%)
   ' end-of-move interrupt handling goes here
END SUB

SUB InputAlert (AxisNum%)
   ' input interrupt handling goes here
END SUB
```

Move program in Pascal

```
program example;

uses te5000p;

const

BOARD_ADDR  = $300;
IRQ_NUM     = 3;

var

wAxisNum    : word;
wBoardNum   : word;
wVersion    : word;
sRetCode    : integer;

procedure MoveDone (var pwAxis : word); far;
begin
end;

procedure InputAlert (var pwBoard : word); far;
begin
end;

begin

wAxisNum := 0;
wBoardNum := 0;

{ initialize the software }
wVersion := InitSw;

{ initialize the board }
```

```
sRetCode := InitBoard(BOARD_ADDR);

{ enable interrupts }
InterruptHooks(MoveDone, InputAlert);
sRetCode := InputAlertOn(wBoardNum);
sRetCode := EnableIRQ(wBoardNum, IRQ_NUM);

{ load the parameters }
sRetCode := Distance(wAxisNum, 10000);
sRetCode := Multiplier(wAxisNum, 100);
sRetCode := LowVelocity(wAxisNum, 1);
sRetCode := Velocity1(wAxisNum, 1000);
sRetCode := Acceleration(wAxisNum, 1000);
sRetCode := Deceleration(wAxisNum, 1000);
sRetCode := DownPoint(wAxisNum, 610);

{ select preset mode and the move direction of "down" }
sRetCode := ModeSelect(wAxisNum, POSMODE_DOWN);

{ always reset move before starting up }
sRetCode := StartStop(wAxisNum, RESET_MOVE);

{ start the move }
sRetCode := StartStop(wAxisNum, START1_MOVE_INT);

{ wait for move to be complete }
while (IsBusy(wAxisNum) <> 0) do;
sRetCode := DisableIRQ;

end.
```

Velocity mode

This code segment shows how to run the motor in velocity mode.

```
unsigned short wAxisNum = 0;

/* initialize the software */
InitSw();

/* initialize the board */
InitBoard(0x300);

/* load the parameters */
Multiplier(wAxisNum, 100);
LowVelocity(wAxisNum, 1);
Velocity1(wAxisNum, 1000);
Acceleration(wAxisNum, 1000);
Deceleration(wAxisNum, 1000);
DownPoint(wAxisNum, 610);

/* select velocity mode, move direction of "down" */
ModeSelect(wAxisNum, VELMODE_DOWN);
```

```
/* always reset move before starting up */
StartStop(wAxisNum, RESET_MOVE */

/* start move */
StartStop(wAxisNum, START1_MOVE);

/* to change velocity, use "other" slew velocity register */
Velocity2(wAxisNum, 1500);
StartStop(wAxisNum, START2_MOVE);
```

Homing

This routine homes the motor by running it until it hits a limit, reverses the direction, and then looks for the home input.

```
unsigned short wAxisNum = 0;

/* enter parameters */
Multiplier(wAxisNum, 1000);
DownPoint(wAxisNum, );
LowVelocity(wAxisNum, 1);
Velocity1(wAxisNum, 10);
Acceleration(wAxisNum, 0x3FFF);
Deceleration(wAxisNum, 0x3FFF);

/* select down direction and velocity mode */
ModeSelect(wAxisNum, VELMODE_DOWN);

/* always reset move before starting up */
StartStop(wAxisNum, RESET_MOVE */

/* start move */
StartStop(wAxisNum, START1_MOVE);

/* wait for limit to stop move */
while (IsBusy(wAxisNum));

/* select origin return mode */
ModeSelect(wAxisNum, HOMEMODE_UP);

/* always reset move before starting up */
StartStop(wAxisNum, RESET_MOVE */

/* start move */
StartStop(wAxisNum, START1_MOVE);

/* wait for axis to home */
while (IsBusy(wAxisNum));

/* for future moves, put in position mode*/
ModeSelect(wAxisNum, POSMODE_UP);
```

Another method for homing the motor is to run it in one direction until it hits a mechanical stop, and then run it in the other direction until encountering the Home input. This method can be used when limit switches are not used and the motor can SAFELY run against a mechanical stop.

```
unsigned short wAxisNum = 0;

/* enter parameters */
/* choose a large enough value for the move distance */
/* such that the motor is sure to hit the mechanical stop */
Distance(wAxisNum, 0x0FFFFFF);
Multiplier(wAxisNum, 1000);
LowVelocity(wAxisNum, 1);
Velocity1(wAxisNum, 10);
Acceleration(wAxisNum, 0x3FFF);
Deceleration(wAxisNum, 0x3FFF);

/* select down direction and position mode */
ModeSelect(wAxisNum, POSMODE_DOWN);

/* always reset move before starting up */
StartStop(wAxisNum, RESET_MOVE);

/* start move */
StartStop(wAxisNum, START1_MOVE);
/* wait for move to complete */
while (IsBusy(wAxisNum));

/* select origin return mode */
ModeSelect(wAxisNum, HOMEMODE_UP);

/* always reset move before starting up */
StartStop(wAxisNum, RESET_MOVE);

/* start move */
StartStop(wAxisNum, START1_MOVE);

/* wait for axis to home */
while (IsBusy(wAxisNum));

/* for future moves, put in position mode */
ModeSelect(wAxisNum, POSMODE_UP);
```

These are fairly common methods of homing the motor, and they offer better repeatability than simply running to a limit switch or a mechanical stop.

Reading position

This routine moves the motor and displays the value of the down-counter. The down-counter value represents the distance in pulses left to move.

```
unsigned short wAxisNum = 0;

/* enter parameters */
Distance(wAxisNum, 100000);
Multiplier(wAxisNum, 100);
LowVelocity(wAxisNum, 1);
Velocity1(wAxisNum, 1000);
Acceleration(wAxisNum, 1000);
Deceleration(wAxisNum, 1000);
DownPoint(wAxisNum, 610);

/* select down direction and position preset mode */
ModeSelect(wAxisNum, POSMODE_DOWN);

/* always reset move before starting up */
StartStop(wAxisNum, RESET_MOVE);

/* start move */
StartStop(wAxisNum, START1_MOVE);

/* report position until move is complete */
do{
  /* read and display the down-counter */
  printf("Down Counter = %ld", PulsesLeft(wAxisNum));
} while (IsBusy(wAxisNum));
```

3
Move Parameters

Ranges

The permissible range of values for each parameter are as follows:

distance: 0 to FFFFFFh (0 to 16,777,215)

multiplier register (R7): 2h to 03FFh (2 to 1,023)

Permissible ranges for velocity and acceleration are a function of the multiplier register. Assuming a clock rate of 5 MHz, the ranges are shown in table 3-1.

Table 3-1
Permissible velocity and acceleration ranges

R7	Full scale velocity (pps)	Max acceleration (pps^2)
2	2,500,000	762,939,453
5	1,000,000	305,175,781
10	500,000	152,587,891
20	250,000	76,293,945
50	100,000	30,517,578
100	50,000	15,258,789
200	25,000	7,629,375
500	10,000	3,051,758
1000	5,000	1,525,879

Velocity units

The value given for multiplier register, R7, sets the full scale velocity as follows:

$$\text{Full Scale Velocity} = \frac{f_{clock}}{R7}$$

where: f_{clock} is the clock frequency (5 MHz as shipped).

The slew (high-speed) velocity is then set as follows:

$$\text{Slew Velocity} = \text{Full Scale Velocity}\left(\frac{R2}{8192}\right)$$

$$R2 = \frac{(8192)(\text{Slew Velocity})}{\text{Full Scale Velocity}}$$

Since R2 can be a maximum of 8191, the maximum velocity that can be specified is slightly less than the full scale velocity.

The start (low speed) velocity is set in a similar fashion:

$$\text{Start Velocity} = \text{Full Scale Velocity}\left(\frac{R1}{8192}\right)$$

$$R1 = \frac{(8192)(\text{Start Velocity})}{\text{Full Scale Velocity}}$$

Acceleration/deceleration units

The value for acceleration in pulses per second^2 is a function of both the acceleration register, R4, and the multiplier register, R7:

$$\text{Acceleration} = \frac{(f_{clock})^2}{(8192)(R4)(R7)}$$

$$R4 = \frac{(f_{clock})^2}{(8192)(\text{Acceleration})(R7)}$$

If precise acceleration is not important, remember that the greater the value of R4, the smaller the acceleration.

The equation for deceleration is similar, with R5 substituted for R4:

$$\text{Acceleration} = \frac{(f_{clock})^2}{(8192)(R5)(R7)}$$

$$R5 = \frac{(f_{clock})^2}{(8192)(\text{Acceleration})(R7)}$$

Distance units

The values for the distance register, R0, and the rampdown point register, R6, are both in units of output pulses.

Given values for four of the other registers, and assuming the move stops after ramping down, use the following formula to calculate R6:

$$R6 = \frac{(R2 + R1 - 1)(R2 - R1)(R5)}{16384(R7)}$$

This expression simplifies to approximately:

$$R6 = \frac{(R2^2 - R1^2)R5}{16384(R7)}$$

If you want the move to continue at the start speed for x pulses after ramping down, add x to the result of the above equation.

4
Interrupt Handling

Introduction

The 5000 driver simplifies the use of interrupts. When an interrupt occurs, the driver handles all interrupt overhead and then calls your routines to act on the interrupts.

Enabling interrupts

The first routine you need to call is EnableIRQ before interrupts can be used. At the end of the program, call DisableIRQ to restore the interrupt vectors and interrupt masks to their original state. You need to supply two routines to handle the two interrupt sources: the axis controllers and the user inputs. Both are described below.

For BASIC, the names given below are fixed. The linker will expect to find two routines with these names. For C or Pascal, the routines can be named anything because the address rather than the name of each routine is passed to the InterruptHooks routine.

MoveDone — This routine will be called when the axis controller causes an interrupt. A single argument is passed by reference, the axis number causing the interrupt.

InputAlert — This routine will be called when an external interrupt from the user input causes an interrupt. A single argument is passed by reference, the axis number corresponding to the input causing the interrupt.

Interrupts in C or Pascal

The example programs in Section 2 show how interrupts are set up. Interrupt hook routines are installed by calling InterruptHooks. A warning will be generated if you attempt to install improper routines (routines that do not accept the proper number and type of arguments). Turn off stack-checking for the interrupt hook functions and any routines they call.

Interrupts in BASIC

The example program given in Section 2 shows how interrupts are used. You must provide two routines: MoveDone and InputAlert.

You can use interrupts in the QuickBASIC environment, but the interrupt handling routines must be in the QuickLibrary te5000qb.qlb. To do this, use the INTR5000.BAS file to write your interrupt hook routines. Run the batch file QLB5000.BAT to compile INTR5000.BAS and add it to the libraries, te5000qb.qlb and te5000qb.lib. The library te5000qb.lib is an alternative to using te5000b.lib and is supplied to provide a command line equivalent library to the QuickLibrary. You can develop a program in the environment with the QuickLibrary and then compile and link on the command line without modification. If you use te5000b.lib, you will have to add your interrupt hook routines to the source file before compiling.

General notes on using interrupts

There are some important points to be aware of when using interrupts:

1. **DOS is not re-entrant.** If an interrupt is generated while in a DOS call, the interrupt routine can not call another DOS function. With Basic, C, and Pascal, DOS is usually used for screen output, keyboard input, and disk and file I/O. Do not use DOS in your interrupt routines. One method for avoiding this is to set a global flag in your interrupt routine, and then have the main routine check this flag and call DOS when the flag is set. For example, if you want to print a message when an interrupt occurred, the interrupt routine sets a flag. When the main program sees the flag set, it will print the message.
2. **Turn off stack checking when using interrupts with C.** If you encounter a stack overflow, stack-checking is not turned off. Check the compiler manual for instructions on how to do this.

5
Routine Summary

Introduction

The 5000 driver software consists of the following routines. A more complete description of each is given in Appendix A.

Table 5-1
Notational conventions

Prefix	Variable type
c	character, signed or unsigned
s	short integer, signed
w	short integer, unsigned
l	long integer, signed
dw	long integer, unsigned
p	pointer

Initialization and hardware control routines

DisableIRQ()	Restores old interrupt vectors and disables IRQ lines.
EnableIRQ(wBoardNum, sIRQLevel)	Sets up interrupt vector and enables IRQ line on the bus.
InitBoard(wBoardAddr)	Initializes 5000 board.
InitSw()	Initializes 5000 software.
InputAlertOff(wAxisNum)	Disables input interrupts.
InputAlertOn(wAxisNum)	Enables input interrupts.
InterruptHooks(*MoveDoneHook, *InputAlertHook)	Defines which user functions are to be called upon interrupt (not usable in BASIC).

Axis command routines

Acceleration(wAxisNum, wAcc)	Writes to acceleration register, R4.
ClockOff(wBoardNum, sClocks)	Disables axis output pulses.
Deceleration(wAxisNum, wDec)	Writes to deceleration register, R5.
Distance(wAxisNum, dwPulses)	Writes to the down-counter (distance) register, R0.
DownPoint(wAxisNum, dwPulses)	Writes to the rampdown point register, R6.
IOControl(wAxisNum, sControls)	Sends I/O control command.
LowVelocity(wAxisNum, wVel)	Writes to start-stop (low) velocity register, R1.
ModeSelect(wAxisNum, sMode)	Sends mode select command.
Multiplier(wAxisNum, wMultReg)	Writes to multiplier register, R7.
OutputHigh(wAxisNum)	Sets user output HIGH.

OutputLow(wAxisNum)	Sets user output LOW.
StartStop(wAxisNum, sCmd)	Sends a start-stop command.
Velocity1(wAxisNum, wVel)	Writes to slew velocity register, R2.
Velocity2(wAxisNum, wVel)	Writes to slew velocity register, R3.
WriteReg(wAxisNum, wRegister, lValue)	Writes to register.

Axis data reporting routines

IsBusy(wAxisNum)	Returns axis busy status.
PulsesLeft(wAxisNum)	Returns current down-counter (register R0) value.
ReadState(wAxisNum)	Returns axis controller state buffer.
ReadStatus(wAxisNum)	Returns axis controller status.

A

Driver Routine Descriptions

Appendix A

Driver Routine Descriptions

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Notational conventions

The declarations for each routine is shown for C, BASIC, and Pascal.

In C or Pascal, the type of a parameter is denoted by its one letter lower-case prefix:

Prefix	Variable type
c	character, signed or unsigned
s	short integer, signed
w	short integer, unsigned
l	long integer, signed
dw	long integer, unsigned
p	pointer

For instance, wAxis indicates that this variable is an unsigned short integer.

In BASIC, the type of a parameter is always explicitly indicated by a type suffix:

Prefix	Variable type
%	short integer, signed or unsigned
&	long integer, signed or unsigned
$	character, signed or unsigned

For instance, Axis% indicates that this variable is a short integer.

Routine names are printed in bold sans serif font, **InitSw**.

Parameter names are printed in italics, *wAxisNum*.

Constants are defined with all caps, ALL_AXES. Underscores must be replaced by periods for use with BASIC.

Acceleration

Load acceleration register

Declarations:

C:
```
short Acceleration(unsigned short
wAxisNum, unsigned short wAcc);
```

BASIC:
```
DECLARE FUNCTION Acceleration%(BYVAL
AxisNum%, BYVAL Acc%)
```

Pascal:
```
function Acceleration(wAxisNum, wAcc :
word) : integer;
```

Description: Acceleration loads the specified value into acceleration register, R4. To convert an acceleration given in pulses per second per second into register R4 units, use the following equation:

$$R4 = \frac{(f_{clock})^2}{(8192)(Acceleration)(R7)}$$

where: R7 is the multiplier register value specified in the Multiplier routine.
f_{clock} is the system clock.
The system clock is jumpered to 5 MHz when shipped.

Given a ramp time between the low-speed and high-speed velocities, calculate R4 using the following equation:

$$R4 = \frac{Tf_{clock}}{R2 - R1}$$

where: R2 is the value specified for the Velocity1 routine.
R1 is the value specified for the LowVelocity routine.
T is the ramp time in seconds.

If precise acceleration is not important, simply note that as R4 increases, ramp time increases and acceleration decreases.

Parameters:

AxisNum	Axis number (0 to 17).
Acc	Acceleration in R4 units ranging from 2h to 3FFFh (2 to 16,383).

Return Code:

(0)	No error.
(-1)	Invalid axis number or acceleration register value.

See Also: Deceleration, Multiplier

Clockoff

Disable motor output

Declarations:

C:
```
short ClockOff(unsigned short
wBoardNum, short sClocks);
```
BASIC:
```
DECLARE FUNCTION ClockOff%(BYVAL
boardNum%, BYVAL Clocks%)
```
Pascal:
```
function ClockOff(wBoardNum:word;
sClocks:integer): integer;
```

Description: This routine disables the motor output from the specified axes. This is useful in synchronizing axes. For instance, you can disable the axes, issue a start command to each axis, and then enable the axes.

Parameters:

BoardNum	Board number (0 to 5).
Clocks	Clocks to disable.

Clocks can be the OR of any of the following:

- CLK_A The first axis on the board is disabled.
- CLK_B The second axis on the board is disabled.
- CLK_C The third axis on the board is disabled.
- CLK_ALL All three axes on the board are disabled.

If a constant is not included, the corresponding axis is enabled.

Return Code:

(0)	No error.
(-1)	Invalid board number.

Deceleration

Load deceleration register

Declarations:

C:
```
short Deceleration(unsigned short
wAxisNum, unsigned short wDec);
```
BASIC:
```
DECLARE FUNCTION Deceleration%(BYVAL
AxisNum%, BYVAL Dec%)
```
Pascal:
```
function Deceleration(wAxisNum, wDec :
word) : integer;
```

Description: Deceleration loads the specified value into deceleration register, R5. To convert a deceleration given in pulses per second per second into register R5 units, use the following equation:

$$R5 = \frac{(f_{clock})^2}{(8192)(Acceleration)(R7)}$$

where: R7 is the multiplier register value specified in the Multiplier routine.
f_{clock} is the system clock. The system clock is jumpered to 5 MHz when shipped.

Given a ramp time between the low-speed and high-speed velocities, calculate R5 using the following equation:

$$R4 = \frac{Tf_{clock}}{R2 - R1}$$

where: R2 is the value specified for the Velocity1 routine.
R1 is the value specified for the LowVelocity routine.
T is the ramp time in seconds.

If precise acceleration is not important, simply note that as R4 increases, ramp time increases and deceleration decreases.

Parameters:

AxisNum	Axis number (0 to 17) or the constant ALL_AXES.
Dec	Deceleration in R5 units ranging from 2h to 3FFFh (2 to 16,383).

Return Code:

(0)	No error.
(-1)	Invalid axis number or deceleration register value.

DisableIRQ

Disable IRQ lines

Declarations:

C:	`short DisableIRQ(void);`
BASIC:	`DECLARE FUNCTION DisableIRQ%()`
Pascal:	`function DisableIRQ : integer;`

Description: This routine masks the IRQ lines selected with EnableIRQ and restores the corresponding interrupt vectors to their original values. If EnableIRQ has been called at least once, call DisableIRQ before exiting from the program.

Parameters: None.

Return Code: (0) No error.

See Also: EnableIRQ

Distance

Load distance register

Declarations:

C:	`short Distance(unsigned short wAxisNum, unsigned long dwPulses);`
BASIC:	`DECLARE FUNCTION Distance%(BYVAL AxisNum%, BYVAL Pulses%)`
Pascal:	`function Distance(wAxisNum : word; dwPulses : longint) : integer;`

Description: This routine loads the specified distance in pulses into register R0.

Parameters:

AxisNum	Axis number (0 to 17) or the constant ALL_AXES
Pulses	Distance in R0 units ranging from 0 to FFFFFFh (0 to 16,777,215).

Return Code:

(0)	No error.
(–1)	Invalid axis number or distance register value.

See Also: Acceleration, Deceleration, DownPoint, LowVelocity, Multiplier, Velocity1, Velocity2

DownPoint

Load downpoint register

Declarations:

C:
```
short DownPoint(unsigned short
wAxisNum, unsigned long dwPulses);
```
BASIC:
```
DECLARE FUNCTION DownPoint%(BYVAL
AxisNum%, BYVAL Pulses&);
```
Pascal:
```
function DownPoint(wAxisNum : word;
dwPulses : longint): integer;
```

Description:

This routine loads a value into the downpoint register R6. Given values for four of the other registers, and assuming the move stops after ramping down, use the following formula to calculate R6:

$$R6 = \frac{(R2 + R1 - 1)(R2 - R1)(R5)}{16384(R7)}$$

This expression simplifies to approximately:

$$R6 = \frac{(R2^2 - R1^2)R5}{16384(R7)}$$

If you want the move to continue at the start speed for x pulses after ramping down, add x to the result of the above equation.

Parameters:

AxisNum	Axis number (0 to 17) or the constant ALL_AXES.
Pulses	Rampdown distance in R6 units ranging from 0 to FFFFFFh (0 to 1,048,575).

Return Code:

(0)	No error.
(–1)	Invalid axis or downpoint register value.

See Also: Deceleration, LowVelocity, Multiplier, Velocity1, Velocity2

EnableIRQ

Enable IRQ line

Declarations:

C:
```
short EnableIRQ(unsigned short
wBoardNum, short sIRQLevel);
```
BASIC:
```
DECLARE FUNCTION EnableIRQ%(BYVAL
BoardNum%, BYVAL IRQLevel%)
```
Pascal:
```
function DisableIRQ(wBoardNum : word;
sIRQLevel : integer) : integer;
```

Description:

This routine reassigns the selected interrupt vector to point to the driver interrupt handler for the specified board. It also saves the old vector and unmasks the interrupt on the PC.

Each board must use a unique interrupt request.

Restore the original vectors by calling DisableIRQ before exiting from the program.

Parameters:

BoardNum	Board number (0 to 5).
IRQLevel	IRQ number (2 to 7).

Return Code:

(0)	No error.
(–1)	Invalid board number or IRQ number, or the IRQ number has previously been assigned to another board.

See Also: DisableIRQ

InitBoard

Initialize board

Declarations:

C:
```
short InitBoard(unsigned short
wBoardAddr);
```

BASIC:
```
DECLARE FUNCTION InitBoard%(BYVAL
BoardAddr%)
```

Pascal:
```
function teIntrNum(wBoardAddr : word) :
integer;
```

Description:

This routine initializes a 5000 board jumpered to the address specified in wBoardAddr. Call InitSw first to initialize the software, then call InitBoard once for every 5000 board in the system.

Each board in the system will be sequentially assigned a number from 0 to 5, called the board number, which will be used to identify the board in calls to other routines.

Likewise, each axis in the system will be sequentially assigned an axis number from 0 to 17. Each board will be assigned three axis numbers regardless of the actual number of axes on the board. Therefore, there will be three times as many axis numbers as board numbers.

InitBoard first does a hardware reset of the board by toggling the appropriate bits in the reset latch. The following additional initialization is done for each axis:

1. The start-stop velocity register, R1, is loaded with the minimum value of 1.
2. The axis is put in preset (position) mode.
3. The general purpose user output is set HIGH.

Parameters:

BoardAddr	Board base address set by jumpers.

Return Code:

(0)	No error.
(–1)	Too may boards initialized.

See Also: InitSw

InitSw

Initialize software

Declarations:

C:	`short InitSw(void);`
BASIC:	`DECLARE FUNCTION InitSw%()`
Pascal:	`function InitSw : integer;`

Description: This routine initializes the 5000 software. Call this routine **before** calling any other driver routine in your program.

Parameters: None.

Return Code: The version number (4 hex digits) of the 5000 driver.

See Also: InitBoard

InputAlertOff

Disable input interrupt

Declarations:

C:	`short InputAlertOff(unsigned short wAxisNum);`
BASIC:	`DECLARE FUNCTION InputAlertOff%(BYVAL AxisNum%)`
Pascal:	`function InputAlertOff(wAxisNum : word) : integer;`

Description: This routine disables the general purpose input for the specified axis from causing an interrupt.

Parameters: AxisNum Axis number (0 to 17).

Return Code:

(0)	No error.
(–1)	Invalid axis number.

See Also: InputAlertOn

InputAlertOn

Enable input interrupt

Declarations:

C: `short InputAlertOn(unsigned short wAxisNum);`

BASIC: `DECLARE FUNCTION InputAlertOn%(BYVAL AxisNum%)`

Pascal: `function InputAlertOn(wAxisNum : word) : integer;`

Description: This routine enables the general purpose input for the specified axis to cause an interrupt when the input goes active (LOW).

Parameters: AxisNum Axis number (0 to 17).

Return Code:

(0) No error.
(–1) Invalid axis number.

See Also: InputAlertOff

InterruptHooks

Install interrupt hooks

Declarations:

C: `typedef void HookType(unsigned short *pwParm); void InterruptHooks (HookType *MoveDoneHook, HookType *InputAlertHook);`

BASIC: `(not available)`

Pascal: `type HookType = procedure(var pwParm : word); procedure InterruptHooks (MoveDoneHook, InputAlertHook : HookType);`

Description: This routine installs two interrupt service routines as interrupt hooks to be called when an interrupt occurs. See the discussion in Section 4 for more on interrupt handling.

Parameters:

MoveDoneHook Routine called when move-done interrupt occurs.
InputAlertHook Routine called when general purpose input interrupt occurs.

Return Code:

(0) No error.
(-1) Invalid axis number.

See Also: Interrupt

IOControl

Write I/O control register

Declarations:

C:	`short IOControl(unsigned short wAxisNum, short sControls);`
BASIC:	`DECLARE FUNCTION IOControl%(BYVAL AxisNum%, BYVAL sControls%)`
Pascal:	`function IOControl(wAxisNum : word; sControls : integer) : integer;`

Description: This routine writes the specified value to the I/O control register.

Parameters:

AxisNum	Axis number (0 to 17) or the constant ALL_AXES.
Controls	I/O control command to be written.

Controls can be the logical combination of any of the following:

IO_PULSE_OUTC	CW & CCW output pulses are used.
IO_FREEZE	Ramping is stopped.
IO_LOW_SENSE	Low sensitivity is used for home and limit inputs.

If a constant is not included, the corresponding function is disabled.

Return Code:

(0)	No error.
(–1)	Invalid axis number.

ISBusy

Read busy bit

Declarations:

C:	`short IsBusy(unsigned short wAxisNum);`
BASIC:	`DECLARE FUNCTION IsBusy%(BYVAL AxisNum%)`
Pascal:	`function IsBusy(wAxisNum : word) : integer;`

Description: This routine returns the state of the busy bit in the status register.

Parameters:

AxisNum	Axis number (0 to 17).

Return Code:

(0)	Busy.
(1)	Not busy.
(–1)	Invalid axis number.

LowVelocity

Load start velocity register

Declarations:

C:
```
short LowVelocity(unsigned short
wAxisNum, unsigned short wVel);
```
BASIC:
```
DECLARE FUNCTION LowVelocity%(BYVAL
AxisNum, BYVAL Vel)
```
Pascal:
```
function LowVelocity(wAxisNum, wVel :
word) : integer;
```

Description: This routine loads the specified start-stop (low-speed) velocity into register R1. To convert a velocity given in pulses per second into register R1 units, use the following equation:

$$R1 = \frac{(\text{Start Velocity})(8192)(R7)}{f_{clock}}$$

where: R7 is the value specified for the Multiplier routine.
f_{clock} is the system clock.
The system clock is jumpered to 5 MHz when shipped.

Alternatively, R1 can be thought of as a scaled velocity. Velocity can be scaled from 1 to 8191. The actual velocity in pulses per second is equal to the scaled velocity, divided by 8192, times the full-scale velocity.

$$\text{Start Velocity} = \text{Full Scale Velocity}\left(\frac{R1}{8192}\right)$$

Parameters:

AxisNum — Axis number (0 to 17) or the constant ALL_AXES.
Vel — Start-stop velocity in R1 units ranging from 1 to 1FFh (1 to 8191).

Return Code:

(0) — No error.
(–1) — Invalid axis number or velocity register value.

See Also: Multiplier

ModeSelect

Load mode select register

Declarations:

C:
```
short ModeSelect(unsigned short
wAxisNum, short sMode);
```
BASIC:
```
DECLARE FUNCTION ModeSelect%(BYVAL
AxisNum%, BYVAL Mode%)
```
Pascal:
```
function ModeSelect(wAxisNum : word;
sMode : integer) : integer;
```

Description: This routine writes the specified value to the mode select register.

Parameters:

AxisNum	Axis number (0 to 17) or the constant ALL_AXES.
Mode	Mode select command.

Mode can be the OR of any of the following:

MODE_ORIGIN	Home input will stop pulse output.
MODE_PRESET	Preset Mode (register R0 is move distance).
MODE_RAMPDOWN	Rampdown inputs affect ramping down.
MODE_DOWN	Direction is down.

Alternatively, one of the following could be used for Mode:

VELMODE_UP	(0)
VELMODE_DOWN	(MODE_DOWN)
POSMODE_UP	(MODE_PRESET)
POSMODE_DOWN	(MODE_PRESET || MODE_DOWN)
HOMEMODE_UP	(MODE_ORIGIN)
HOMEMODE_DOWN	(MODE_ORIGIN || MODE_DOWN)

Return Code:

(0)	No error.
(–1)	Invalid axis number.

Multiplier

Load multiplier register

Declarations:

C:
```
short Multiplier(unsigned short
wAxisNum, unsigned short wMultReg);
```
BASIC:
```
DECLARE FUNCTION Multiplier(BYVAL
AxisNum%, BYVAL MultReg%)
```
Pascal:
```
function Multiplier(wAxisNum, wMultReg
: word) : integer;
```

Description:

This routine loads the specified value into multiplier register, R7. This determines the full-scale velocity. The maximum velocity that you can specify is:

$$\text{Full Scale Velocity} = \frac{f_{clock}}{R7}$$

where: f_{clock} is the system clock jumpered to 5 MHz when shipped.

Actually, on a scale of 1 to 8192, (8192 being full-scale velocity), only 1 to 8191 can be specified in Velocity1 or Velocity2. Choose a full-scale velocity a little higher than the maximum velocity required.

Parameters:

AxisNum	Axis number (0 to 17) or the constant ALL_AXES.
MultReg	Multiplier register value in R7 units ranging from 2 to 3FFh (2 to 1023). Use a value of at least 20 to assure stable operation.

Return Code:

(0)	No error.
(–1)	Invalid axis number or multiplier register value.

See Also: Acceleration, Deceleration, Distance, LowVelocity, Velocity1, Velocity2

OutputHigh

Set GP output HIGH

Declarations:

C:	`short OutputHigh(unsigned short wAxisNum);`
BASIC:	`DECLARE FUNCTION OutputHigh%(BYVAL AxisNum%)`
Pascal:	`function OutputHigh(wAxisNum : word) : integer;`

Description: This routine sets the general purpose output HIGH. Whether this is ACTIVE or INACTIVE depends on the polarity of the output.

Parameters: AxisNum Axis number (0 to 17) or the constant ALL_AXES.

Return Code:

(0)	No error.
(–1)	Invalid axis number.

See Also: OutputLow

OutputLow

Set GP output LOW

Declarations:

C:	`short OutputLow(unsigned short wAxisNum);`
BASIC:	`DECLARE FUNCTION OutputLow%(BYVAL AxisNum%)`
Pascal:	`function OutputLow(wAxisNum : word) : integer;`

Description: This routine sets the general purpose output LOW. Whether this is ACTIVE or INACTIVE depends on the polarity of the output.

Parameters: AxisNum Axis number (0 to 17) or the constant ALL_AXES.

Return Code:

(0)	No error.
(–1)	Invalid axis number.

See Also: OutputHigh

PulsesLeft

Return distance left

Declarations:

C:	`short PulsesLeft(unsigned short wAxisNum);`
BASIC:	`DECLARE FUNCTION PulsesLeft%(BYVAL AxisNum%)`
Pascal:	`function PulsesLeft(wAxisNum : word) : integer;`

Description: This routine reads and returns the down counter register, R0. This will be number of pulses remaining in the move.

Parameters: AxisNum Axis number (0 to 17).

Return Code: Number of pulses remaining in the move.

(-1) Invalid board number.

ReadState

Read state buffer

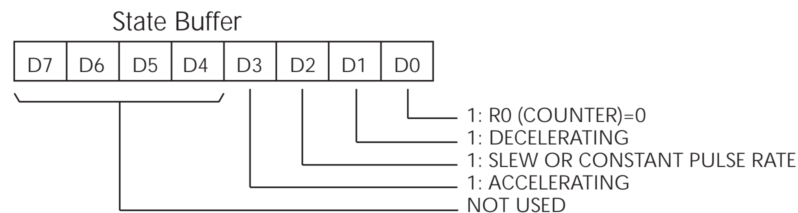
Declarations:

C:	`short ReadState(unsigned short wAxisNum);`
BASIC:	`DECLARE FUNCTION ReadState%(BYVAL AxisNum%)`
Pascal:	`function ReadState(wAxisNum : word) : integer;`

Description: This routine reads and returns the contents of the state buffer.

The format of the state buffer is as follows:

Figure A-1
State buffer



You can mask out bits using the following constants or logical combinations of the following constants:

STATE_ZERO	Down counter equals Zero.
STATE_DOWN	Output pulses decelerating.
STATE_UP	Output pulses accelerating.
STATE_KEEP	Output pulses not ramping.

Parameters: AxisNum Axis number (0 to 17).

Return Code: State value.

(-1) Invalid axis number.

ReadStatus

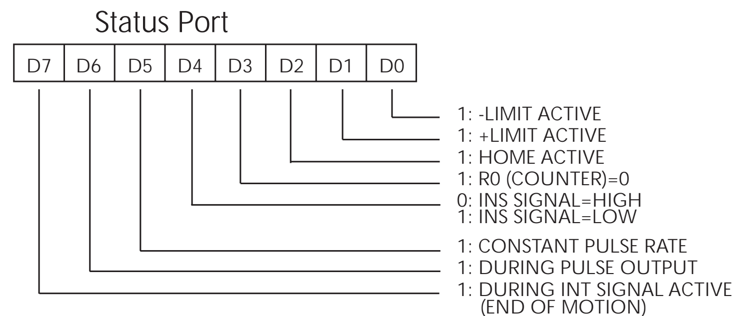
Read status register

Declarations:

C:
```
short ReadStatus(unsigned short
wAxisNum);
```
BASIC:
```
DECLARE FUNCTION ReadStatus%(BYVAL
AxisNum%)
```
Pascal:
```
function ReadStatus(wAxisNum : word) :
word;
```

Description: This routine reads and returns the contents of the status register according to the following format:

Figure A-2
Status buffer



The bits of the status can be masked out using the following constants or logical combinations of the following constants:

STS_NLIMIT	-Limit input.
STS_PLIMIT	+Limit input.
STS_ORIGIN	Home input.
STS_ZERO	Down counter equals zero.
STS_INPUT	General purpose input.
STS_KEEP	Output pulses not ramping.
STS_BUSY	Operation in progress.
STS_NOT_INT	INT not active.

Parameters: AxisNum Axis number (0 to 17).

Return Code: Status word.

(-1) Invalid axis number.

StartStop

Load start-stop register

Declarations:

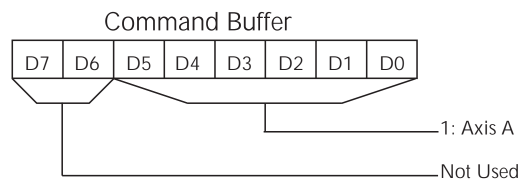
C:
```
short StartStop(unsigned short
wAxisNum, short sCmd);
```

BASIC:
```
DECLARE FUNCTION StartStop(BYVAL
AxisNum%, BYVAL Cmd)
```

Pascal:
```
function StartStop(wAxisNum : word;
sCmd : integer) : integer;
```

Description: This routine writes the specified value to the start-stop command register. Depending on the sCmd argument, this routine can start an axis, stop an axis, or reset an axis interrupt. The format of the command register is as follows:

Figure A-3
Command buffer



Command mode selection		
D7	D6	Command mode
0	0	Operating mode
0	1	Control mode
1	0	Data register
1	1	Output pulse mode
Command modes are selected from the command buffer.		

Parameters:

AxisNum	Axis number (0 to 17) or the constant ALL_AXES.
Cmd	Start-stop command.

Cmd can be the OR of any of the following:

S_HIGH1	The target pulse rate is set by R2.
S_HIGH2	The target pulse rate is set by R3.
S_RAMPING	Ramping is enabled.
S_STOP	Pulse output is stopped.
S_START	Pulse output is started.
S_INT	Interrupt is enabled.

Alternatively, Cmd can be one of the following:

RESET_MOVE	(S_STOP)
START1_MOVE	(S_START || S_HIGH1 || S_RAMPING)
START2_MOVE	(S_START || S_HIGH2 || S_RAMPING)
STOP_MOVE	(S_START || S_STOP || S_RAMPING)

ABORT_MOVE	(S_STOP)
START1_MOVE_INT	(START1_MOVE || S_INT)
START2_MOVE_INT	(START2_MOVE || S_INT)
STOP_MOVE_INT	(STOP_MOVE || S_INT)
ABORT_MOVE_INT	(ABORT_MOVE || S_INT)

Return Code:

(0) No error.
(–1) Invalid axis number.

Velocity1

Load FH1 register

Declarations:

C:
```
short Velocity1(unsigned short
wAxisNum, unsigned short wVel);
```
BASIC:
```
DECLARE FUNCTION Velocity1%(BYVAL
AxisNum%, BYVAL Vel%)
```
Pascal:
```
function Velocity1(wAxisNum, wVel :
word) : word;
```

Description:

This routine loads the specified slew (high-speed) velocity into register R2. To convert a velocity given in pulses per second into register R2 units, use the following equation:

$$R2 = \frac{(\text{Slew Velocity})(8192)(R7)}{f_{clock}}$$

where: R7 is the value specified for the Multiplier routine.
f_{clock} is the system clock.
The system clock is jumpered to 5 MHz when shipped.

Alternatively, R2 can be thought of as a scaled velocity from 1 to 8191. The actual velocity in pulses per second is equal to the scaled velocity, divided by 8192, times the full-scale velocity.

$$\text{Slew Velocity} = \text{Full Scale Velocity}\left(\frac{R2}{8192}\right)$$

Parameters:

AxisNum Axis number (0 to 17) or the constant ALL_AXES.
Vel Slew velocity in R2 units ranging from 1 to 1FFFh (1 to 8191).

Return Code:

(0) No error.
(–1) Invalid axis number or FH1 velocity register value.

Velocity2

Load FH2 register

Declarations:

C:
```
short Velocity2(unsigned short
wAxisNum, unsigned short wVel);
```
BASIC:
```
DECLARE FUNCTION Velocity2%(BYVAL
AxisNum%, BYVAL Vel%)
```
Pascal:
```
function Velocity2(wAxisNum, wVel :
word) : word;
```

Description:

This routine loads the specified slew (high-speed) velocity into register R3. To convert a velocity given in pulses per second into register R3 units, use the following equation:

$$R3 = \frac{(\text{Slew Velocity})(8192)(R7)}{f_{clock}}$$

where: R7 is the value specified for the Multiplier routine.
f_{clock} is the system clock.
The system clock is jumpered to 5 MHz when shipped.

Alternatively, R3 can be thought of as a scaled velocity from 1 to 8191. The actual velocity in pulses per second is equal to the scaled velocity, divided by 8192, times the full-scale velocity.

$$\text{Slew Velocity} = \text{Full Scale Velocity}\left(\frac{R3}{8192}\right)$$

Parameters:

AxisNum	Axis number (0 to 17) or the constant ALL_AXES.
Vel	Slew velocity in R3 units ranging from 1 to 1FFFh (1 to 8191).

Return Code:

(0)	No error.
(–1)	Invalid axis number or FH2 velocity register value.

WriteReg

Write register

Declarations:

C:
```
short WriteReg(unsigned short wAxisNum
unsigned short wRegister, long lValue);
```
BASIC:
```
DECLARE FUNCTION WriteReg%(BYVAL
AxisNum%, BYVAL Register%, BYVAL
Value&)
```
Pascal:
```
function WriteReg(wAxisNum, wRegister :
word; lValue : longint) : integer;
```

Description:

This routine writes the specified value to the specified register.

Parameters:

AxisNum	Axis number (0 to 17) or the constant ALL_AXES.
Register	Register number (0 to 7) corresponding to R0 to R7, respectively.
Value	Value to write.

Return Code:

(0)	No error.
(–1)	Invalid axis number.

B
Profile Utility

If you have installed the 5000 software on your disk, the profile utility program, PRO5000.EXE is located in the subdirectory in which the software resides.

The Profile program lets you enter physical parameters for a trapezoidal move on any of three axes. The internal register values corresponding to these parameters are calculated and displayed on the screen. A move can then be triggered either on a single axis, or globally on all the axes that are enabled. During the move, the number of pulses left to move, the status register, and the state register are displayed for each axis.

This program is useful for optimizing the multiplier n to obtain the greatest velocity resolution possible. For a complete discussion on optimizing n, see Appendix E of the Model 5000 Technical Reference.

Executing the program

To load the program, type:

```
pro5000 <base address> <color number>
```

The program will not load without the necessary arguments. For example, for a 5000 strapped to a base address of 300h and using color scheme 3, type:

```
pro5000 300 3
```

Base address

The base address is the address to which you strapped the 5000 board jumpers — W7, SW1, and SW2. Appendix C of the Model 5000 Technical Reference contains a map of the entire PC I/O space. The board is shipped strapped to a base address of 300h.

Color number

A number from 0 to 9 configures the screen colors according to table B-1.

Table B-1
PRO5000 color selections

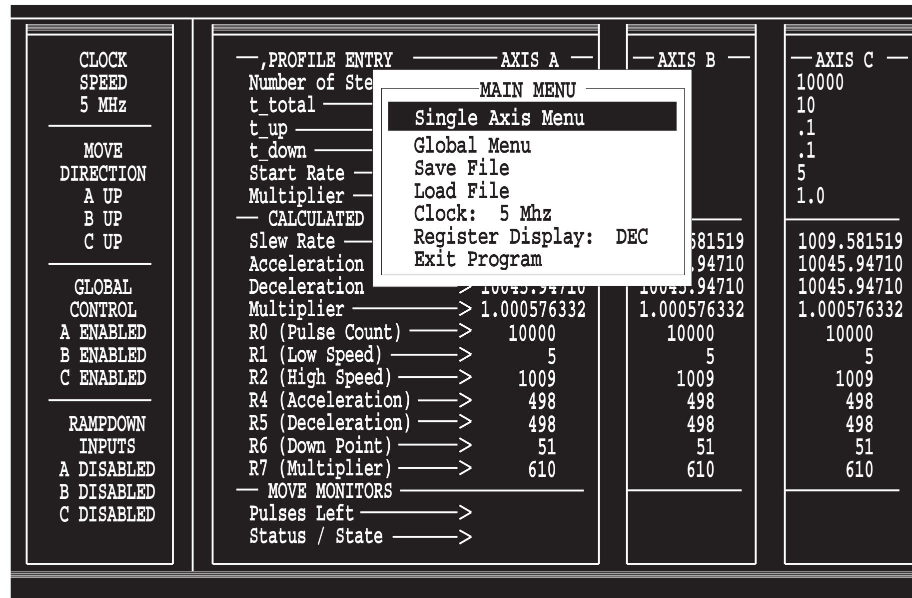
Color number	Text	Highlight	Border
0	Yellow/Black	Red/Black	Brown/Black
1	Yellow/Blue	Black/Gray	Black/Gray
2	Cyan/Blue	Black/Gray	Cyan/Blue
3	Black/Gray	White/Black	White/Red
4	Blue/Cyan	White/Black	Black/Cyan
5	White/Red	Yellow/Black	Lt. Red/Red
6	Yellow/Brown	Green/Black	Red/Brown
7	Black/Green	Yellow/Black	Yellow/Brown
8	White/Magenta	Yellow/Black	Yellow/Gray
9	Gray/Blue	Gray/Black	White/Cyan

Note: The first color listed is the foreground, and the second is the background.

Main menu

After pressing any key to continue, the following screen appears:

Figure B-1
Single axis menu screen



Navigating inside the program

To move between choices, press <Up> or <Down>.

Pressing <Enter> is equivalent to pressing <Down>, except pressing <Enter> after the last field returns the program to the current menu level. Pressing <Ctrl><End> also returns the program to the current menu level.

Pressing <Esc> will abort and exit to the previous level menu, restoring all the previous values.

<Delete> and <Backspace> allow you to edit field contents in the usual manner.

Pressing <Insert> toggles the insertion mode. While insertion is active, the cursor appears as a block.

Monitoring axis configuration

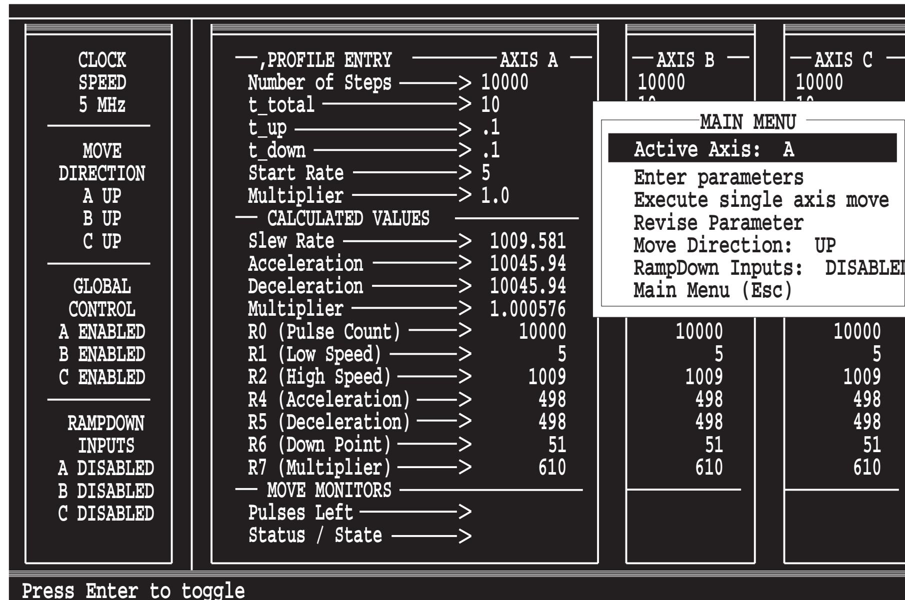
The configuration information window is located on the left-hand side of the screen and displays clock speed, move direction, global control enables, and rampdown input enables.

Information in this window is defined through menu selections defined in the following paragraphs.

Single axis menu

To move up or down in the menu, use the <Up> and <Down> arrows. Exit to Main Menu by pressing <Esc> at any time.

Figure B-2
Active axis: a menu screen



Active Axis

With Active Axis highlighted, make an axis current by pressing <Enter>. Each axis in turn will advance to the PROFILE ENTRY window where you can set up a profile as discussed below. The current axis displays in the menu window.

Enter parameters

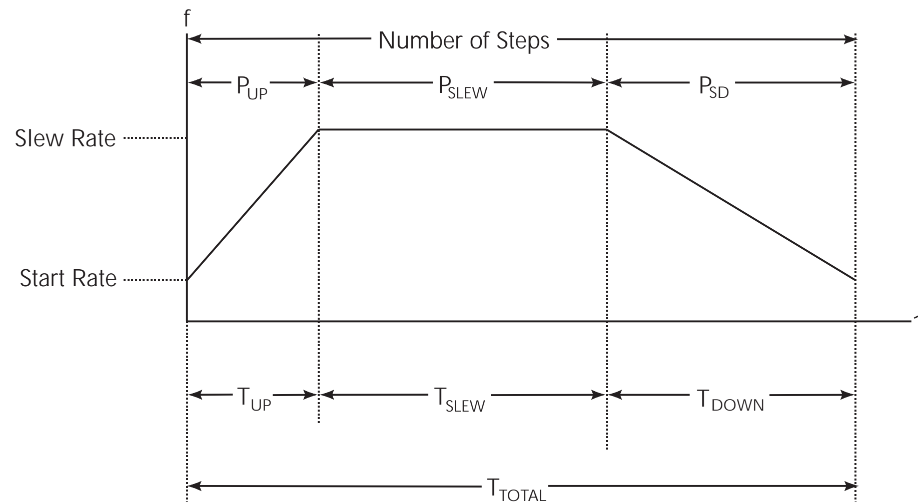
When highlighted, press <Enter> to enter parameters on the current axis. (The figure above shows axis A as current.) Each time you enter a value and press <Enter> or press <Enter> to accept the displayed value, the cursor advances to the next value. You can also use the <Up> and <Down> arrows to selectively enter values. Exit to the Single Axis Menu by pressing <Esc> at any time, or, after entering the Multiplier value, you will exit to the menu automatically.

Generating a profile

Generating a profile consists of entering a set of typically specified parameters. These parameters calculate the remaining variables and register values necessary to create a move. You can generate the same profile on all axes, or you can profile all three axes differently and independently. Move status is displayed in the Move Monitor and axis state and configuration are displayed on the left-hand side of the screen.

Setting the parameters

Figure B-3
Trapezoidal parameters



Number of Steps This is the total number of pulses during the move.

$$\text{Number of Steps} = P_{up} + P_{slew} + P_{sd}$$

t_total This is the total time required for the move.

$$t_total = t_{up} + t_{slew} + t_{down}$$

t_up At the start of the move, this is the time required to ramp up from the start velocity (start rate) to the maximum velocity (slew rate). For the 5000, t_up and t_down can be set independently.

t_down At the end of the move, this is the time required to ramp down from the maximum velocity to the start velocity.

Start Rate This is the velocity in pulses per second from which the stepper motor must start. Stepper motors can not begin a move at zero velocity like servo motors. The start rate is normally specified on the motor and typically ranges from 50 to 500 pulses per second.

Multiplier This is the value of the multiplier constant. The multiplier sets the velocity resolution of the controller. For a complete discussion on optimizing the multiplier, see Appendix E.

Calculating the values

Slew Rate This is the maximum rate in pulses per second during the move. Depending on the acceleration and deceleration, the slew rate may not be attained. In that case, the velocity cusp will be something less than the slew rate, and the profile will take on the characteristic of a triangle.

Acceleration This is the ramp-up acceleration in pulses per second^2. Acceleration is dependent on ramp-up time or distance and the difference between the start rate and the slew rate.

Deceleration This is the ramp-down deceleration in pulses per second^2. Dependencies are similar to that of acceleration.

Multiplier This is the rate multiplier constant. This multiplier is a scaler to maximize the resolution of the controller registers to the maximum velocity of your system.

R0 (Pulse Count) This is the distance value register in units of pulses.

R1 (Low Speed) This is the starting velocity value register that sets the velocity at which the profile will accelerate to the slew velocity.

R2 (High Speed) This is one of two slew velocity registers (FH1). The second register is R3 (FH2). However, PRO5000 uses only R2. Register R3 is designed to allow you to contour complex profiles by preloading a second or the next in series of slew velocities for use on the fly.

R4 (Acceleration) This is the acceleration rate register.

R5 (Deceleration) This is the deceleration rate register.

R6 (Down Point) This is the rampdown point register. The rampdown point determines when the profile will begin decelerating to the start velocity.

R7 (Multiplier) This is the multiplier register. For a frequency of 5 MHz, a multiplier value of 610 represents a multiplier of unity.

Values that are calculated out of range will generate an error in the CALCULATED VALUES area, and executing a move is prevented.

Execute single axis move

When highlighted, press <Enter> to start a move according to the set parameters on the current axis. During the move, monitor status and state in the lower region of the PROFILE ENTRY window.

Pulses Left This is the number of pulses left to move.

Status/State This monitors the move status and state in hexadecimal notation.

Figure B-4
Status buffer

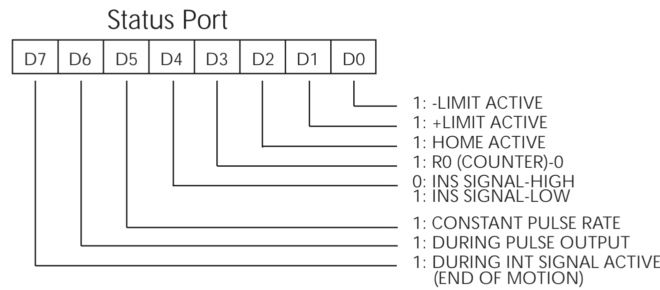
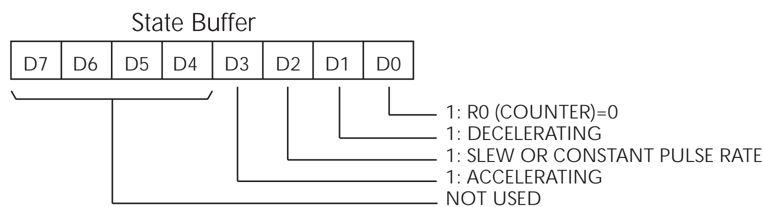


Figure B-5
State buffer



Revise parameters

When highlighted, this option allows you to back-calculate the physical parameters from the register values. Since the physical parameters are calculated in floating point arithmetic and the register values are calculated in integer arithmetic, the register values represent only an approximation based on the resolution set by the multiplier value.

Each time you press <Enter>, the screen will toggle between entered values and back-calculated values.

This feature is useful when optimizing *n* or when analyzing whether a move is possible with the current set of parameters.

Move direction

When highlighted, this option determines which direction to move. Each time you press <Enter>, the direction will toggle between UP and DOWN.

RampDown inputs

When highlighted, this option determines whether rampdown inputs are enabled or disabled. Each time you press <Enter>, the enable will toggle between ENABLED and DISABLED.

When enabled, the rampdown point is determined by external switches mounted on the axis traverse as well as the value loaded into the rampdown register.

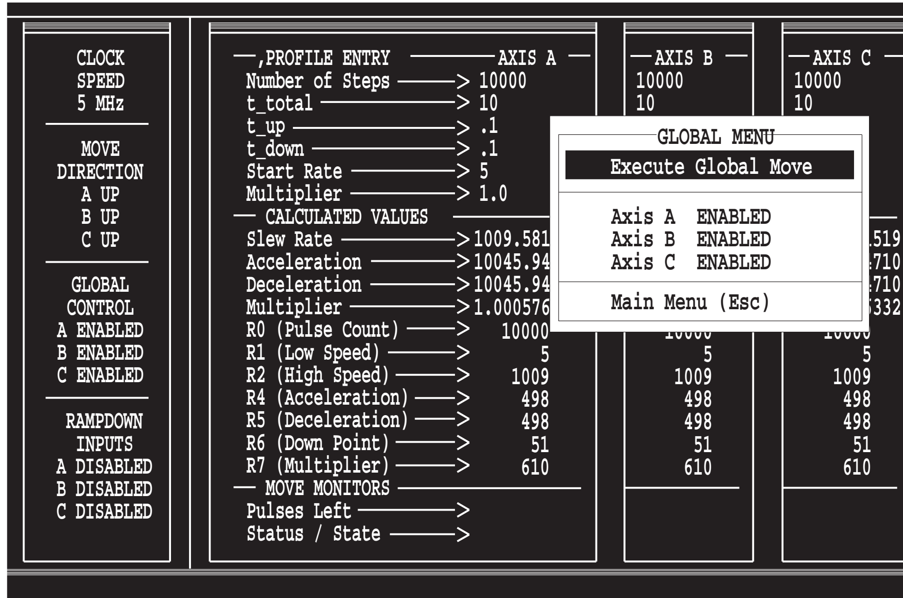
Main menu (esc)

When highlighted, this option returns the program to Main Menu. Alternatively, you can press <Esc> at any time to return.

Global menu

To move up or down in the menu, use the <Up> and <Down> arrows. Exit to Main Menu by pressing <Esc> at any time.

Figure B-6
Execute global move menu screen



Execute global move

This option allows you to enable any combination of axes A, B, and C, and execute a synchronized move. When highlighted, press <Enter> to start a move.

Axis A (B or C)

When highlighted, this option enables or disables an axis for a global move. Each time you press <Enter>, the enable will toggle between ENABLED and DISABLED for the respective axis.

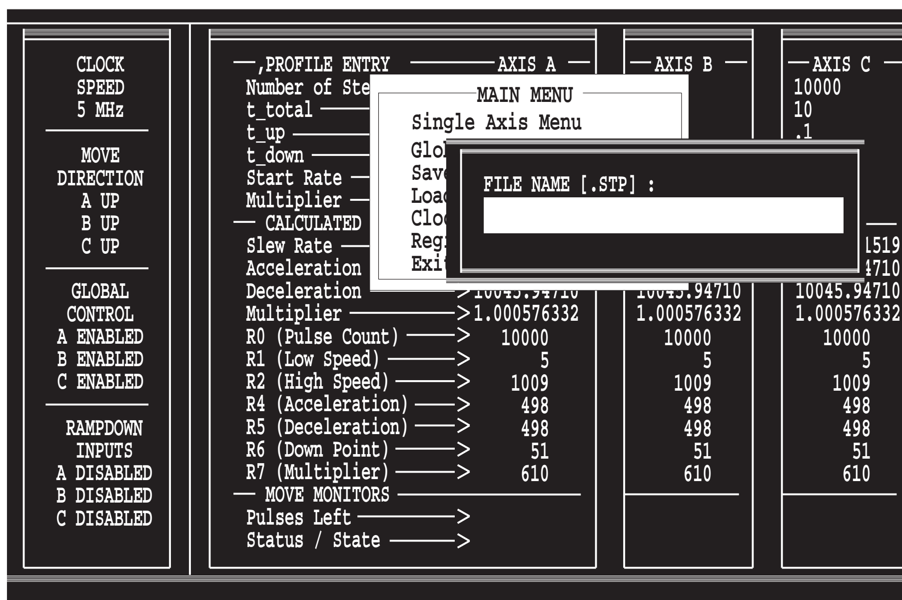
Main menu (esc)

When highlighted, this option returns the program to Main Menu. Alternatively, you can press <Esc> at any time to return.

Save file/load file

Exit without saving/loading by pressing <Esc> at any time.

Figure B-7
Save file/load file



The Save File option allows you to save parameter settings for later use, and the Load File option allows you to retrieve parameter settings previously saved.

By default, files are saved or loaded with the extension [.STP], but you can save or load by specifying the entire file name with extension.

Clock

When highlighted, this option allows you to select a desired clock frequency. Each time you press <Enter>, the clock frequency will change according to the following table.

Table B-2
Selecting a clock speed

Frequency (MHz)
0.625
1.25
2.50
5.00*

* Default setting.
Select the base clock rate used by axes A to C.
Note: To obtain the maximum rate of 240,000 pulses per second, use the default clock setting.

Register display

When highlighted, this option allows you to change the displayed values from hexadecimal to decimal by pressing <Enter>. Each time you press <Enter>, the displayed valued will toggle between HEX and DEC.

Exit program

When highlighted, press <Enter> to exit to a DOS prompt, or press <Esc> at any time. Exiting without first saving will cause you to lose all current parameter settings.

C
Visual C++ Demonstration Program

Product overview

This software product is a 16-bit Windows program written in Visual C++. It is intended to show Visual C++ programming techniques using the Model 5000 driver functions. See the Model 5000 Visual BASIC Profiler for a more comprehensive demonstration of the Model 5000 capabilities.

System requirements

The system requirements are an IBM-compatible PC with either Windows 95 or Windows 3.1, a mouse, and a properly installed, addressed and jumpered 5000 in the backplane. Please review the Model 5000 Technical Reference for board installation issues. Minimum host hardware requirements include two megabytes of RAM and three megabytes of available hard disk space. Of course, these values are well below the minimum for Windows systems anyway.

Installation

This program does not require any formal installation. It can be run from either the diskette or the hard drive. However, we recommend that you install it onto your hard drive simply by copying all files on the diskette onto a discrete hard drive directory. All the files you need to run the program, including the source, make, library and dynamic linking library (DLL) files are included on the diskette.

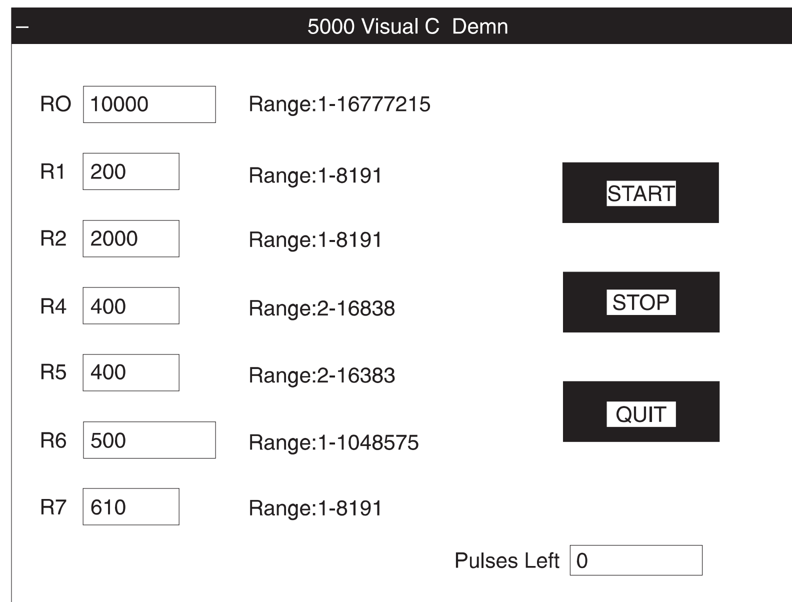
Operation

Launch the demo5kcp.exe program in one of the following ways.

- From Program Manager in Windows 3.1, double click on the icon or pull down File and choose Run, then enter `demo5kcp.exe` in the data field.
- From Windows Explorer in Windows 95, double click on the icon or click on Start, choose Run and enter `demo5kcp.exe` in the data field.

Once you 1aunch the program, the main user window shown in Figure C-1 will appear.

Figure C-1
5000 C++ demonstration program main user window



The demo will default at values that will run most stepper motors. There may be some aspects of your system that could complicate operation. The following can help you with many common configuration problems.

NOTE *The board and program are set up for operation at address 300h which is available on most PC configurations. If another board occupies that address space in your backplane and you don't want to change its address, you will need to alter both the board's hardware and software. Please see Model 5000 Technical Reference for instructions on how to change the address jumpers (SW1 and SW2). To change the board address for the program, you will need to go into the BOARD_ADDRESS macro (in the source code) and set the address to a value that does not conflict with any other board in your backplane and agrees with your jumper settings. Then rebuild the project under your Visual C++ development environment.*

The demo is set to use conservative values that will run most stepper motors. To change a register value, highlight its data field and enter the desired value in place of the previous value. Then either click in another data field or the Start command and the value will be accepted. Pressing **Stop** will abruptly halt the move.

Program architecture

The intent of this program is to show the use of the 5000 driver functions and to keep the code simple. Thus, many desirable features were left out for simplicity sake. The result is a barebones demo. For a more complete demo, please see the 5000 Visual BASIC Profiler.

For simplicity sake, the source file is partitioned into two sections, Section1 and Section2. Section1 derives the application and window classes. To simplify matters, it will not be discussed. Section2 delineates the classes containing the driver functions and will be discussed in detail below.

Class Stepper1 is the base class for the 5000 board application object. (See Source code below.) The only operative function is the constructor. Other data and function members may be added as desired.

In the Stepper1 class constructor, functions InitSw and InitBoard are called upon program startup. These functions can only be called once per program instance so the constructors are the logical place to put them. Functions InitSw, InitBoard and other 5000 routines do return values. Although the return values are not used in this example for simplicity, we recommend that you use them in your application in order to ensure that the functions complete successfully.

In the PushedStart function, driver routines that load the registers are called. Though the sequence in which the functions are called is typical, it is not critical, provided that StartStop is the last function called. Note that the Distance and PointDown functions pass [LONG] values. The PushedStop calls the StartStop function while in the stop mode. Additionally, in the timer function, the pulse count is sampled every 10 ms.

```
//———————— Section 2 ————————

//- A base class for the 5000
    class Stepper1
    {
   public:
        Stepper1();          //-The constructor
   };
//- An instance of the Stepper class.
    Stepper1 Stepper1Inst;
   {
        (void)  InitSw();    //-These functions are called (void)
InitBoard(BOARD_ADDRESS); //-upon startup
   }

   void UserWindow: :PushedStop()
   {
      (void) StartStop (AXIS, S_STOP);  //-Stop the move
   }

   void UserWindow: :PushedStart()
   {
     char temp [30];
      char *stop;

   //- Get data from edit boxes
       GetDlgItemText(hR0, temp, 30);      //- Note conversion
_Pulses = strtol(temp, &stop, 10);  //- from text to long

   StartVel = GetDlgItemInt(hR1);
   Vel1 = GetDlgItemInt (hR2);
   Accel = GetDlgItemInt(hR3);
   Decel = GetDlgItemInt(hR4);

   GetDlgItemText(hR5, temp,  30);     //-Note conversion    Dp =
strol(temp,  &stop, 10);   //-from text to long

   Multi = GetDlgItemInt(hR6);

   //-Load registers
   (void) Distance(AXIS, Pulses);
```

```
(void) Multiplier(AXIS, Mult);
(void) LowVelocity (AXIS,  StartVel);
(void) Velocity1 (AXIS, vel1);
(void) Acceleration(AXIS, Accel);
(void) Deceleration (AXIS, Decel);
(void) DownPoint (AXIS, Dp);
(void) ModeSelect(AXIS, POSMODE_DOWN);
(void) StartStop (AXIS, RESET_MOVE);
(void) StartStop(AXIS, START1_MOVE);    //- Start the move
 }

 //- The timer function
void UserWindow::OnTimer(UNIT id)
{
for(i=0; i<100; i++) s[i] = '\0'; //-Initialize the array
ostream ostr(s,  100);              //-Instantentuate ostr
ostr << PulseLeft (AXIS) ;   //-Redirect pulses out to ostr
SetDlgItemText(hPulses,  s);  //-Display the pulses
}
```

D
Visual BASIC Demonstration Program

User's guide

Product overview

The 5000 Visual BASIC Profiler Utility demonstrates Model 5000's capabilities. The program was developed in Visual BASIC for l6-bit and compatible Windows environments. It runs on a IBM compatible PC equipped with Windows 3.1 or Windows 95 with a Model 5000 stepper card in the backplane. The program enables users to enter values into a plethora of data fields in a convenient graphical user interface (GUI).

Installation

Installation is fairly simple. We assume that you have a properly installed, configured and jumpered 5000 board in your backplane. If you have any doubts about this, please review the Model 5000 Technical Reference for all hardware installation issues. To install the software, follow the common procedure of inserting the disk1 setup diskette into your $3^{1}/_{2}$" floppy drive and running setup.exe. How you do this will depend on whether you work in the Windows 3.1 or Windows 95 environments.

Windows 3.1

In the Program Manager, pull down the File menu and select Run. You will get a dialogue box with one data field. Type a:\setup, or b:\setup and press <enter> or click OK. Windows 3.1 will run the installation procedure. Follow the steps as prompted by this procedure.

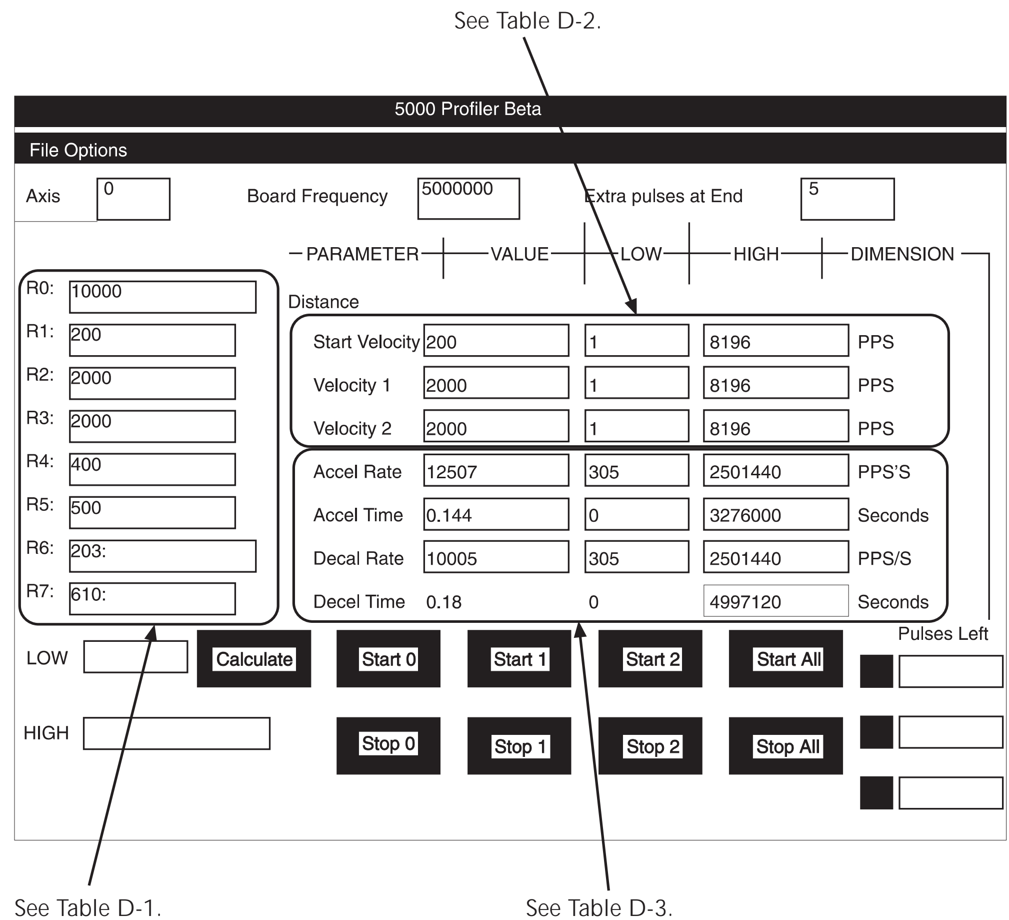
Windows 95

Click on the Start button at the lower left-hand part of your screen. Click on Run. Choose Browse and select Drive A: (or B: where appropriate). Click OK or press <enter> and Windows will run the installation procedure. Follow the steps as prompted by this procedure.

Operation

Double click the Prof1 icon. The main user window shown in Figure D-1 will appear.

Figure D-1
5000 Profiler main user window



On program startup, the demo displays conservative default values that will run almost any stepper motor. The default number of axes is 1. If you have a board with two or three axes, click on the number of axes and change to two or three. To start motion, click START1, START2, START3, or START ALL. The pulses left will be shown on the bottom right of the user window.

NOTE *If you choose a number of axes that is greater than your board allows, you will get an overflow error when you try to start the unsupported axis.*

The demo user window is comprised of two sections. On the left side of the window, registers R0 through R7 are displayed. The user can change the register values by clicking on the desired value. The register limits are displayed on the bottom left of the window in fields LOW and HIGH. It is the user's responsibility to enter values that will produce the desired motion. It is possible to choose values that will not produce motion.

On the right side of the screen, physical parameters may be entered, the limits are displayed on the right side of the screen in the LOW and HIGH data fields. As with the registers, it is possible to choose physical values that will not produce motion. Descriptions of the physical data fields in the main user window follow.

The user window contains data fields, command buttons and menu items. Most of the window's items consist of input or display fields. There are nine command buttons and two menu items. The following is a description of the user window items.

Table D-1
Physical data fields

Data field	Description
R0	This input/display field contains distance information. The value is in pulses.
R1	This input/display field contains a register value that sets the start value.
R2	This is the input/display field that contains a register value that sets the final velocity.
R3	This display field shows the register value and sets the second final velocity. In this version, R3 is set to R2's value as only one final velocity is supported.
R4	This input/display field contains a register value that sets the acceleration rate.
R5	This input/display field contains a register value that sets the deceleration rate.
R6	This input/display field sets the start of the ramp-down point.
R7	This input/display field sets the multiplier register.

Table D-2
Velocity data fields

Data field	Description
LOW and High	This input/display field shows the maximum and minimum start velocities based on register R1 limits.
Start Velocity	This input/display field sets the start velocity. The value displayed is in pulses per second.
Velocity1	This input/display field sets the final velocity of the motor.
Velocity2	This input/display field shows the final velocity of the motor. In this version, Velocity2 is always set to Velocity1.

Table D-3
Accel and decel data fields

Data field	Description
VALUE	Actual user inputted value.
LOW and HIGH	These fields show the upper and lower limits for each parameter.
Accel Rate	This input/display field sets the acceleration rate of the motor.
Accel Time	This display field shows the acceleration time of the motor.
Decel Rate	This input/display field sets the deceleration rate of the motor.
Decel Time	This display field shows the deceleration time of the motor.

Table D-4
Miscellaneous data fields

Data field	Description
LOW and HIGH	These display fields show the acceleration and deceleration time low and high limits.
Low	This display field shows the minimum value of the register field selected for input.
High	This display field shows the maximum value of the register field selected for input.
Axis	This display field shows the current active axis.
Board Frequency	This display field shows the board frequency selected.
Extra Pulses at End	This display field shows the extra pulses at the end of a move.
Pulses Left	This display field shows the pulses left during a move.

Menu items

In addition to the various input and display fields shown in Figure D-1, there are two menu items from which to select at the top of the window. They are described below.

File Pull this menu down to exit.

Options Pull this menu down to change the active axis and to change the board frequency used in calculations.

Developer's guide

This section describes the development process for this product. Since none of the source code is available, this section is for your information only.

Program architecture

The 5000 Profiler Utility is event-driven from either user input or hardware response. The flow diagram in Figure D-2 shows how the central event is an input or command from the user. Figure D-3 shows the text-box value assignments.

Figure D-2
Flow diagram for 5000 Visual BASIC Profiler

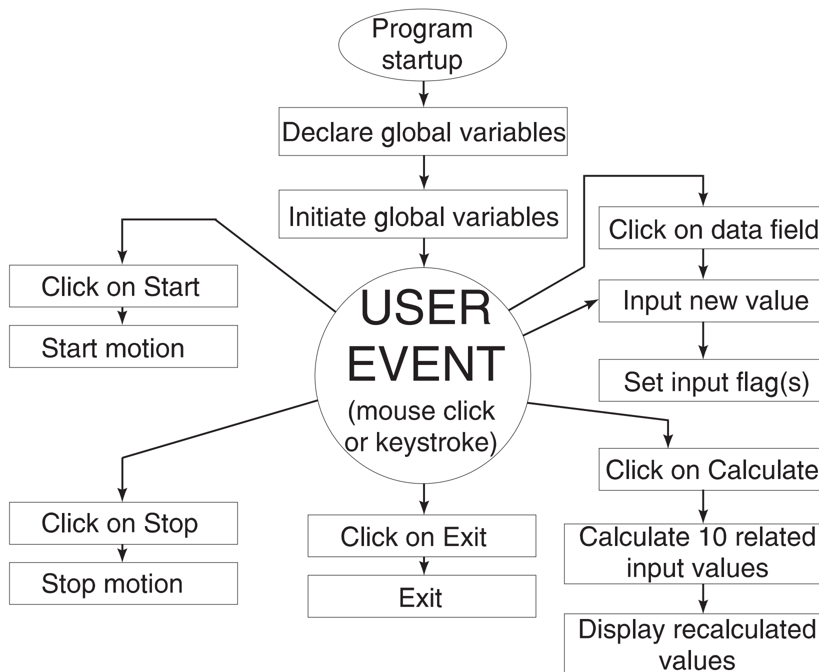


Figure D-3
Text box value assignments for 5000 Profiler main user window

Text35Val Text33Val Text34Val Text41Val
Text0Val
Text1Val Text8Val Text15Val Text22Val
Text2Val Text19Val Text16Val Text23Val
Text3Val Text10Val Text17Val Text24Val
Text4Val Text11Val Text18Val Text25Val
Text5Val Text12Val Text19Val Text26Val
Text6Val Text13Val Text20Val Text27Val
Text7Val Text14Val Text21Val Text28Val
Text36 Val | Calc | Start Cmd | Start1 Cmd | Start2 Cmd | Start3 Cmd
Text37 Val | Stop Cmd | Stop1 Cmd | Stop2 Cmd | Stop3 Cmd
Text38 Val
Text39 Val
Text40 Val

Program organization

The program consists of five code modules and four main form modules. For those unfamiliar with Visual BASIC, code modules are the guts of the program. They instruct the computer and board to perform various functions. Form modules enable users to talk to the code modules in a user-friendly way. They ensure that telling the program to execute certain functions is merely a matter of clicking on command buttons and entering data in fields.

Form module descriptions

PROFSK.FRM is the program's main form module. It contains the three general objects and 72 procedure objects described below. The other three form modules — ADDR.FRM, AXISFR.FRM, and FREQ.FRM — are also described.

Table D-5
Code module descriptions

Library	Module type	Action
5000H.BAS	GENERAL OBJECT, DECLARATION	This code module contains 5000 board register constants, DLL function declarations, and all DLL prototypes.
DECLARE.BAS	GENERAL OBJECT, DECLARATION	This code module contains program constants, user defined types, array variables, and flag variable definitions.
STARTUP.BAS	GENERAL OBJECT, MAIN PROCEDURE	This code module is called on program startup, it calls the INIT subroutine to initialize the array.
INIT.BAS	GENERAL OBJECT, DECLARATION	This code module initializes the array.
CALCDATA.BAS	GENERAL OBJECT, CALCULATE DATA PROCEDURE	This code module performs necessary calculations as a result of user input. It is called by the CALC form object (see form module descriptions).

Table D-6
Form module descriptions

Module	Object	Description
PROFSK.FRM	Declarations	GENERAL OBJECT: This procedure declares Window API functions for use in the program.
	CalculateData	GENERAL OBJECT: This procedure calculates resultant values from a data field input change. It also displays calculated data.
	TextClear	GENERAL OBJECT: This procedure clears data fields prior to new data being displayed.
	Calc	FORM OBJECT: This procedure evaluates which calculations need to be performed according to the priority of active input flags.
	StartCmd	FORM OBJECT: This procedure calls the 5000 board functions and starts motion.
	StopCmd	FORM OBJECT: This procedure calls the 5000 board function and stops motion.
	TextXVal	FORM OBJECTS: These procedures display input and output data on the user window data fields (X is a variable). There are three main procedure types users can follow in these fields. First, KeyPress procedures assign the text box values to its corresponding variable upon an <enter> keystroke. Second, MouseDown clears the text box. Third, LostFocus assigns the text box value to the variable in the event that the user does not press <enter> after selecting a text box.
	LabelX	FORM OBJECTS: These procedures only display labels on the user window.
	MenuX	FORM OBJECTS: These procedures display the menu items on the user window.
ADDR.FRM		This form module contains address selection command buttons which select the desired frequency.
AXISFR.FRM		This form module contains axis selection command buttons which select the active axis.
FREQ.FRM		This form module contains frequency selection command buttons which select the desired frequency.

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Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139

Printed in the U.S.A.