

# User Programming Information

## for users of Standard Pumps with Electronics (AP & APV)

This multiple pump/valve module system is controlled by a customer-supplied host computer via Rs232 serial COM port connection. Up to four pump/valve modules may be operated from one logic module.

Syringe and valve movements may be invoked with simple commands, building complex movements that are executed sequentially by the AP/APV module.

The communications protocol is 9600 baud, 7 data bits, even parity, 1 stop bit (9600-7-E-1).

The serial port DSR (data set ready) line is the ready/busy status line to the host. User-written host software should check the status of this line before sending each command character to the AP/APV.

The AP/APV signals is the host system when the operation is complete, or returns an error code if an invalid condition is encountered. A parity error will cause echo of a \* character.

Each pump module (numbered 0 though 13) has its own set of memory registers that contains its syringe-run parameters.

To set the parameters for a pump, first point to select it by setting the PUMP\_NUM. Subsequent commands and data entries will apply to the selected pump, until PUMP\_NUM (range 0-3) is changed.

Some commands are PUMP\_NUM independent:

- INITIALIZE, which resets all parameters to their defaults and clears any entered syringe movement data.
- CLEAR PUMPS, which resets multiple-pump entries to correct user-entry errors.
- The data entered for a new HOME position is PUMP\_NUM independent (i.e., 24H)

It is necessary to initialize each pump after power-up by first invoking the HOME command, which finds LIMIT, then pulls the syringe back several steps from the LIMIT switch. This will allow the pump to establish its position reference, prevent unexpected limit errors caused by the hysteresis of the limit opto, and preload the syringe piston in the fill direction. The HOME default is 24 steps, but may be changed globally (all pumps) by entering another value preceding the "H" command (i.e., 18H).

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Enhanced syringe movements may improve dispensing consistency by backstepping a small amount at the end of delivery. By making an opposite direction step-entry for the current pump, the syringe will move by the main step entry plus the backsteps, then immediately reverse by the backstep entry. If the backstep entry is large (i.e., >12 steps), the syringe piston will be preloaded in the reverse direction, ready for accurate movement in that direction. See the *Optimizing Pump Performance* page for more detail on liquid-handling techniques.

When syringe movement and data entry commands are given, absolute position of syringe is verified. If total movement is out of available range, an error code is returned.

<b>Completion and Error Codes</b>		
These characters are sent back to the host system of the action, to indicate status.		
NORMAL	.	Operation Complete
NODATAERR	#	Numeric data was expected for this command, none received
NO_FILL_ROOM	>	No room to fill by specified data
NO_DSP_ROOM	<	No room for next delivery
LIMIT_ERR	0-3	Pump_num of unexpected limit
DATA_RANGE	%	Data entry out of range
ALREADY_FULL	=	POS_CNT ≥ MAXFILL
ALREADY_LIM	I	Already at limit
VAL_TIMEOUT	\$	Valve never reached destination
INVALID_CMD	?	Unrecognized command

# AP & APV Command Summary

## Set Pump Parameters

N	SET_PUMPNUM	0 - 3
S	SET_SPEED	1•500 = 10•500 steps/second
D	DISP_ENTRY	1•2000 if none: to LIMIT
F	FILL_ENTRY	1•2000, if none: to LIMIT
Z	SAME_END	Both to end at same time
C	CLEAR	To correct entries

## Special Functions

I	INITIALIZE	Clear all default settings (PUMP_NUM independent)
L	LIMIT	Syringe to limit opto
H	HOME	Syringe to limit, then home to opto preceding data sets new HOME
X	SET_MAX_FILL	502050 steps off limit
[	VALVE_DEL	Valve to delivery time
]	VALVE_RES	Valve to reservoir line
V	VALVE_ENTRY	0=delivery, 1=res, I= move on next GO command

## Move Syringes

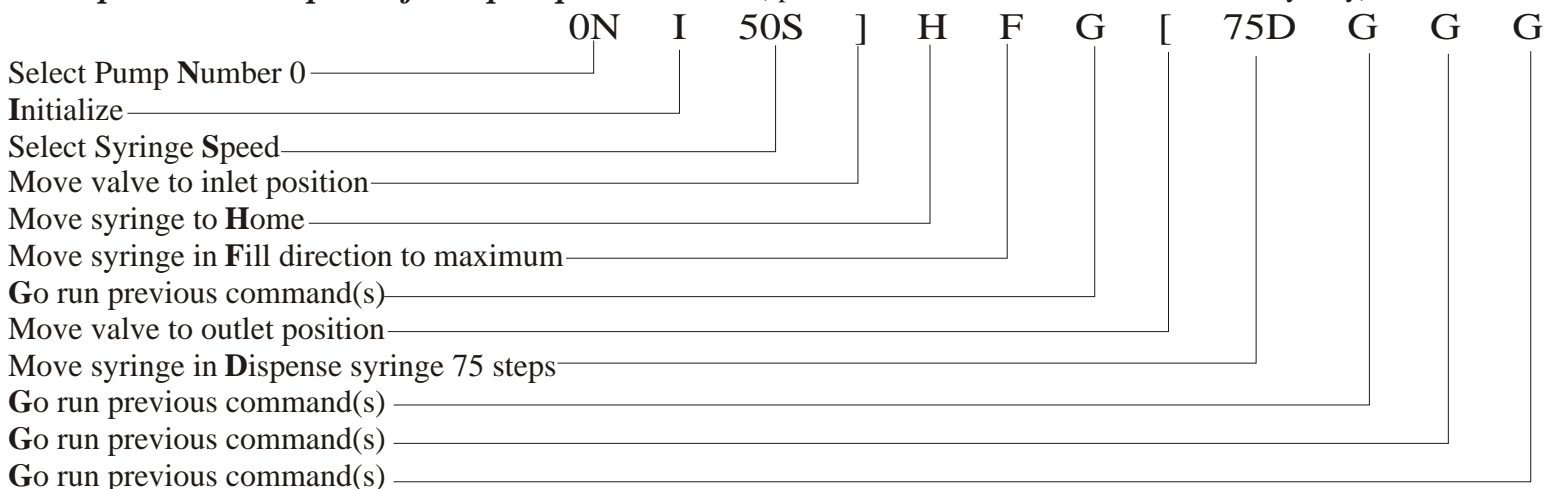
G	GO	Start syringe movement
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## Send Pump Parameters (To create a command sequence)

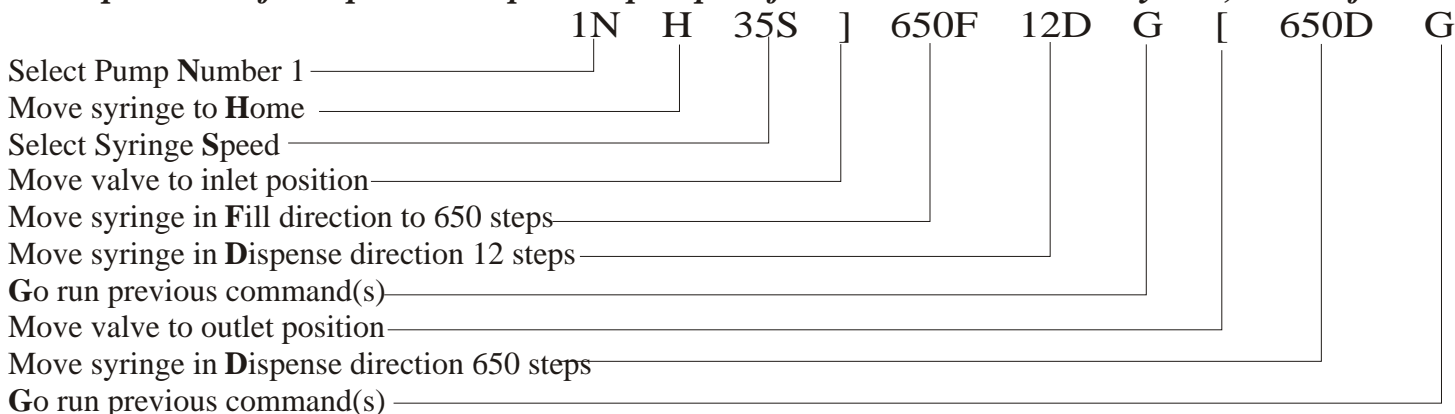
CLEAR (optional)		#V where #=0 for delivery, I for reservoir position. (Simultaneous valve change directions may be mixed)
Set PUMP_NUM	VALVE	8 - WAY VALVE PANEL: Each valve has positions 0-7 The valve is controlled by valve entries 10-17 i.e., Move valve to position 4: 14VG
Make entry	ENTRY	
Repeat for desired pumps ¥¥¥	SPEED ENTRY	#S where #=1¥50 for 10¥500 steps/sec. (Speed entry remains for each pump until changed)
¥¥¥	FILL ENTRY	#F where #=steps in fill direction
	DISP ENTRY	#D where #=steps in dispense direction
¥¥¥	(Valve and syringe entries may be mixed for a single GO command)	[Enhanced (backstep) move - single syringe only]:  #F #D (i.e., 10000F12D fill by 1000 steps and preload syringe piston delivery direction)  #D #F (i.e., 100D4F dispense 100 steps, with 4 backstep to avoid probe tip dripping)
GO command		

# Example Command Strings

**Example: Multi-dispense from pump module #0** (spaces between commands are for readability only)



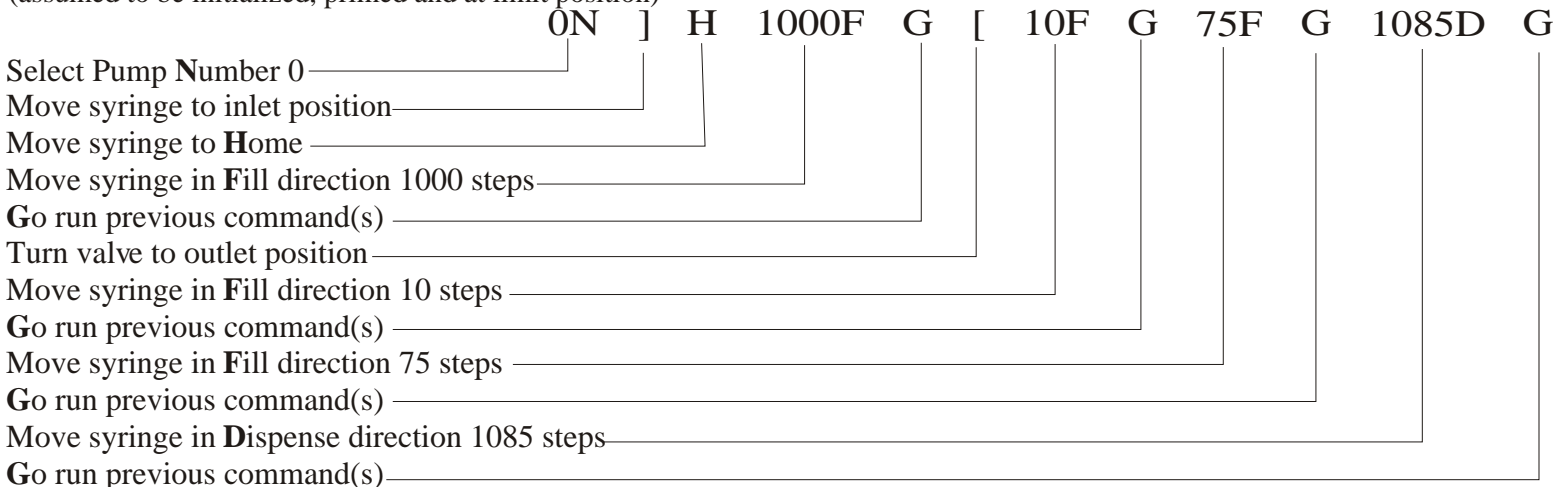
**Example: Transfer Pipet 650 steps with pump #1 from reservoir to delivery line, then refill**



# Example Command Strings (cont.)

**Example: Single syringe dilution, with 10 step gap, 75 step sample, 1000 step diluent.**

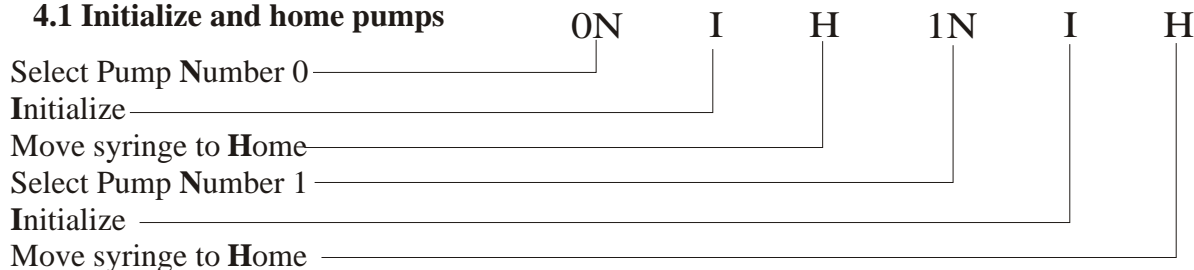
(assumed to be initialized, primed and at limit position)



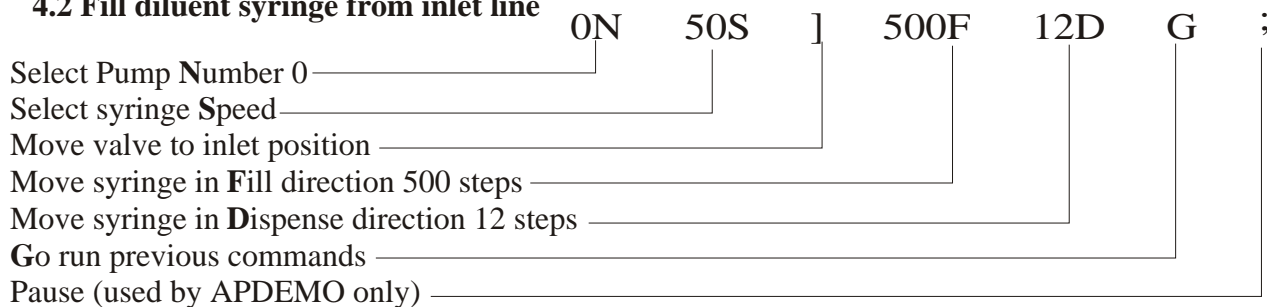
**Example: Two syringe diluter - Pump Number is 0 diluent, Pump Number 1 is sample.**

**Aspirate 500 steps of sample and deliver with 500 steps of diluent with a 20 step airgap between.**

### 4.1 Initialize and home pumps

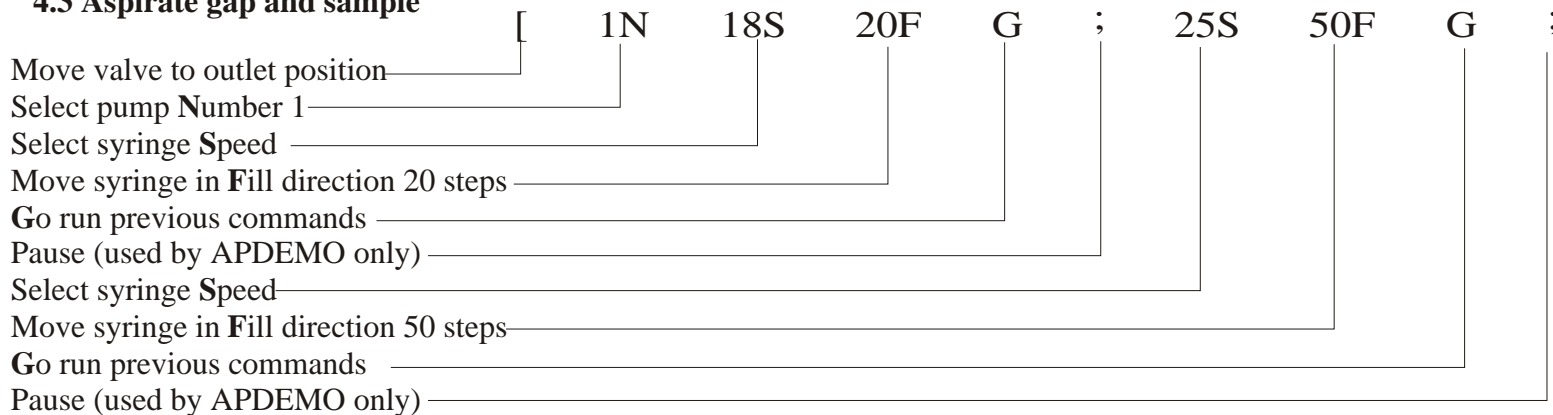


### 4.2 Fill diluent syringe from inlet line

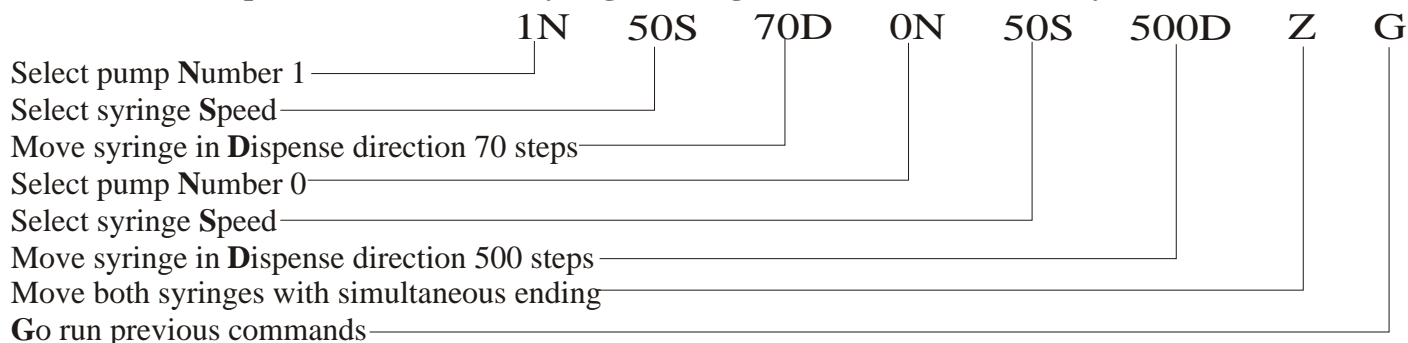


# Example Command Strings (cont.)

## 4.3 Aspirate gap and sample



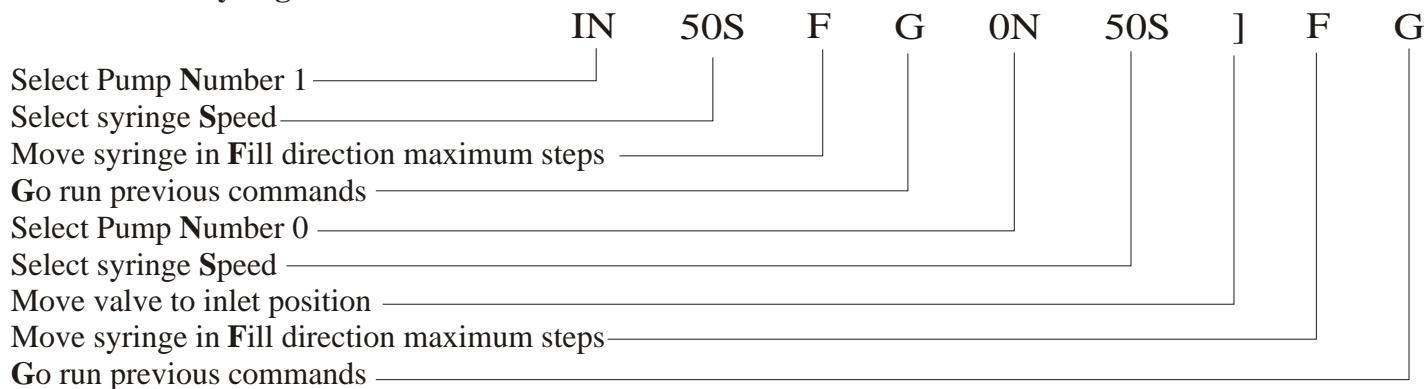
## 4.4 Deliver sample and diluent, with syringes ending movement simultaneously



**Example: Priming a two pump diluter where pump number 0 is a Diluent and pump number 1 is a sample.**

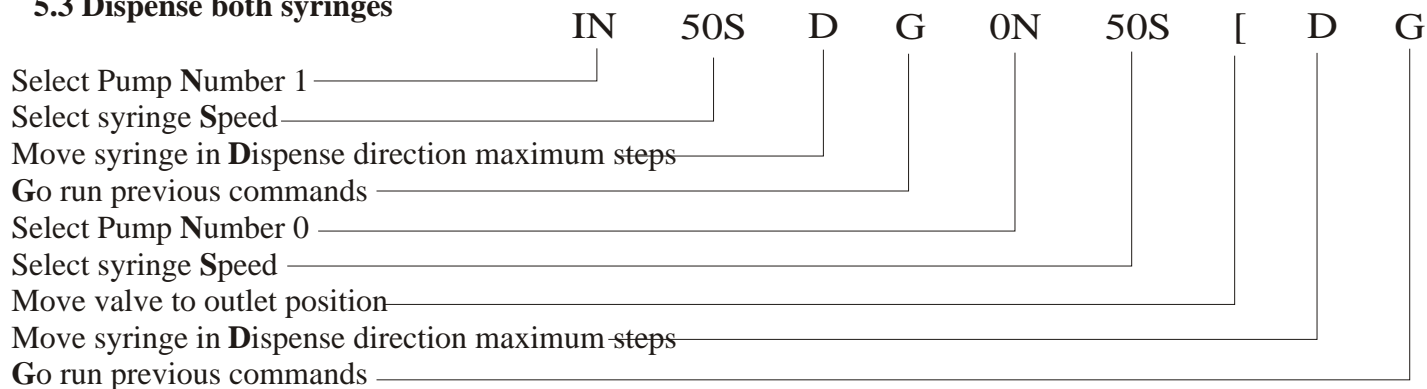
## 5.1 Initialize and home pumps (see example 4.1)

### 5.2 Fill both syringes



# Example Command Strings (cont.)

## 5.3 Dispense both syringes



## 5.4 Repeat steps 5.2 and 5.3 as required.

The basic command sequence to the pump modules is:

1. Set PUMP\_NUM to point to pump
2. Set Speed, if different from last entered speed for this pump
3. Set number of steps for one primary move, followed by “D” or “F” for delivery or fill, respectively
4. Set number of steps for secondary move (backsteps), followed by “F” or “D,” if required
5. Set the “GO” command

**Simple one-syringe movement:** (Fill pump 0 by 1000 steps at 400 steps/sec)

Point to the pump module by setting PUMP\_NUM, enter speed and step data, then GO.

**0N 40S 1000F G**

**Enhanced one-syringe movement:** (Fill pump 1 by 250 steps with 12 backsteps, at 280 steps/sec)

Set PUMP\_NUM, speed, step entry, followed by backstep data, then GO

**1N 28S 250F 12D G**

**Two-syringe movement:** syringes begin movement at the same time, when speeds are equal;

Set PUMP\_NUM, speed, step entry. Set second PUMP\_NUM, speed, step entry, then GO.

(Dispense 500 steps from pump 0 at 500 steps/sec., while dispensing 375 steps from pump 1 at 500 steps/sec.)

**0N 50S 500D 1N 50S 375D G**

**Two-syringe movement:** syringes begin movement at the same time, when speeds are equal;

Send “Z” commands one time before the GO command.

(Dispense 650 steps from pump 0, while dispensing 400 steps from pump 1)

**0N 50S 650D 1N 50S 400D Z G**

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# Programming Notes

## 1. Enhanced Syringe Movements

- a. Syringe movements that include both primary and secondary (backstep) move entries are single-syringe moves.
- b. Maximum backstep entries are 99
- c. The primary move steps are the net movement to the syringe. The syringe will move by the primary step entry, plus the backsteps, then reverse by the backsteps.
- d. Backsteps are re-executed at the same speed as the primary move. At speed settings, you may wish to have the backsteps at a lower step rate. Send the command “B” to invoke this option (backsteps at fixed 200Hz rate).

## 2. Repeat Movements

- a. The G command, entered without entering pump step or direction data, will repeat the last syringe movement except for moves which used Z command or ganged moves.

## 3. GANG Syringe Movements

- a. If step entries are made for more than two pumps before a G command is sent, the GANG MOVE mode is automatically invoked.
- b. All pumps for which entries were made will move the same, based upon the speed, direction and number of steps of the first pump entry since the last syringe, or Clear Pumps or Initialization commands.
- c. Since ganged syringe moves are exactly the same for all active pumps, it is recommended that a synchronizing move be embedded in the commands (i.e., start by moving all syringes to the limit, then do a ganged move to home).
- d. Gang moves to limit are permitted: “D” entries with no preceding steps will move specified pumps to limit.

## 4. Multiple Valve Changes

- a. Set PUMP\_NUM, then enter 0V for delivery position, or 1V for reservoir position. Repeat for each simultaneous valve change desired. Then send a GO command for simultaneous valve changes.
- b. Immediate valve changes are accomplished with the “[” for delivery position, or “]” for reservoir position, for the current PUMP\_NUM.

# Communication Sequence

For those writing their own software, check that the sequence matches this list.

## The order of events is:

1. Host software checks that the hardware /DSR line is ready.
2. Host software sends a character.
3. Logic board echoes same character back to host.
4. Logic board changes /DSR to “busy.”
5. Command is acted upon.
6. Logic board sends completion code to host (normally a period, unless an invalid entry was made).
7. Logic board changes /DSR to “ready.”

# Detailed Command Description

B	SLOW_BACKST	Causes backsteps to run at a fixed 200-steps/sec rate, instead of the same rate as the primary move.	Slow backsteps: 1B Normal backsteps (default): 0B
C	CLR_PUMPS	Removes all pump modules from the list of multiple pumps to move by the “G” command.	
D	DISP_ENTRY	Enters the number of steps for forward syringe movement. When this command is used without preceding data, the current pump will deliver to the limit opto	Dispense 30 steps with pump 0 0N30DG Dispense 200 steps with 4 backsteps: 200D4FG
E	EMPTY	Empties the delivery line, syringe and reservoir line back to the reservoir. Includes the valve changes and continues for the number of cycles that precede this command. Fill and deliver strokes are based on MAX_FILL and limit.	Empty, cycling 3 times: 3E
F	FILL_ENTRY	Enters the number of steps for fill movement. When this command is used without preceding data, the current pump will fill to the maximum steps off limit.	Fill pump 1 by 250 steps 1N250FG Fill by 1000 steps with 12 backsteps: 1000F12DG
G	GO	Triggers movement of syringes or valves for which data has been entered.	
H	HOME	Moves syringe to the limit opto sensor, then back from the limit opto by a specified number of steps. A user entered home position can be defined by preceding this command with data in the range of 0-2000 steps. The default from initialization is 24 steps.	Set home to 10 steps off limit then go to home position: 10HH
I	INITIALIZE	Resets all parameters to their default values and clears all volume data entries.	Initialize, pump 1 valve to reservoir; go to limit: I 1N]L
L	LIMIT	Moves the current pump’s syringe to the limit opto	
N	SET_PUMPNUM	Sets the current pump module for subsequent data entry or action commands. Set this first, then execute all other commands. Pump modules are numbered 0-3 for each logic board and this number corresponds to the jumper position on the pump circuit board. Initialization leaves PUMP_NUM at 0.	
P	PRIME	Fills the syringe and lines from the reservoir to the delivery probe. Includes valve changes and continues for the number of cycles that precede this command.	Prime pump 2 with 4 cycles: 2N 4P
R	RAMP_UP	Sets the number of steps for the acceleration ramp of a syringe movement. Default is 5: maximum is 25.	

# Detailed Command Description

S	SPEED_ENTRY	Sets the speed for the current pump to 10-500 steps per second. Data entry range is 1-50.	Aspirate a 50-step sample at 120 steps/sec: 12S 50F G
V	VALVE_ENTRY	Sets the position for multiple/simultaneous valve changes upon next GO command.	Change valves 0 & 1 to reservoir, & valve 3 to delivery pos: 0N1V1N1V 3N0V G
W	RAMP_DOWN	Sets the number of steps for the deceleration ramp of a syringe movement. Default is 0 and max. is 10	
X	SET_MAX_FILL	Sets the maximum steps off limit. The default is 2039 steps, allowing space for 12-step dispense movement to reload in dispense direction and leaving 2000 steps left to home position 24 steps off limit.	Set pump 1 to a 1000 step max fill limit: 1N 1000X
Z	SAME_END	Causes next GO command of two syringes to run so that both syringes end their runs at the same time.	Fill pump 0 by 250 steps and pump 1 by 700 steps, both ending at same time 0N250F1N700FZG
[	VALVE_DEL	Changes the valve for the currently selected pump to the delivery position.	
]	VALVE_RES	Changes the valve for the currently selected pump to the reservoir position.	

# APEDIT - Text Editor

## Features

APEDIT.com is an easy-to-use full-screen text editor for files up to 64K in length. It supports scroll, cut, copy, paste and print operations, and is excellent for creating and editing AP/APV command files for use with APCMND.EXE or APDEMO.EXE.

## Opening a File

APEDIT (filespec) <RETURN> If the file exists, the file is opened for editing.  
 If the file does not exist, the file will be created and opened for editing.  
 (Filespec) is a valid DOS file name such as MYFILE.APP  
 (8 characters, 3 characters, no spaces or punctuation)

## Commands

F1	QUIT	Abandons all changes made and ends APEDIT
F2	UNDO	Restores characters deleted by the <DELETE> key, if cursor has not moved
F3	PRINT	Prints text that has been marked
F4	MARK	Marks block of text. Press F4 to turn mark on.
F5	CUT	Removes marked text and stores it in a buffer
F6	PASTE	Inserts the last block of text that was cut at the current cursor position
F7	EXIT	Saves the current text and ends APEDIT
F8	DEL EOL	Deletes from cursor position to end of the line
F9	DEL L	Deletes entire line
F10	UDEL L	Restores the last deletion done with F8 or F9
HOME	HOME	Moves cursor to beginning of current line
END	END	Moves cursor to end of current line
PG UP	SCROLL UP	Moves cursor up on screen minus five lines of text
PG DN	SCROLL DOWN	Moves cursor down one screen minus five lines of text
CTRL PGUP	TOP	Moves cursor to top of file
CTRL PGDN	BOTTOM	Moves cursor to the bottom of file.

# MS-DOS Demo Software

**Two programs are available to support your evaluation of the AP/APV systems. They require a PC-compatible computer with one COM port (1 or 2).**

1. **APDEMO.EXE** is a menu-based program that will permit you to manually operate the pumps and valves. The program provides an easy and immediate way to work with the AP/APV at various levels of complexity.
  - 1.1 Preprogrammed selections of various operating modes are provided, such as DISPENSE, PIPET, 1-syringe DILUTE, 2-syringe DILUTE and DUAL DISPENSE.
  - 1.2 The programmer's screen permits you to send immediate commands to the AP/APV, from this document or from the on-screen command summary, and view the completion codes as they are returned from the AP/APV systems.
  - 1.3 The sequence screen provides a place to enter complex strings of commands, including user-specified the AP/APV repeatedly. The sequence screen menu will allow you to save and reload ASCII text command files from a disk.
  - 1.4 To use APDEMO, either run directly from the floppy disk, or copy to your hard drive.
  - 1.5 On the command line, type: **APDEMO <com port#>**
  
2. **APCMND.EXE** is a DOS command-line program that will send strings of commands to the AP/APV from an ASCII text file.
  - 2.1 Use your text editor to create a file containing the sequence of commands you wish to send to the pumps. Be sure that the file is plain ASCII (non-document mode), and that the commands are upper case characters. Carriage returns and tabs are ignored, so the file may be broken into blocks for clarity.
  - 2.2 A semicolon ";" will pause, prompting you for a keystroke.
  - 2.3 A looping instruction permits you to send a portion of the command string to the AP/APV repeatedly (N times, or continuously). This permits you to send an initialization string, followed by a repeating action string. Insert the characters @N\* immediately preceding the commands to be repeated, where N = number of times to repeat and\* = asterisk. You may omit the N value for infinite looping. If you wish the entire file to be resent continuously, place an @ character at the end. Example command files (with an AP extension) are on the demo disk.
  - 2.4 To use APCMND, either run directly from the floppy disk in drive A or copy to your hard drive.
  - 2.5 On the command line type: **APCMND <com port#> <filespec>**

# MS-DOS Demo Software (cont.)

## Full Stroke Use of Pump #1 in APDEMO

The Dual Pump Evaluation system (two pumps with RS-232 logic, power supply and serial interface cable) is commonly used to explore diluter applications with a half-stroke syringe installed in the PUMP\_NUM =1 position (50mL/250mL/syringes).

To avoid accidentally sending full-stroke commands to pump #1 of this combination, the APDEMO program automatically sends a command string to limit the maximum stroke of pump #1 to 1039 steps from the limit sensor. This is done upon entering the Programmer's screen or the Sequence screen.

For applications using 2000-step syringes, this default must be overridden when using these screens of APDEMO program. This may be done by either if the following:

Once in the Sequence of Programmer's screen:

Send the command "I," which will initialize the AP/APV (it internal default for maximum fill steps from limit for all syringes is 2039 steps).

**-OR-**

Send the command string "1N2039X", which will set the maximum fill steps from limit to pump #1 only.