Digital VCM Driver for Pick and Place

Model: VCP-03

Version: 1.1 2009-11-25

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Features of version 3.0：

- Several new features and functions as compared to version 2 are described as follows:

  1. Half size as compared to version 2.

  2. 4 programmable positions can be controlled through 2 external digital inputs to perform point-to-point movement.

  3. Built-in motion profile generator is provided for point-to-point movement to eliminate the use of expensive PC-based motion control card.

  4. Two more alarm sources, emergency stop and position command over range, are provided in addition to the original alarm sources of version 2.

  5. Upon alarm, the driver will park the motor to upper limit before the power stage is servo off in order to prevent the VCM from unwanted drop.

  6. Dedicated analog input can be used to control the force profile after contact.

1. Features：

- **Built-in intelligent soft-landing operation:** There are two modes of soft-landing operation, namely direct mode and segmented mode, for different applications. The searching speed and the contact force can be pre-programmed through serial communication interface. As a result, the complex soft-landing operation can be achieved by just 2 external I/O's without master PC intervention in which an external digital input (BOND) triggers the operation and an external digital output (DO0) detects the completion of contact.
- **Flexible interface for position command input**： This driver has two input sources for position command, namely pulse/dir differential interface and digital I/O interface.
- **High performance servo control loop**： The drive implements various

parameters including the gravity and the friction compensations for servo control loop to achieve high performance of motion.

- **Complete status monitoring**： Two 16-bit registers are used to record the complete drive status. These 2 registers are updated per servo-loop cycle and can be read out thru serial communication interface.
- **Serial communication**：Both RS232 and RS485 are implemented in this drive for easy application.
- **Robust anti-noise performance**：All digital I/O's including serial communication interface and Pulse/Dir differential interface are isolated by using phoptocouplers.
- **Absolute position encoder**：Absolute position encoder is employed for this drive. Consequently, it is not necessary to perform home searching after power on.
- **Shared digital Input/output functions**： To decrease the number of wires, the digital inputs and outputs may have different functions or meanings with respect to different operation mode. For example, the SVON input can servo on the motor and do alarm clear simultaneously. The digital output DO0 may represents contact complete in soft-landing operation, or higher than mechanical-safe threshold position in position mode.
- **PC-based Tuning console**：The Digital VCM Driver Motion Console 3.0 implements a software oscilloscope to inspect the detailed motion profile for easy servo tuning. You can download it from our website www.magtronics.com.tw.

2. Electrical specification：

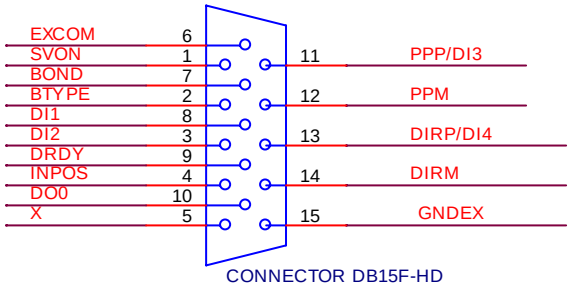
Items	Specification	Unit
Main supply voltage	12~24	V
Maximal output current	1	A/ channel
Continuous output current	0.2	A/ channel
Operating temperature	0～70	℃
Humidity range	20～90	%
Supply voltage for isolated external I/O	12~24	V
Maximal sink current of external I/O	20	mA
Voltage of Pulse/Dir differential interface	5	V
Maximal Freq of Pulse/Dir interface	10	MHz(max)

3. Specification of servo control loop:

Items	Specification	Unit
Position loop update frequency	5	kHz
Velocity loop update frequency	5	kHz
Bandwidth of current loop	100	kHz
Special functions	Gravity compensation[KGC] Static/Dynamic Friction compensation [KFS][KFD]	

4. Definition of connector pins and LED display：

a. Digital Input/Output connector (JP3)



DSUB-15 high density female

EXCOM: external power supply (12~24V)

GNDEX: external power ground

SVON: servo on/off and alarm clear

BOND: soft-landing operation trigger input

BTYPE: soft-landing mode selection input

DI1: position selection (bit 1)

DI2: position selection (bit 2)

PPP/DI3: positive differential pulse input

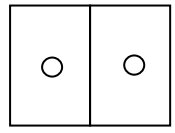
PPM: negative differential pulse input

DIRP/DI4: positive differential direction input

DIRM: negative differential direction input

X: should not be connected

b. Emergency stop connector (JP2)

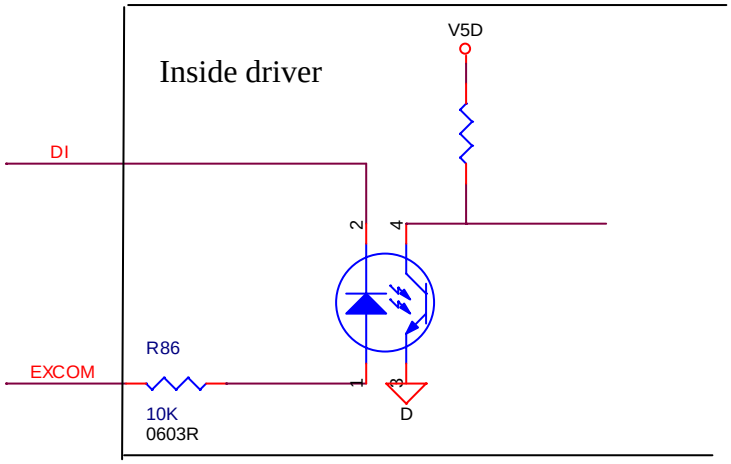


GNDEX EMS

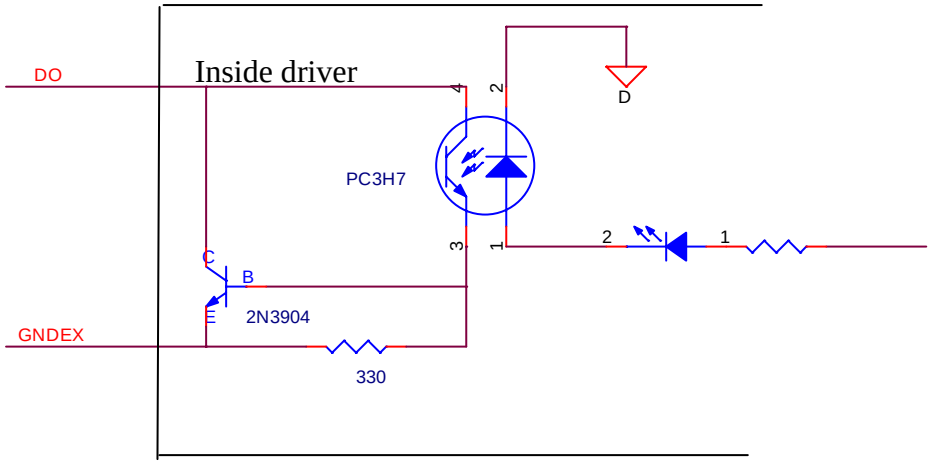
2 pin 3.5 mm pitch screw terminal

c. Circuit inside driver

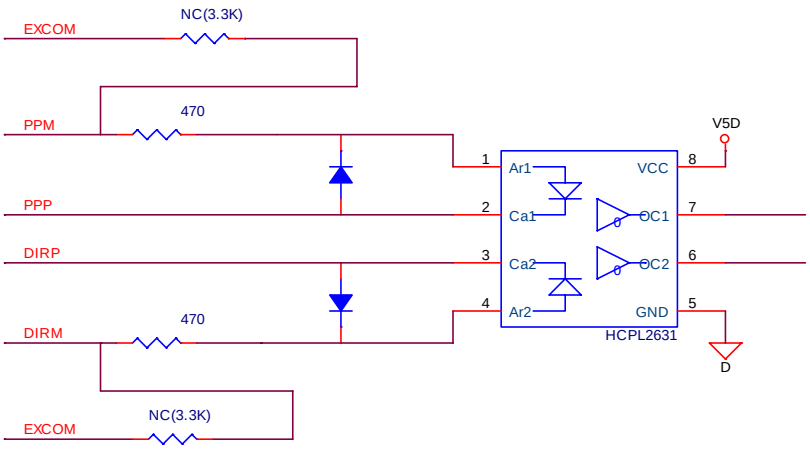
Digital input circuit



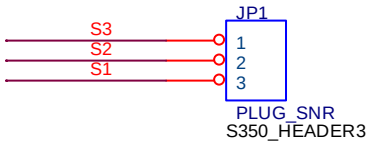
Digital output circuit



Differential Pulse/Dir input circuit

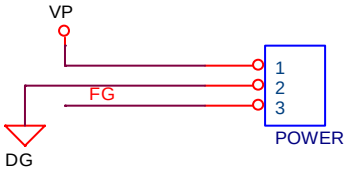


d. Sensor input connector (JP1)



3 pin 3.5 mm pitch screw terminal

e. Power input connector (JP5)



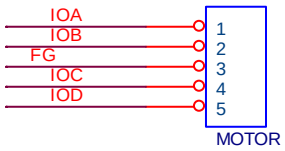
3 pin 3.5 mm pitch screw terminal

VP: Drive Main power supply (12~24V)

DG: Drive Main power ground

FG: Frame ground

f. Motor wire connector (JP4)



5 pin 3.5 mm pitch screw terminal

IOA: Motor wire A

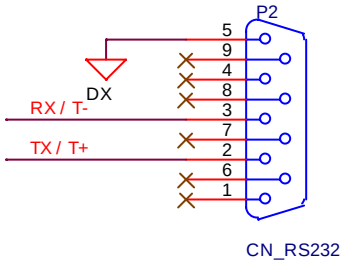
IOB: Motor wire B

FG: Frame ground

IOC: Motor wire C

IOD: Motor wire D

g. Serial interface connector (RS232/RS485) (JP6)



DSUB-9 female

TX/T+:	RS232 Tx pin or RS485 positive
RX/T- :	RS232 Rx pin or RS485 negative
DX:	RS232 ground

h. LED display

LP1: MCU status LED

slow blinking: MCU normal and servo off

fast blinking: MCU normal and servo on

no blinking: MCU fail

LP2: Motor power stage status LED

on: servo on and no alarm

off: servo off or alarm

LP3: Main power status

on : power supply normal

off: no power input

5. Theory of operation

This drive is designed to control voice coil motor for pick and place application. Four major topics are described in detail in the following sections.

1. **Soft-landing operation**

   Soft-landing operation plays an important role in pick-and-place application. This drive implements two modes of soft-landing operation, both of which can be controlled by handshaking just 2 wires.

   Segmented mode: (BTYPE open from GNDEX)

   i. The motor is brought from a upper position to a position somewhat higher than the target in position mode.

   ii. Short the BOND to GNDEX will trigger the soft-landing operation. The drive enters velocity mode immediately to drive the motor at a constant searching speed VSV toward the target.

   iii. Upon contact, the drive enters current mode immediately and applies a constant contact force VCF on the target. At the same time, the DO0 output will be short to GNDEX to inform the master that the contact is completed.

   iv. After a period of time determined by the master, the soft-landing operation can be terminated by opening BOND from GNDEX. The drive goes back to position mode and brings the motor to the position where soft-landing starts.

   v. The drive then moves the motor to the upper position in position mode to complete a cycle.

   Note that this drive does not have a real-time position feedback path to the master, however, an INPOS digital output is provided so that the master can monitor this signal in real time to verify whether the motor is within a range VIP with respect to position command.

Direct mode: (BTYPE short to GNDEX)

i. The motor stops at the upper position in position mode.

ii. Short BOND to GNDEX to notify the drive that the following movement is a soft-landing operation.

iii. Changing the position command to a position somewhat lower than the target so that the contact is guarantied. The motor moves toward the target.

iv. When the motor pass through the start-search threshold position HTx, the drive actually limits the current to provide a constant contact force VCF. Upon contact, the DO0 output will be short to GNDEX to inform the master that the contact is completed.

v. After a period of time determined by the master, the soft-landing operation can be terminated by sending the position command of upper position. The drive goes back to position mode without current limit if the position is higher than the start-searching threshold position. The motor finally stops at the upper position and complete a cycle.

Note that the speed should be considerably low when the motor approaching the target, otherwise, the impact force due to high landing speed may destroy the target.

2. **Motion profile generator**

This drive implements an internal motion profile generator for the movement controlled by external digital inputs. The maximal speed of the movement is determined according to the value of VI2, while the acceleration is determined by the smooth factor VAC. See Fig. 1 for the motion profile with respect to different VAC settings.

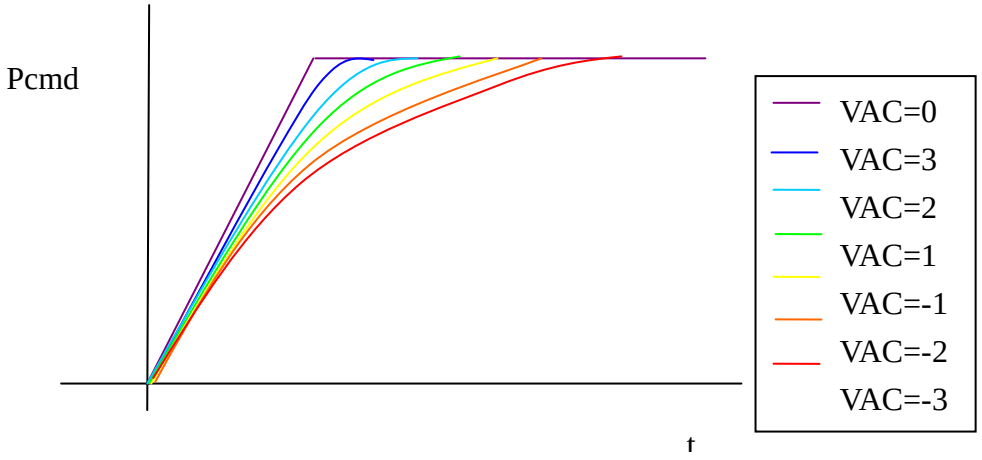


Fig. 1 Pcmd profile with different VAC setting.

3. **Mechanical-safe threshold position (VT1)**

When the VCM is carried by another axis, in order to increase the UPH, it is common to start the movement of another axis if the motor is higher than a so called mechanical-safe threshold position. Since this drive does not provide the real-time position feedback to the master, this drive uses a register VT1 to store the value of mechanical-safe threshold position and a digital output DO0 to indicate whether the motor position is higher than the mechanical-safe threshold position. As aforementioned, this digital output DO0 also represents the contact status. Note that the motor position higher than mechanical-safe threshold position under position mode and the contact complete under soft-landing operation will not happen simultaneously. Consequently, we can use one digital output to represents these two conditions. Please see Figure 2 for detailed DO0 logic.

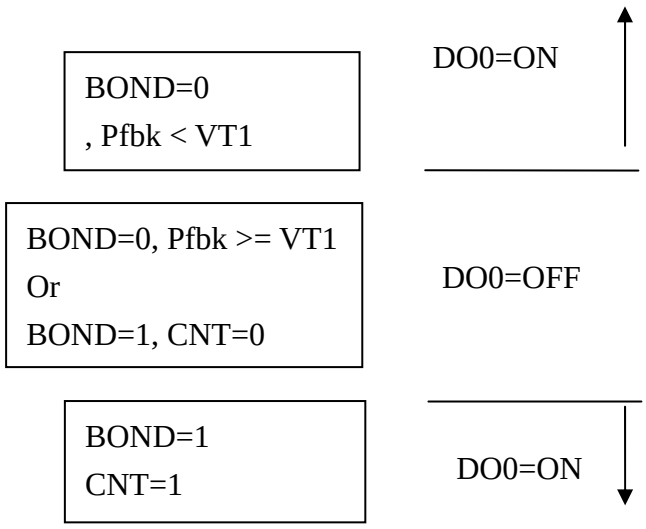


Fig. 2 Description of DO0 logic

4. Control block diagram

The block diagram of the servo control loop is depicted in Figure 3. The meaning of the control parameters and the state variables can be found in chapter 9 and 10, respectively.

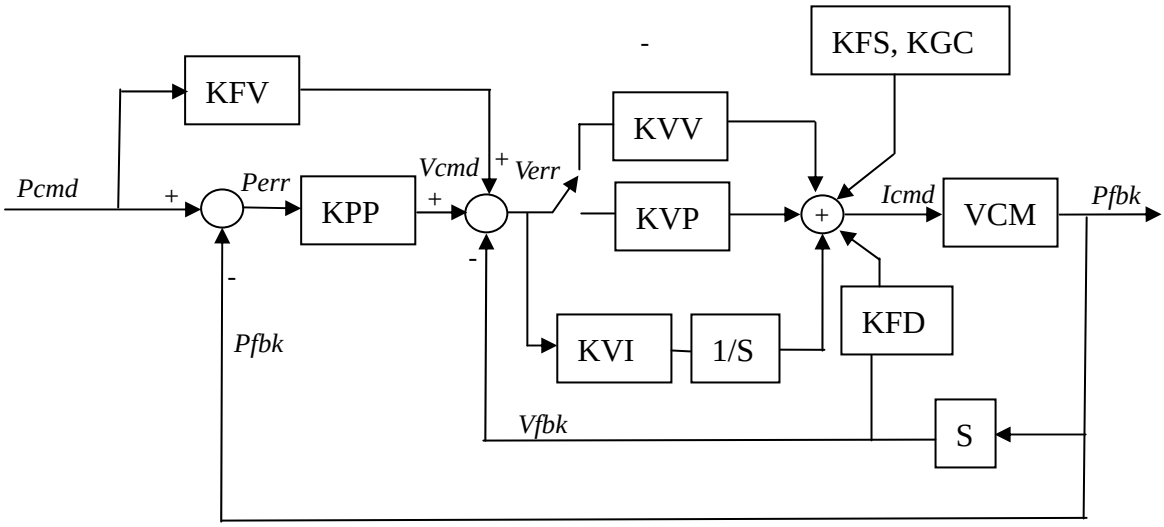


Fig. 3 Control block diagram

6. External digital input functions：

8 external digital inputs are implemented in this driver. The status of these input pins can be read from the internal status register [ST1]. See the following description for details.

SVON	This input is used to [servo on/off] the motor or do [alarm clear] Short to GNDEX: Servo ON (level triggered) Open from GNDEX: Servo OFF (level triggered) From open to short to GNDEX: Alarm clear (edge triggered).
BOND	This input is used to trigger the soft-landing operation. Short to GNDEX: start soft-landing operation till contact complete. Open from GNDEX: return from soft-landing operation to position mode.
BTYPE	This input is used to select soft-landing modes Short to GNDEX: Direct mode is selected Open from GNDEX: Segmented mode is selected.
DI1	This input is the first bit for position selection(bit 1) Short to GNDEX: set bit.(bit 1=1) Open from GNDEX: clear bit. (bit 1=0)
DI2	This input is the second bit for position selection(bit 2) Short to GNDEX: set bit.(bit 2=1) Open from GNDEX: clear bit. (bit 2=0)
PPP/ PPM	1. Differential pulse input (PPP: positive pulse input、PPM:

	negative pulse input)
DIRP/ DIRM	1. Differential direction input (DIRP: direction positive input 、 DIRM: direction negative input)
EMS	Emergency Stop input (locate at JP2) Short to GNDEX: Normal operation (This input must short to ground for normal operation. Open from GNDEX: Emergency stop

7. External digital output functions：

There are 3 digital outputs implemented in this driver. The detailed description is shown below.

DRDY	Shows servo on/off or alarm status Short to GNDEX: Servo ON **AND** no alarm Open from GNDEX: Servo off **OR** alarm
INPOS	Shows in-position status Short to GNDEX: Perr <= +/-【VIP】 Open from GNDEX: Perr > +/-【VIP】
DO0	Shows contact status under soft-landing operation or position status with respect to the mechanical-safe threshold. See Fig. 2 for details. Short to GNDEX: Contact complete under soft-landing operation, or Pbk<VT1 (Safe) under position mode. Open from GNDEX: Not contact under soft-landing operation or Pbk>=VT1 (not Safe) under position mode.

8. Status register description【ST1】【ST2】:

This driver uses 2 16-bit registers to store the internal status. These values can be read thru serial communication interface by sending command RV 8 and RV 9. The driver will respond with 4 ASCII characters to represent the 16-bit HEX value. The meanings of each bit in these four bytes are explained as follows.

ST1: (2 Bytes)

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
x	DO0	INPOS	DRDY	ALM_PC	ALM_SB	ALM_PE	ALM_OL
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
x	x	DI2	DI1	EMS	BTYPE	BOND	SVON

ST2: (2 Bytes)

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
ILIM	ALM	PT2	PT1	SRH-1/2	CNT	OPM_2	OPM_1
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
x	RS485	UP_DN	x	x	x	x	x

X means no function

Item	Description
ALM_OL	Overload alarm is set when the motor current exceeds rated current for 0.3 sec and cleared by servo on again.
ALM_PE	Position error over range alarm is set when Perr>abs(【VPX】) and cleared by servo on again.
ALM_SB	Sensor break alarm is set when there is no sensor signal and cleared by servo on again.
ALM_PC	Position command over range alarm is set when pulse position command exceeds the range of 0~Max_Pcmd

	and cleared by servo on again.
DRDY	Status of external digital output DRDY When SVON=1 and ALM=0, then DRDY=1， DRDY short to GNDEX
INPOS	Status of external digital output INPOS When Perr < +/-【VIP】, INPOS =1, INPOS short to GNDEX
DO0	Status of external digital output DO0 If BOND=1 and CNT=1, then DO0=1. DO0 short to GNDEX. If BOND=0 and Pbk<VT1, then DO0=1. DO0 short to GNDEX. See Fig.2 for the detail.
SVON	Status of external digital input SVON When SVON short to GNDEX, SVON =1.
BOND	Status of external digital input BOND When BOND short to GNDEX, BOND =1.
BTYPE	Status of external digital input BTYPE When BTYPE short to GNDEX, BTYPE =1.
EMS	Status of external digital input EMS When EMS short to GNDEX, EMS =1.
DI1	Status of external digital input DI1 When DI1 short to GNDEX, DI1 =1.
DI2	Status of external digital input DI2 When DI2 short to GNDEX, DI2 =1.

(OPM_2, OPM_1)	Control mode (1,1) Position mode with current limit (1,0) Position mode (0,1) Velocity mode (0,0) Current mode
SRH-1/2	This bit displays the status of search process under soft-landing operation. If (Vfbk)>1/2[VSV], SRH-1/2=1.
CNT	This bit displays the status of contact under soft-landing operation. If abs(Vfbk)<[VCW], CNT=1.
PT1	This bit display whether the motor position is larger than the mechanical-safe threshold position [VT1]. If Pfbk>VT1, PT1=1.
PT2	This bit display whether the position is larger than the start-search threshold position [HTx]. If Pfbk>HTx, PT2=1.
ALM	This bit will be set if any of the alarm sources is detected. This bit can only be cleared by servo on again.
ILIM	This bit will be set when output current bump to [VCF] value under direct mode of soft-landing operation.
UP_DN	This bit shows the position command is from differential pulse input (UP_DN=1) or from external digital input (UP_DN=0)

RS485	This bit shows the status of the bit2 of onboard DIP switch. RS485=1， RS485 interface is selected. RS485=0，RS232 interface is selected.

9. Description of the control parameters：

There are 5 groups of control parameters. K group is used for servo loop parameters. V group is used for operation parameters. U, D, H groups are used for position selection through external digital input. These parameters can be read or written through RS232/RS485.

		0	1	2	3	4	5	6	7	8	9
K	0	KPP	KFV	KVP	KVI	KVV	KFS	KFD	KGC		
V	1	VCW	VIP	VPX	VT1	AGN	VSV	VCF	VPK	VI2	VAC
U	2	UP0 (0,0)	UP 1 (1,0)								
D	3	DN0 (0,1)	DN 1 (1,1)								
H	4	HT0	HT 1								

K Group

Item	Range of value	Description
KPP	0~32767	Proportional gain of position loop
KFV	0~32767	Feed forward gain from position command to velocity command
KVP	0~32767	Proportional gain of velocity loop under position mode
KVI	0~32767	Integral gain of velocity loop under position mode
KVV	0~32767	Proportional gain of velocity loop under velocity mode

KFS	0~8191	Compensation of static friction
KFD	0~8191	Compensation of dynamic friction
KGC	-8191~8191	Compensation of gravity

V Group

Item	Range of value	Unit	Description
VCW	0~512	Count	Window of contact
VIP	0~512	Count	Window of in-position
VPX	0~Max_Pcmd	Count	Maximal allowed position error
VT1	0~Max_Pcmd	Count	Mechanical-safe threshold position for DO0
AGN	0~ 32767	x	Gain of analog input.
VSV	0~100	counts /0.2ms	Search speed of soft-landing
VCF	0~32767	Count	Contact force (32767 means maximal Force)
VPK	0~100	counts /0.2ms	Park speed, unit:
VI2	0~100	counts /0.2ms	Speed setting for internal motion profile generator , unit:
VAC	-3~3	x	Acc/Dec smooth factor 0: disable smooth function See Fig.1 for different VAC setting

U、D、H Groups

Item	Range of value	Description
UPx	0~Max_Pcmd	(DI1=0, DI2=0) select UP0 position

		(DI1=0, DI2=1) select UP1 position
DNx	0~Max_Pcmd	(DI1=1, DI2=0) select DN0 position (DI1=1, DI2=1) select DN1 position
HTx	0~Max_Pcmd	Start-search threshold position for direct mode of soft-landing operation. (DI1=x, DI2=0) select HT0 position threshold (DI1=x, DI2=1) select HT1 position threshold

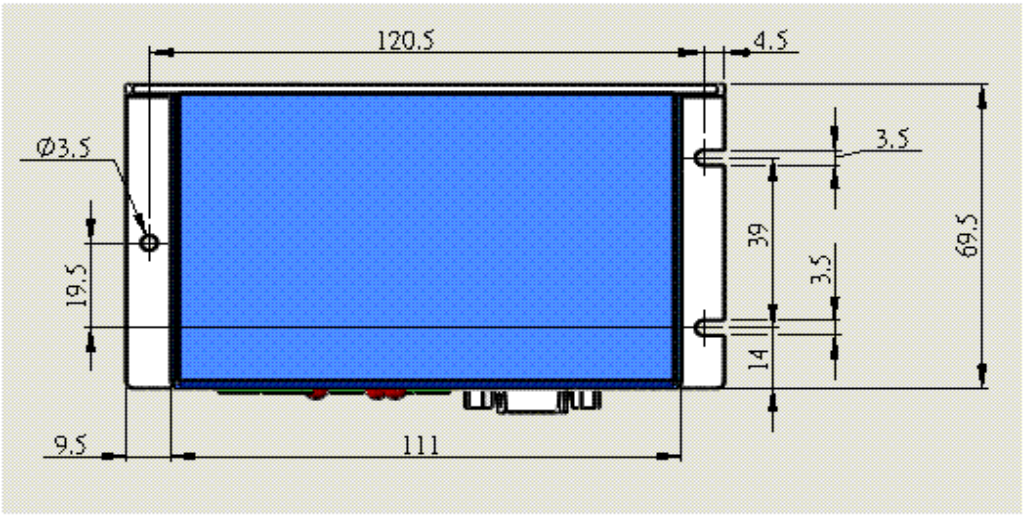
10. State variable description：

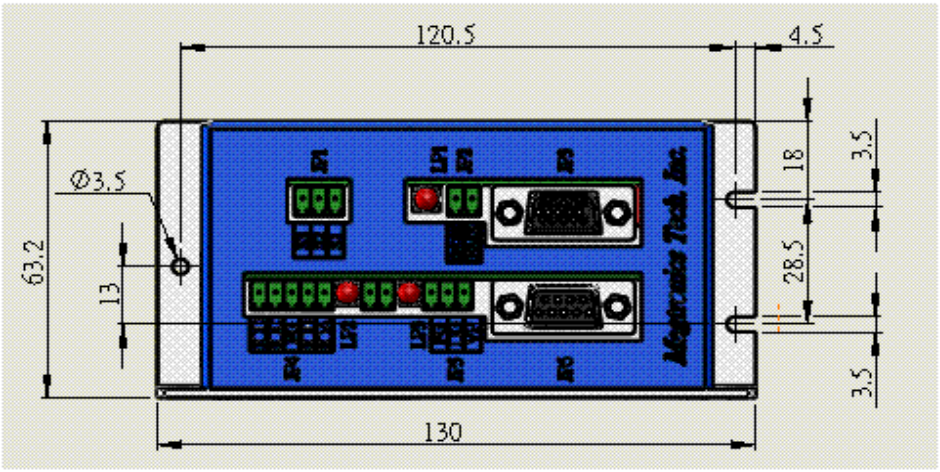
There are 10 variables for monitoring the servo-loop state of this drive. These parameters can only be read through RS232/RS485.

index	0	1	2	3	4	5	6	7	8	9
RV	PCMD	PFBK	PERR	VCMD	VFBK	VERR	ICMD	Max_Pcmd	ST1	ST2

Item	Range of value	Description
PCMD	0~Max_Pcmd	Position command
PFBK	0~Max_Pcmd	Position feedback
PERR	-32768~32767	Position error=(PCMD-PFBK) x 2
VCMD	-32768~32767	Velocity command
VFBK	-32768~32767	Velocity feedback
VERR	-32768~32767	Velocity error
ICMD	-32768~32767	Current command
Max_Pcmd	1XXXX	Range of position command (depends on different motor type.
ST1	0xXXXX	The first status register (16 bit)
ST2	0xXXXX	The second status register (16 bit)

11. Dimensional drawing：





12. Serial communication setup

a. Specification

Item	value
Baud rate	38400
Data bits	8
Parity check	no
Stop bit	1
Handshake	None
RS485 station	0~15

b. RS485 and RS232 J1 jumper and SW1 setting

Note: the selection of RS485 and its station number by setting the SW1 and J1 switch should be done before power on.

1. RS485: short3-5,4-6 of J1, BRS of SW1 is ON, select AD1~4 for station number.

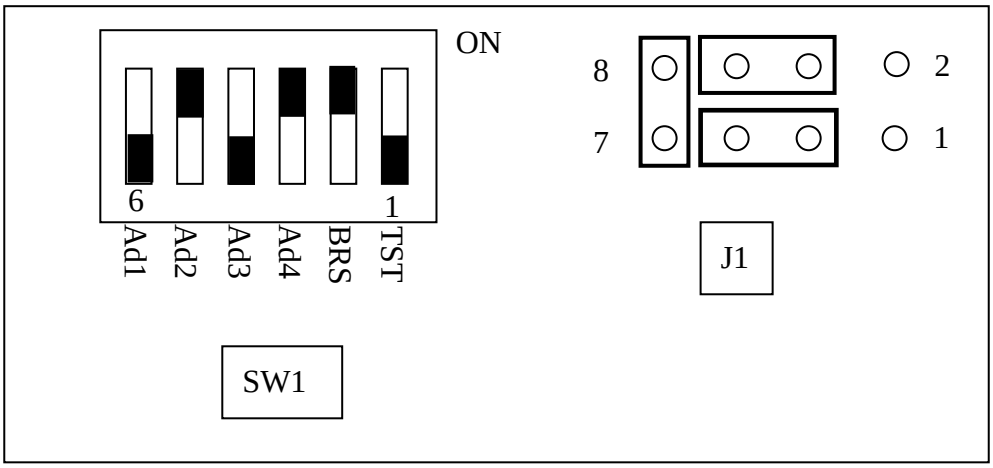
   Note: if the drive is at the end of a RS485 chain, the terminal resister can be activated by short 7-8 of J1.

2. RS232: short 1-3,2-4 of J1, BRS of SW1 is OFF, AD1~4 has no function.

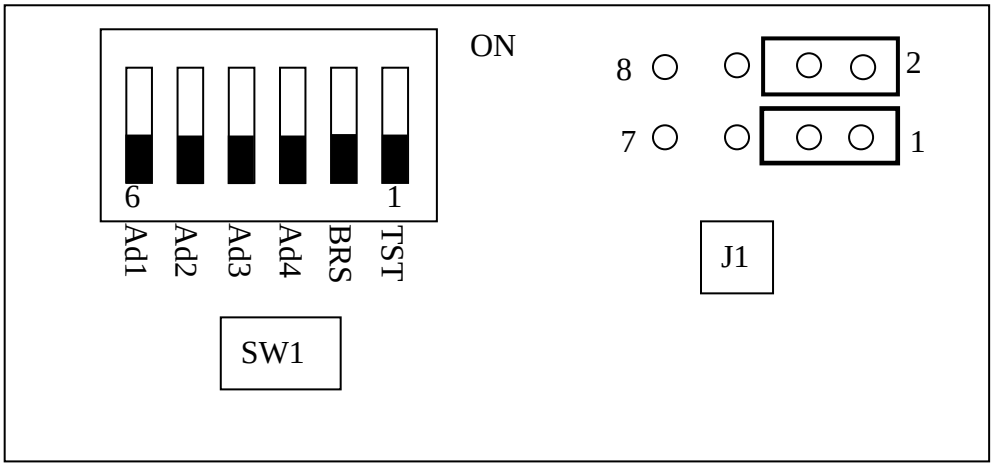
3. Station Settings of SW1:

   Station number=AD4*8+AD3*4+AD2*2+AD1.

4. Example:



RS485 is selected, Station number=10, and this driver is at the end of the RS485 chain.



Rs232 is selected.

c. Serial commands：

WT row column value	Write parameters of K、V、U、D、H groups.
RD row column	Read parameters of K、V、U、D、H groups.
ST [station]	Set station as listener
RV index	Read state variables（RV group）
SV	Save all parameters to EEPROM
UD x	x=1 set external DIO position control x=0 set differential Pulse/Dir position control **Note: UD x must be sent during servo off**

Description

1. All command strings must be end with **CHR（13）** to notify the drive that the command is complete**.**
2. If RS232 is selected, all the sent commands will be Echo. Three ASCII code, ”CR LF >”(0x13,0x10,0x3E), are appended at the end of all response string.
3. If RS485 is selected, the sent command will NOT be Echo. If the station assigned by ST command exists, “CR LF [station] >” will be added to the response string (e.g. “8>”). From now on, the active listener will respond to the master according to the command. If you want to change the listener, you should send “ST [station]” again.

Example：Use RS232 to read PFBK, and the drive returns 1000.

Command	R	V		1	13H							
Response		R	V		1	13H	1	0	0	0	13H	10H	>

Example：Use RS485 to read PFBK of station 8, and the drive returns 1000.

Command	S	T		8	13H							
Response						13H	10H	8	>			
Command	R	V		1	13H							
Response						1	0	0	0	13H	10H	8	>

13. Quick Start

1. Correctly connect the motor cables and the sensor cables to JP4 and JP1 respectively.
2. Connect the necessary external digital I/O's to JP3. At least, the SVON must be provided.
3. Prepare an isolated power (12V~24V) for external digital I/O's where the positive terminal connected to EXCOM of JP3, and the ground connected to GNDEX of JP3.
4. Connect the RS232 serial interface from PC to JP6.
5. Provide an adequate main power supply according to the specification of the dedicated voice coil motor. Connect the main power cable to JP5. Note that do not reverse the polarity of the main power, otherwise, the drive will be damaged permanently.
6. Turn on the main power and the isolated external I/O power. Note that the SVON must be open from GNDEX before turning on the power.
7. Start the program "Digital VCM Driver Motion Console 3.0". Enter the correct port number for RS232 then press [START]. The control parameters, status, and state variables should be updated every 1 second.
8. Click "DI2-Up/Down" option button and press [SET] to receive the position command from external digital I/O.
9. Short SVON to GNDEX of JP3 to servo on the motor. The motor will move to a home position (Pcmd = 2000). Check the in-position lamp is red or not. If in-position is red, the motor enters position mode and follows the position command from now on. Otherwise, the drive will not enters position mode and

will not follow the position command. You need to adjust the gravity compensation KGC until the in-position is red, see the next step.

10. Gravity compensation: When the motor is applied vertically, the gravity of the moving mass of VCM must be compensated. The adjustment is quite easy. Read the Icmd value while servo on. Enter the value you read with minus sign eliminated into KGC. (e.g.: Icmd = -2300 -> KGC = 2300). The compensation is complete. The Icmd value may vibrate within a range. Just choose an approximate average value for KGC within the variation.
11. Enter a new value into UP0, you should see the motor moves to the new position.
12. Please see “User’s Manual of Digital VCM Driver Motion Console 3.0” for tuning the motor.