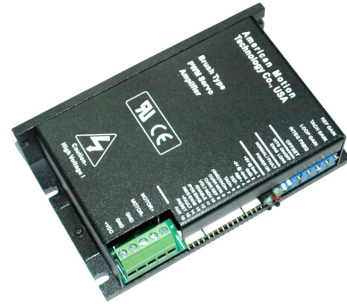


DCS920 Brush DC Servo Drive

1. Introduction

The DCS920 PWM servo drive is designed to drive brush type DC motors at a high switching frequency. The drive can interface with digital controllers or be used stand-alone and requires only a single unregulated DC power supply. Input (Ref) gain, Tach Gain, Loop gain, Integrator Frequency and Offset can be adjusted using 26-turn potentiometers. The offset adjusting potentiometer can also be used as an on-board input signal for testing purposes. Furthermore, 3 red/green LEDs indicate operating status for faster setup. The drive is fully protected against over-voltage, under voltage, over-current, short-circuits from output to output, and over-temperature.



Power Range

Supply Voltage	24 – 80 VDC
Peak Current	20A
Continuous Current	10A

2. Features

- High Performance and Cost-effective
- 3 kHz bandwidth
- Wide load inductance range: 0.2 - 40 mH
- Separate and adjustable current Limits: Continuous, Peak and Peak-time
- No integrator windup when disabled
- Differential Input: ± 10 V Analog
- Current Monitor Output
- 3 LED Indicators for Faster Setup: Normal/Enable, Power-OK, Fault (Short-circuits or over temperature)
- Over/Under-voltage, over-current, short-circuits, over temperature protection
- Surface Mount Technology

Modes of Operation

- Current
- Tachometer Velocity
- Voltage
- IR Compensation

3. Applications

- X-Y Stages
- Robotics
- Automated assembly machinery
- Automatically guided vehicles

4. Block Diagrams

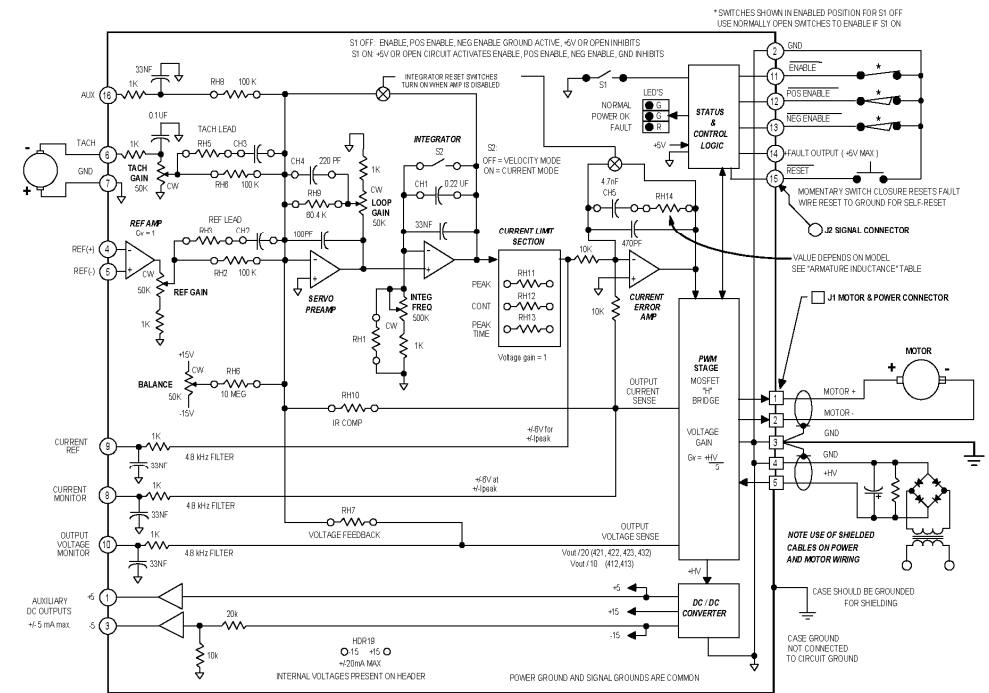


Figure 1: Block diagram of the DCS920

4. Specifications

Power Specifications			
Parameters	Units	Value	
Supply Voltage Input	VDC	24 - 80	
Output Voltage	V	$V_{out} = \pm VDC * (0.97) - (R_o) * (I_o)$	
Over Voltage Limit	VDC	92	
Under Voltage Limit	VDC	22	
Peak Output Current	A	20	
Continuous Output Current	A	10	
Switching Frequency	kHz	25	

Control Specifications		
Parameters	Units	Value
Command Sources	V	Differential, 100K between inputs, 20V maximum
Feedback Supported	-	Tachometer
Modes of Operation	-	Current, Tachometer velocity, Voltage with IR compensation
Motors Supported	-	Brushed, Voice coil
Load Inductance	mH	Selectable with components on header socket: 200 μ H to 40mH
Bandwidth	kHz	Current mode: 3kHz with 200 μ H load at maximum supply voltage, varies with load inductance and RH14, CH5 values. Voltage-feedback mode: 200Hz max.
Hardware Protection	-	Over voltage, Under voltage, Over current, Over temperature, Short circuit (Phase-Phase & Phase-Ground)
Mechanical Specification		
Parameters	Units	Value
Agency Approvals	-	CE Compliance to 89/336/EEC; Recognized Component to UL 508C
Size (H*W*D)	mm	83.3 x 129.3 x 36.3
Weight	kg/lb	0.27 kg / 0.59 lb
Storage Temperature	°C	-20 - 65

Mechanical Specifications (unit:mm, 1 inch = 25.4 mm)

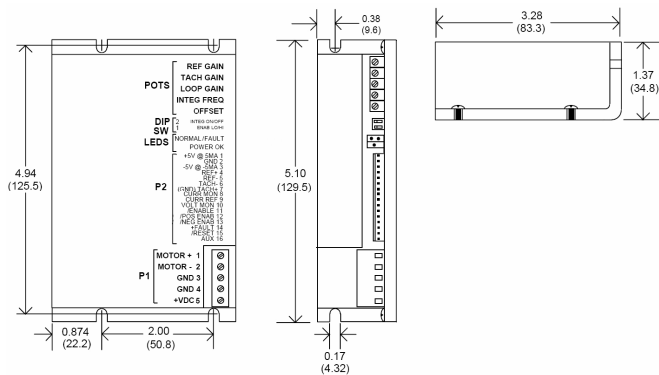


Figure 2: Mechanical specifications

*Recommend use side mounting for better heat dissipation

Notes:

1. Test conditions: 25°C ambient, Load = 200 μ H. in series with 1W. +VDC = 80VDC.
2. Lower inductance is acceptable for bus voltages well below maximum. Use external inductance to meet requirements.
3. Additional cooling and/or heatsink may be required to achieve rated performance.

5. Pin Assignment and Description

P1 – Signal Connector			
Pin	Name	Description	I/O
1	+5V @ 5mA	\pm 5 V @ 5 mA auxiliary power supply for customer use. Short circuit protected. Reference ground common with signal ground.	O
2	GND		GND
3	-5V @ -5mA		O
4	REF+	Differential Reference Input (\pm 10 V Operating Range, \pm 20 V Maximum Input). Connect both Ref inputs to control card: Ref(+) to card output, Ref(-) to card ground. Using both inputs will reject ground noise between control card and drive. Use shielded, twisted-pair cable to minimize noise pickup between drive and controller.	I
5	REF-		I
6	TACH-	Negative tachometer input (Maximum \pm 60 V). Use signal ground for positive input.	I
7	(GND)TACH+	Positive tachometer input and signal ground	I
8	CURR MON	Current Monitor. Analog output signal proportional to the actual current output. This pin has a maximum output of 6V when the drive outputs maximum peak current. Measure relative to signal ground. 6V @ Ipeak (1k Ω , 33nF R-C filter)	O
9	CURR REF	Measures the command signal to the internal current-loop. This pin has a maximum output of 6V when the drive outputs maximum peak current. Measure relative to signal ground. 6V @ demands Ipeak	O
10	VOLT MON	Vout / 10, Bandwidth = 200 Hz	O

11	/ENABLE	TTL level (+5 V) inhibit/enable input. With S1 OFF, all Enable inputs must be grounded for the drive to operate. For operation with cards that output +5V to enable the drive, turn S1 ON. Enable active level is now reversed so that grounding inputs will inhibit and +5V (or open) will enable. S1 flips polarity of all enable inputs. Note: There is a 50ms delay /between Enable TRUE and drive ON. Delay on /Pos and /Neg enables is <1ms.	I
12	/POS ENAB	Positive Direction Inhibit. See related description about /ENABLE.	I
13	/NEG ENAB	Negative Direction Inhibit. See related description about /ENABLE.	I
14	+FAULT	TTL level (+5V) output becomes high when power devices are disabled due to at least one of the following conditions: inhibit, output short circuit, over voltage, over temperature, power-up reset.	I
15	/RESET	With the /RESET input open, output shorts or heatplate over temperature will latch off the drive until power is cycled off & on, or until the /Reset input is grounded. For self-reset from such conditions, wire /Reset to ground and the drive will reset every 50ms.	I
16	AUX	Auxiliary analog input for test/offset. See block diagram please.	I

P2 – Power Connector

Pin	Name	Description	I/O
1	MOTOR+	Positive Motor Output	O
2	MOTOR-	Negative Motor Output	O
3	GND	Power Ground (Common with signal ground)	GND
4	GND		GND
5	+VDC	DC Power Input	I

Switch Functions:

S1: ENAB LO/HI	S1 OFF: Ground enables, open or +5V inhibits (/Enable, /Pos & /Neg enable) S1 ON : Open or +5V enables, ground inhibits (/Enable, /Pos & /Neg enable)
S2: Integrator ON/OFF	S2 ON: Torque mode (integrator off, flat-gain), OFF: velocity mode (integrator on, tachometer mode)

Potentiometer Functions:

REF GAIN	Attenuates Ref input from x1 to 0; controls overall amplifier gain (amps / volt, rpm / volt, or volts / volt)
TACH GAIN	Tach feedback gain: sets basic rpm / volt ratio; also used as IR comp feedback control
LOOP GAIN	Servo preamp DC gain: increases amps / volt gain in torque mode; controls bandwidth in velocity mode
INTEG FREQ	Integrator frequency control: not used in torque mode/; controls stiffness and speed stability in velocity mode
OFFSET/TEST	Use to set output current or rpm to zero. RH6 = 10 M for OFFSET function, RH6 = 100k for Test function

Logic Inputs:

Input voltage range	0 to +24V
Logic threshold voltage (LO to HI transition)	2.5V (Schmitt trigger inputs with hysteresis)
Input resistance	10K pull-up to +5V, R-C filters to internal logic

Logic Outputs:

+Fault (/Normal)	HI = Overtemp OR output short OR power NOT-OK, OR NOT-Enabled; LO = Operating normally AND enabled;
HI output voltage	2.4V min at -5.2 mA max., +5V maximum
LO output voltage	0.5V max at 5.2 mA max.

Indicators (LED's):

Normal	Green: ON = Drive Enabled AND Normal (power OK, no output shorts, no overtemp)
Power OK	Green: ON = Power OK (+VDC >22V AND (+VDC <92V)
Fault	Red: ON = Output short-circuit or over-temperature condition

6. Servo Setup

Setup Sequence

- 1) Set RH11, RH12, and RH13 for motor current-limits to protect motor during setup. Disconnect motor and monitor CURR Ref signal at P1-9 while making settings.
- 2) Set CH5, RH14 on header for armature inductance.
- 3) Connect enable inputs. Set S1 for your enable signal polarity.
- 4) Connect motor and (if used) tachometer.
- 5) Connect drive to transformer-isolated DC power supply.
- 6) Adjust pots and switch S2 according to operating mode.

SMT Component

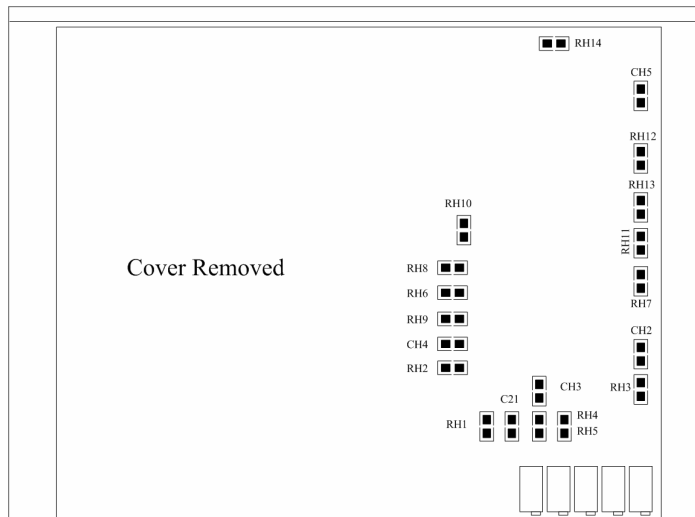


Figure 3: SMT Component

Armature Inductance (CH5 & RH14):

Component	Load (mH)	0.2 - 0.5	0.6 - 0.9	2 - 5.9	6 - 19	20 - 40
CH5 (nF)		4.7	4.7	4.7	4.7	4.7
RH14 (kΩ)		10	49.9	150	330	470

Note: Values in **bold & italics** are factory installed standard. Values shown are for 80V. At lower supply voltages RH14 may be increased and CH5 decreased. To customize values: short CH5, select RH14 for best step response in current-mode, next select CH5 for lowest value that does not degrade

step response.

Values from table work well for most applications. To optimize compensation with custom values:

- 1) Turn S2 ON. Disconnect tachometer if used. Set REF GAIN pot fully CW, Loop Gain pot fully CCW.
- 2) Replace CH5 with a jumper (short).
- 3) Apply 20Hz square wave input to Vref. Adjust for $\pm 0.25V$ at CURR Mon (P1-8).
- 4) Choose value for RH14 that gives best step response without oscillation.
- 5) Replace CH5 with 4.7nF.
- 6) If waveform shows >10% overshoot, try larger capacitor until overshoot is 10% or less. If no change is seen, try smaller value for CH5 until overshoot appears.

Peak Current Limit (RH11):

Drives are shipped with no part installed in RH11. This delivers the drives peak rated current. For lower settings use values from the table.

Peak Current Limit (%)	100	80	60	40	20
RH11 (kΩ)	open	68	33	15	6.2

Note: Values in **bold & italics** are factory installed standard. Peak current limit should be set greater than continuous current limit. If $I_{peak} < I_{cont}$ then peak overrides continuous limit and $I_{cont} = I_{peak}$. Minimum setting for peak current is 0% Minimum setting for continuous current is 16%.with RH12 = 0 W.

Continuous Current Limit (RH12):

Choose RH12 based on the motor manufacturers specification for your motor. Table values give basic settings. This setting keeps the motor within its thermal limits. Note that this limit measures average current and will not work on symmetrical waveforms such as might occur during system oscillation. Use an external thermal circuit breaker for protection from such over-current faults.

Continuous Current Limit (%)	100	80	60	40	20
RH12 (kΩ)	open	100	39	15	1

Note: Values in **bold & italics** are factory installed standard. Continuous current sense is for average current. Symmetrical waveforms with zero average value may cause over-temperature shutdown of drive or motor damage due to high I^2R losses.

Peak Current Time-Limit (RH13):

Header component RH13 controls the length of time for which the drive will output peak current. When peak currents that are less than the drives peak rated current, this time will increase, eventually becoming infinite as you reach the continuous current. After a polarity reversal, the peak time will be twice that of a unipolar current change.

Peak Current Limit (s)	<i>I</i>	0.8	0.6	0.4	0.2
RH13 (MΩ)	<i>open</i>	10	2.2	1	330

Note: Values in **bold & italics** are factory installed standard. Peak times double after polarity reversal.

7. Typical Connections and Settings

A complete servo system should include servo motor, servo driver, power supply, controller and feedback device. Typical connections of three operation modes are shown as the following Figure4 to figure6.

Current (Torque) Mode

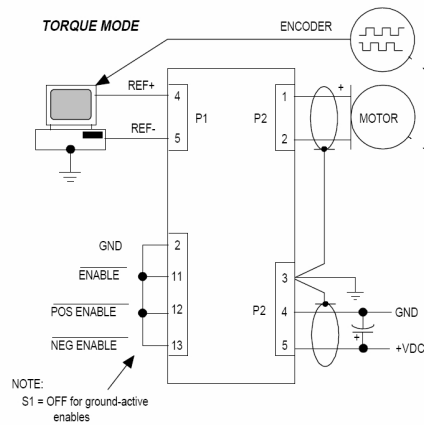


Figure 4: Typical connection of torque mode

For transconductance:

$$(I_{out} / V_{ref}) = I_{peak} / 10V$$

- 1) Set S2 ON.
- 2) Set Ref Gain fully CW.
- 3) Set Loop Gain fully CCW.
- 4) To increase gain, turn Loop Gain CW. To decrease gain, turn Ref Gain CCW.

Velocity Mode with Brush Tachometer

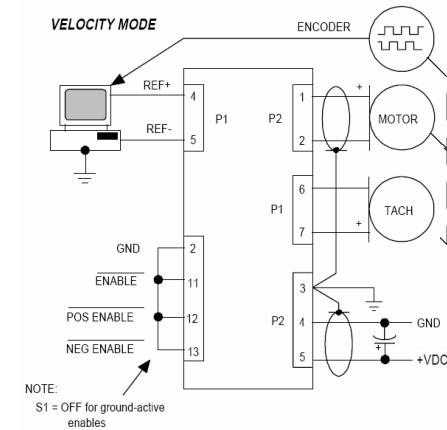


Figure 5: Typical connection of velocity mode

Disconnect motor from machinery during setup! Tachometer reversal will cause uncontrolled run-away! Set Tach Gain, Loop Gain and Integ. Freq. pots fully CCW.

- 1) Set S2 ON. Connect motor and tach and DC power, enable drive and spin shaft. If motor runs away, reverse tachometer connections.
- 2) Apply 5Hz square wave to Ref inputs. Adjust for $\pm 0.25V$ at Tach input (P1-6).
- 3) Adjust Loop Gain pot CW until oscillation begins, then back-off 2 turns. If oscillation cannot be eliminated, reduce RH9 until adjustment is possible.
- 4) Set S2 OFF. Turn Integ Freq CW until overshoot exceeds 10%, or oscillation begins. Back off for best step response. If overshoot is excessive with pot CCW, change CH1 to 0.47mF and retry. Use value of CH1 that gives good adjustment range for Integ Freq pot.
- 5) Adjust Tach Gain pot for desired V_{tach} / V_{ref} ratio. Repeat steps 2-4. Ref Gain pot will reduce V_{tach} / V_{ref} ratio without affecting tuning. If oscillation occurs when motor is connected to load, repeat steps 2-4.

Voltage Feedback & IR Comp

In voltage mode, the voltage that is output to the motor is fed back to close a voltage loop. Since the voltage across the motor is proportional to the speed of the motor, this will allow coarse control of the motor speed, suitable for AGV's, conveyors, or a Mars Lander. Operation will be much like a tachometer.

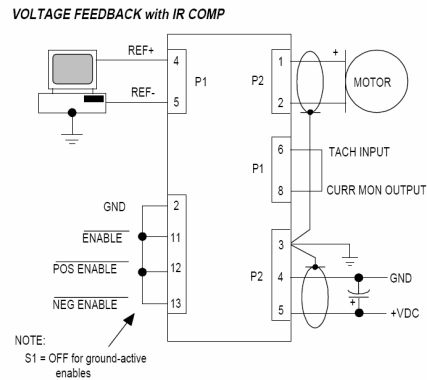


Figure 6: Typical connection of voltage feedback with IR comp

Voltage mode with no IR comp

Procedure

Determine the voltage gain required. Example: If 24V output is required with 10V input then, Gain = Output Voltage / Input Voltage = 24V/10V = 2.4

Use the table for RH7 if the gain is common or use the formula to calculate uncommon gains. Install the resistor in the amplifier header Position RH7.

Gain	1.2	2.4	7.5	15
RH7 (kΩ)	12	24	75	150

Use exact or next larger value. (RH2 must be factory default 100K Ohms) See functional diagram.

Set S2 OFF, Ref Gain, Integ Freq & Tach Gain pots fully CW, Loop Gain pot fully CCW.

Connect oscilloscope to P1-10, Output Voltage monitor. Apply ±1V, 10Hz square wave to Ref inputs. Check for oscillation. If oscillation occurs, decrease RH9 to 10kΩ. Oscillation should now be gone.

The Loop Gain and Integration Gain can be adjusted to effect the step response. Critical damping is recommended. See the Step Response diagram.

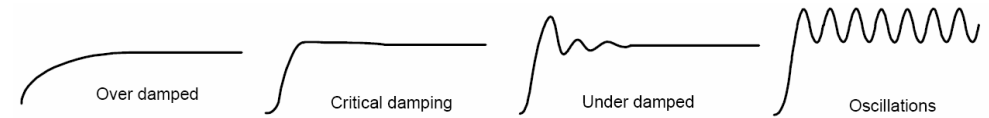


Figure 7: Step response

Note: If the motor has a large resistance, refer to the following section for the IR compensation procedure.

However, for most motors with low motor resistance and a normal back-EMF range, no IR compensation will be required.

Example: Motor resistance R = 0.5 Ohm, Back-Emf constant Ke = 10V/krpm

What is the speed lost at 3000rpm if 5Amps of current is continuously delivered?

Answer: 5Amps * 0.5ohms = 2.5V / 10V/krpm = 0.25krpm or 250rpm loss of speed, not bad regulation.

Voltage mode with IR comp

Voltage mode with no IR comp is used with position loops that have no “D” term, or that output a position error signal only. IR comp is used mostly with open-loop speed control systems.

Procedure

- 1) (Skip this step if no IR comp.) Jumper P1-6 to P1-8. Tach Gain pot now functions as IR comp adjustment (full CW = no IR comp).
- 2) Select RH7. Use exact or next larger value.
- 3) Set S2 OFF, Ref Gain, Integ Freq & Tach Gain pots fully CW, Loop Gain pot fully CCW.
- 4) Connect oscilloscope to P1-10, Output Voltage monitor.

7. Wiring Notes

IMPORTANT! ALWAYS REMOVE POWER WHEN CHANGING HEADER PARTS!!

1. All drive grounds are common (P2-3,4 & P1-2,7) Case is isolated from drive circuits.
2. For ground-active enable inputs, set S1 OFF For +5V active enables, set S2 ON (open inputs will enable drive via internal pullups to +5V).
3. For best noise immunity, use twisted shielded pair cable for reference and tachometer inputs.
4. For EMI reduction and CE compliance, use shielded cable for motor and DC power.

Grounding & Power Supplies

Connect positive terminal of power supply to P2-5, negative terminal to P2-4. For best results do not ground power supply, but ground each drive with heavy wire from P2-3 to equipment ‘star’ ground point. If power supply is >1m. from drives, add local filter capacitor near drives (250μF minimum per drive).

8. Order Information

DCS920	20A peak, 10A continuous, 24-80 VDC brush motor drive
--------	-------------------------------------------------------