NEW EM1800 AMPLIFIER MODULE SERIES
(Single & Dual Power Supply Models)

5249658 KOLLMORGEN CORP, INLAND 38C 00217 D T-74-17-01

UNITS		Output power max Case(s) at 25°C (Watts)	Derating (Watts/°C)	No-Load Output @ Nominal Supply (volts DC)	Full-load output @ nominal supply (volts DC)	Output current max Case(s) at 25°C (AMP)	Output current limit Adjustment range (AMP)	Dynamic output impedance (OHM)	Input impedance (OHM)	Frequency response: Small signal (Hz)	Frequency response: Full output (Hz)	Frequency response: Slew rate @ unity gain (V/µ sec)	DC Deadband (Rel. to input) (µv)	Gain (adjustable): Voltage amplifier (v/v)	Gain (adjustable): Current amplifier (A/V)	Drift (ref. to input) (µV/°C)	Positive Supply Voltage (VDC)	Positive Quiescent Current (AMP)	Negative Bias Supply voltage (VDC)	Negative Quiescent Current (AMP)	Weight (oz.)
EM1801-00	-A	25	0 15	± 25	± 20	± 1 25	0.2 to 1.25	0.1	10,000	10,000	2,000	0 18V/µ sec	± 15 µv	20	0 5	10	28 ± 4	0 035	-15 ± 2	0 035	4
	-B	25	0.15	± 25	± 20	± 1.25	0.2 to 1.25	0.1	10,000	10,000	2,000	0 18V/µ sec	± 15 µv	20	0 5	10	28 ± 4	0 095	✱	✱	4
EM1802-00	-A	200	1 25	± 25	± 20	± 10	1 to 10	0.1	10,000	10,000	2,000	0 18V/µ sec	± 15 µv	20	0 5	10	28 ± 4	0 035	-15 ± 2	0.035	10
	-B	200	1 25	± 25	± 20	± 10	1 to 10	0.1	10,000	10,000	2,000	0 18V/µ sec	± 15 µv	20	0 5	10	28 ± 4	0 095	✱	✱	10
EM1803-00	-A	300	1 75	± 25	± 20	± 15	1 to 15	0.1	10,000	10,000	2,000	0 18V/µ sec	± 15 µv	20	0 5	10	28 ± 4	0 035	-15 ± 2	0 035	10
	-B	300	1 75	± 25	± 20	± 15	1 to 15	0.1	10,000	10,000	2,000	0 18V/µ sec	± 15 µv	20	0 5	10	28 ± 4	0 095	✱	✱	10
EM1806-00	-A	25	0.15	± 55	± 50	± 0.5	0.2 to 0.5	0.1	10,000	10,000	1,000	0 18V/µ sec	± 15 µv	20	0 5	10	60 ± 6	0 035	-15 ± 2	0 035	4
	-B	25	0.15	± 55	± 50	– 0.5	0.2 to 0.5	0.1	10,000	10,000	1,000	0 18V/µ sec	± 15 µv	20	0 5	10	60 ± 6	0 095	✱	✱	4
EM1807-00	-A	200	1.25	± 55	± 50	± 4	1 to 4	0.1	10,000	10,000	1,000	0.18V/µ sec	± 15 µv	20	0 5	10	60 ± 6	0 035	-15 ± 2	0 035	10
	-B	200	1.25	± 55	± 50	± 4	1 to 4	0.1	10,000	10,000	1,000	0 18V/µ sec	± 15 µv	20	0 5	10	60 ± 6	0 095	✱	✱	10
EM1808-00	-A	500	2 6	± 55	± 50	± 10	1 to 10	0.1	10,000	10,000	1,000	0 18V/µ sec	± 15 µv	20	5	10	60 ± 4	0 035	-15 ± 2	0 035	60
	-B	500	2 6	± 55	± 50	± 10	1 to 10	0.1	10,000	10,000	1,000	0 18V/µ sec	± 15 µv	20	5	10	60 ± 4	0 095	✱	✱	60
EM1809-00	-A	1000	1 75	± 55	± 50	± 20	1 to 20	0.1	10,000	10,000	1,000	0 18V/µ sec	± 15 µv	20	5	10	60 ± 4	0 035	-15 ± 2	0 035	86
	-B	1000	1 75	± 55	± 50	± 20	1 to 20	0.1	10,000	10,000	1,000	0 18V/µ sec	± 15 µv	20	5	10	60 ± 4	0 095	✱	✱	86
EM1810-00	-A	750	3 9	± 55	± 50	± 15	1 to 15	0.1	10,000	10,000	1,000	0 18V/µ sec	± 15 µv	20	5	10	60 ± 4	0 035	-15 ± 2	0 035	68
	-B	750	3 9	± 55	± 50	± 15	1 to 15	0.1	10,000	10,000	1,000	0 18V/µ sec	± 15 µv	20	5	10	60 ± 4	0 095	✱	✱	68
EM1811-00	-A	1500	2 25	± 55	± 50	± 30	1 to 30	0.1	10,000	10,000	1,000	0 18V/µ sec	± 15 µv	20	5	10	60 ± 4	0 035	-15 ± 2	0 035	94
	-B	1500	2 25	± 55	± 50	± 30	1 to 30	0.1	10,000	10,000	1,000	0 18V/µ sec	± 15 µv	20	5	10	60 ± 4	0 095	✱	✱	94
EM1812-00	-A	450	2 6	± 25	± 20	± 22.5	1 to 22 5	0 1	10,000	10.000	1 000	0 18V/µ sec	± 15 µv	20	5	10	28 ± 4	0.035	-15 ± 2	0 035	60
	-B	450	2 6	± 25	± 20	± 22.5	1 to 22.5	0 1	10,000	10,000	1 000	0 18V/µ sec	± 15 µv	20	5	10	28 ± 4	0.095	✱	✱	60
EM1813-00	-A	750	1 75	± 25	± 20	± 37.5	1 to 37.5	0 1	10,000	10.000	1 000	0 18V/µ sec	± 15 µv	20	5	10	28 ± 4	0.035	-15 ± 2	0 035	86
	-B	750	1.75	± 25	± 20	± 37.5	1 to 37.5	0 1	10,000	10.000	1 000	0 18V µ sec	± 15 µv	20	5	10	28 ± 4	0.095	✱	✱	86
EM1814-00	-A	600	3 9	± 25	± 20	± 30	1 to 30	0 1	10,000	10,000	1 000	0 18V µ sec	± 15 µv	20	5	10	28 ± 4	0.035	-15 ± 2	0 035	68
	-B	600	3 9	± 25	± 20	± 30	1 to 30	0 1	10,000	10 000	1 000	0 18V µ sec	± 15 µv	20	5	10	28 ± 4	0.095	✱	✱	68
EM1815-00	-A	1000	2 25	± 25	± 20	± 50	1 to 50	0 1	10,000	10,000	1,000	0 18V µ sec	± 15 µv	20	5	10	28 ± 4	0.035	-15 ± 2	0 035	94
	-B	1000	2 25	± 25	± 20	± 50	1 to 50	0 1	10,000	10 000	1 000	0 18V µ sec	± 15 µv	20	5	10	28 ± 4	0.095	✱	✱	94
EM1817-00	-A	25	0 15	± 45	± 40	± 0 625	0 2 to 0.625	0 1	10,000	10.000	1,000	0 18V µ sec	± 15 µv	20	0 5	10	48 ± 6	0 035	-15 ± 2	0 035	4
	-B	25	0.15	± 45	± 40	± 0 625	0 2 to 0 625	0 1	10,000	10.000	1,000	0 18V µ sec	± 15 µv	20	0 5	10	48 ± 6	0.095	✱	✱	4
EM1818-00	-A	200	1 25	± 45	± 40	± 5	1 to 5	0 1	10,000	10.000	1 000	0 18V µ sec	• 15 µv	20	0 5	10	48 • 6	0 035	-15 ± 2	0 035	10
	-B	200	1 25	± 45	± 40	± 5	1 to 5	0 1	10,000	10.000	1 000	0 18V µ sec	• 15 µv	20	0 5	10	43 • 6	0 095	✱	✱	10
EM1819-00	-A	400	2 6	± 45	± 40	· 10	1 to 10	0 1	10,000	10.000	1 000	0 18V µ sec	± 15 µv	20	5	10	48 ± 4	0 035	-15 ± 2	0 035	60
	-B	400	2 6	± 45	± 40	± 10	1 to 10	0 1	10,000	10 000	1 000	0 18V µ sec	± 15 µv	20	5	10	48 ± 4	0 095	✱	✱	60
EM1820-00	-A	800	1 75	• 45	± 40	• 20	1 to 20	0 1	10,000	10 000	1 000	0 18V µ sec	± 15 µv	20	5	10	48 ± 4	0 035	-15 ± 2	0 035	86
	-B	800	1 75	• 45	± 40	• 20	1 to 20	0 1	10,000	10 000	1.000	0 18V µ sec	± 15 µv	20	5	10	48 ± 4	0 095	✱	✱	86
EM1821-00	-A	600	3 9	• 45	± 40	• 15	1 to 15	0 1	10,000	10 000	1 000	0 18V µ sec	± 15 µv	20	5	10	48 ± 4	0 035	-15 ± 2	0 035	68
	-B	600	3 9	• 45	± 40	• 15	1 to 15	0 1	10,000	10.000	1 000	0 18V µ sec	± 15 µv	20	5	10	48 ± 4	0 095	✱	✱	68
EM1822-00	-A	1200	2 25	± 45	• 40	• 30	1 to 30	0 1	10,000	10 000	1 000	0 18V µ sec	± 15 µv	20	5	10	48 • 4	0.035	-15 ± 2	0 035	94
	B	1200	2 25	• 45	• 40	• 30	1 to 30	0 1	10,000	10 000	1 000	0 18V µ sec	± 15 µv	20	5	10	48 • 4	0.095	✱	✱	94

✱ No negative bias supply required (Single power-source unit with same form, fit and function as —A model)

Glossary of Terms:

C_F = Conversion Factor (1.36 for lb. ft. units and 0.00706 for oz. in units)

C_R = Temp. Correction Factor

$C_R = \frac{(T_A + 234.5)}{259.5}$ @ 25°C ambient

D_F = Derating Factor for Amplifier

F_I = Infinite Impedance Viscous Damping Coefficient

I_M = Motor Armature Current

J_L = Load Inertia

J_M = Motor Inertia

K_B = Motor Back emf Constant

K_M = Motor Constant

K_T = Motor Sensitivity

PD_{RX} = Power Dissipation of Current Limit Resistor

R_M = Motor DC Resistance

T_A = Stabilized Arm.Winding Temp. (Watts Losses × TPR + T_{amb})

T_{amb} = Ambient Temperature

T_D = Developed Torque ($T_F + \omega F_I + T_L$)

T_F = Friction Torque

T_L = Load Torque

T_S = Mounting Surface Temperature

TPR′ = Approximately one-half catalog value for unmounted TPR

V_M = Motor Terminal Voltage

V_S = Amplifier Supply Voltage

W_{DA} = Power dissipation rating of amplifier at 25°C

W_{DISS} = Power dissipation by the amplifier

W_{DP} = Peak Instantaneous Power Dissipation During Plug.

W_{DT} = Power dissipation rating of amplifier at 25°C<T_C<125°C

W_{IN} = Input to Motor in Watts

W_{STALL} = Armature Dissipation Power at Stall

α = Acceleration

θ_{SA} = Thermal Resistance of Heatsink to Ambient when used with Modular Amplifiers.

ω = Speed in Radians per Second

Amplifier Connections for Plug-In Modules

PIN CONNECTION AND FUNCTION

1. −15VDC Bias Supply, except for (−B) models
2. Voltage Feedback — For voltage amplifier mode, connect to Pin 20. In voltage feedback, connect pins 14 and 15 to power ground, Pin 13.
3. Current Feedback — For current amplifier mode, connect to Pin 14.
4. Input
5. Current Feedback — For current amplifier mode, connect to Pin 15.
6. For current limit operation, connect to Pin 17 where external resistor (R_x) is connected between Pins 17 & 18.
7. Offset Adjust — Connect to Signal Ground Pin 9 directly or through balance circuitry dependent on voltage or current mode operation. (See discussion under "Offset Adjustment").
8. Voltage Feedback — For voltage amplifier mode, connect to Pin 11. In voltage feedback, connect Pins 14 & 15 to power ground, Pin 13.
9. Signal Ground (positive return for negative 15 volt bias supply on −A models).
10. Base Drive — For use when 25 watt amplifier is used to drive a power bridge (see Figure 2).
11. Output — Polarity is in-phase with input on Pin 4.
12. Base Drive — For use when 25 watt amplifier is used to drive a power bridge. (See Figure 2)
13. Power Ground — Connect to negative side of high voltage, high current supply. (Input ground & power ground internally connected (-00-models).
14. Load Current Sense — See Pin 3. Connects also to Pin 10 when 25 watt amplifier is used without external bridge. (See Figure 3).
15. Load Current Sense—See Pin 5. Connects also to Pin 19 when 25 watt amplifier is used without external bridge (see Figure 3).
16. Base Drive — For use when 25 watt amplifier is used to drive a power bridge (see Figure 2).
17. Supply voltage point for external bridge transistors (see Figure 2). Jumpered to Pin 6 when external current limit resistor (R_x) is used.
18. High-voltage positive supply (+28VDC, +48VDC, or +60VDC depending on model).
19. Base Drive — For use when 25 watt amplifier is used to drive a power bridge (see Figure 2).
20. Output — Polarity is out-of-phase with input on Pin 4.

Definition of Amplifier Specifications

OUTPUT POWER: The dc power rating with heatsink mounting temperature at 25°C. Power-Temperature derating must be observed to protect against excessive transistor junction temperatures.

INTERNAL POWER DISSIPATION: The internal power dissipation in the amplifier is a maximum when the output power of the amplifier is a minimum. See discussion under "Temperature Dependance of Amplifier Output".

INTERNAL POWER DISSIPATION DERATING: The slope of the power-temperature relationship between 25°C and 125°C that reduces allowable internal dissipation as the heatsink mounting temperature increases to insure operation below maximum transistor junction temperatures.

OUTPUT VOLTAGE: The minimum output voltage swing under full load with nominal power supply voltage on Pin 18 and heatsink mounting surface temperature at 25°C.

OUTPUT CURRENT: The minimum output current swing under full load with nominal power supply voltage on Pin 18 and heatsink mounting surface temperature at 25°C.

OUTPUT CURRENT - LIMIT ADJ. RANGE: The internal current-limit circuitry is factory set for 0.2 amperes and can be adjusted to increase the limit up to the maximum output current rating of the amplifier using an external resistor (R_x). (See eq. 1 and eq. 2.)

DYNAMIC OUTPUT IMPEDANCE: The impedance between the output pins when there is an output voltage variation and the amplifier is not saturated.

DC DEADBAND: A range over which no output change is produced by input variations. Special circuitry minimizes deadband especially in the current amplifier mode.

SLEW RATE: The maximum rate of change of the output voltage with respect to time that the amplifier can produce in its linear operating region with unity gain.

Frequency Response

SMALL SIGNAL. Small signal frequency response is defined as the frequency at which the output voltage amplitude decreases to .707 of its DC value when developed across the rated load resistance of the amplifier with a nominal output of 3 volts peak-to-peak.

LARGE SIGNAL: Large signal frequency response is defined as the frequency at which the output voltage amplitude decreases to .707 of its DC value when developed across the rated load resistance of the amplifier with full rated output voltage.

Offset Adjustment

VOLTAGE AMPLIFIER MODE: To null out offset, depending upon its polarity, a resistance should be connected between terminals 7 and 9, or in series with terminal 4. In the latter case, terminal 7 should be tied directly to terminal 9.

CURRENT AMPLIFIER MODE: A potentiometer should be connected between a regulated positive or negative voltage and terminal number 9. The wiper should be tied to terminal number 7.

In either of the aforementioned cases, the magnitude of acceptable offset in a particular application depends upon the magnitude of dc gain in front of the device, i.e., assuming that an external operational amplifier is used.

Matching the DC servo amplifier with a DC Torque Motor.

AMPLIFIER SELECTION BASED ON WATTS REQUIRED — Assuming that a DC torque motor has been selected based on size, torque, and power requirements, a match can then be achieved between the numerous possible windings for the motor and the various output voltage and current ratings of the DC servo amplifier line.

The amplifiers are categorized in terms of output wattage, and a tentative choice of an amplifier can be made on the basis of the maximum input watts needed to operate the motor. Input watts are equal to the output watts plus watts losses as expressed by the following equation:

Input Watts = output watts + watts losses

Output **Arm. Losses** **Running Losses** **Accel, Losses**

$$W_{in} = C_F\omega T_L + \frac{T_D^2}{K_M^2} C_R + C_F\omega(T_F + \omega F_I) + C_F\omega\alpha(J_M + J_L) \quad \text{Eq. 3}$$

Assume that a motor is required to drive a load at a constant speed. The watts required would involve the output term plus the internal losses. The acceleration term could be neglected. The watts that the amplifier must supply will be:

$$W_{in} = C_F\omega T_L + \frac{T_D^2}{K_M^2} C_R + C_F\omega (T_F + \omega Fi)$$

Stall watts would be simply: Eq. 4

$$W_{stall} = \frac{T_D^2}{K_M^2} C_R$$

This value of watts would enable a tentative amplifier choice to be made. The output voltage and current would need to be determined as well as the output power derating of the amplifier based on the dissipation and mounting surface temperature. The amplifier dissipation is primarily dependent upon the output voltage requirement so that a suitable motor winding should be selected to achieve an acceptable level of dissipation for the amplifier.

MOTOR VOLTAGE RELATION TO AMPLIFIER DISSIPATION

The values of voltage and current required are dependent upon the winding constants of the motor. These constants can be shifted higher or lower by the relationships given in Table A. Because the amplifiers must dissipate unused power (volts times current) from a constant-voltage power source, the most efficient match is obtained whenever the voltage needed is just slightly less than the rated output voltage of the amplifier. The amplifier dissipation that results must then be controlled by ambient temperature, heatsink, fan cooling, or combinations of these temperature reduction techniques.

Table A

WINDING CONSTANT		NEW VALUE FOR LOWER VOLTAGE	NEW VALUE FOR HIGHER VOLTAGE
DC resistance (25°C)	R_M	$R_M / (1.59)^n$	$R_M \times (1.59)^n$
Voltage, stalled at T_p	V_P	$V_P / (1.26)^n$	$V_P \times (1.26)^n$
Peak current	I_P	$I_P \times (1.26)^n$	$I_P / (1.26)^n$
Torque sensitivity	K_T	$K_T / (1.26)^n$	$K_T \times (1.26)^n$
Back EMF constant	K_B	$K_B / (1.26)^n$	$K_B \times (1.26)^n$
Inductance	L_M	$L_M / (1.59)^n$	$L_M \times (1.59)^n$

Where n is a whole number representing the change in AWG wire size numbers higher or lower than that used in a winding.

AMPLIFIER SELECTION BASED ON OPERATIONAL PROFILE: Assume an operation profile as depicted by the shaded area of Figure 6. The maximum current requirement would occur at the highest shaft torque point plus any frictional and running torque components. From the figure, maximum current would be

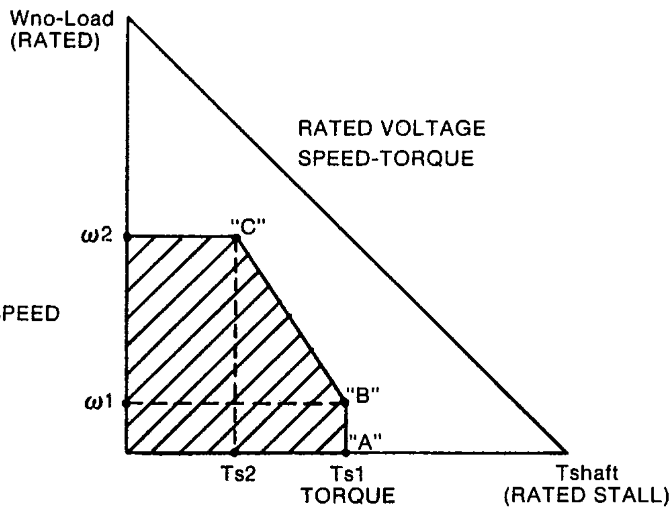

FIGURE 6

required at Point "B", neglecting any acceleration factors.

$$I_{max_B} = \frac{T_F + \omega_1 F_I + T_{S1}}{K_{T(min)}} \qquad \text{Eq. 5}$$

The maximum voltage requirement would occur at the operating point nearest the rated voltage speed-torque curve. From the figure, maximum voltage would be required at point "C".

$$V_{max_C} = \frac{(T_F + \omega_2 F_I + T_{S2})}{K_T(min)} R_M C_R + \omega_2 K_B \qquad \text{Eq. 6}$$

TEMPERATURE DEPENDENCE OF AMPLIFIER OUTPUT: The amplifier dissipation is a factor that influences the heatsink mounting surface temperature and therefore limits the amount of output power that can be obtained for mounting surface temperatures between 25°C and 125°C. In order to minimize this loss in output power capability, the amplifier dissipation must be determined, the case temperature calculated, and the output power derated accordingly. For any operational profile, the dissipation should be determined for the worst-case operation. Usually it is necessary to consider both the stall and the run conditions:

STALL CONDITION

$$W_{DISS} = I_M(V_S - 3 - V_M)$$

Where: $I_M = \dfrac{T_L + T_F}{K_T}$

$$V_M = I_M R_M CR$$

Eq. 7

RUN CONDITION

$$W_{DISS} = I_M{}^1 (V_S - 3 - V_M{}^1)$$

Where: $I_M{}^1 = \dfrac{T_L + T_F + \omega F_I}{K_T}$

$$V_M{}^1 = I_M{}^1 R_M CR + \omega K_B$$

Eq. 8

Examination of the two equations for operation within the shaded area of Figure 6 reveals that the worst-case amplifier dissipation would occur on the stall torque axis. As soon as the motor begins to rotate, the ωK_B term will act to decrease the voltage difference faster than the motor current can increase. The maximum amplifier dissipation on the stall torque axis is found by the following equation:

$$\text{Worst Case Amp. Diss. @ Stall} = \frac{(V_S - 3)^2}{4R_M} \qquad \text{Eq. 9}$$

Protection for the amplifier is needed for plug operation. A plug condition can occur whenever the motor is operating at a speed in one direction of rotation and is suddenly commanded to stop or reverse direction of rotation. The current during plug conditions will rise to the current limit value, and the amplifier must be able to dissipate this extra power transiently or in a duty cycle that will maintain the amplifier mounting surface temperature at a value that will allow the extra watts to be dissipated.

The peak instantaneous watts that the amplifier must dissipate is determined by:

$$W_{DP} = (V_S + \omega K_B - I_{CL} R_M) I_{CL} \qquad \text{Eq. 10}$$

If the wattage so determined cannot be dissipated by the amplifier, the duty cycle must be altered, the current must be reduced, a series resistor added, or an amplifier with a larger dissipation capability selected.

For other operational profiles, the maximum voltage, current and amplifier dissipation can be found using the basic equations for selected points within the profile.

The mounting surface temperature of the modular amplifier depends upon the amplifier dissipation, thermal resistance of the heatsink and the ambient temperature. These variables are related as follows:

$$T_S = (W_{DISS} + 1)\theta_{SA} + T_{amb} \qquad \text{Eq. 11}$$

The allowable dissipation at this surface temperature is determined by the following equation:

$$W_{DT} = W_{DA} - (T_S - 25)\, D_F \qquad \text{Eq. 12}$$

If the allowable watts are less than the output watts needed then four alternatives are available:

ALTERNATIVE 1: Use a heatsink with a lower thermal resistance or use fan cooling.

ALTERNATIVE 2: Use a series power resistor to reduce the dissipation in the amplifier.

ALTERNATIVE 3: Select another amplifier with a larger dissipation rating.

ALTERNATIVE 4: Contact the factory for verification of a different motor winding to more closely match the output voltage capability of the amplifier.

Specialty Products Division
INLAND MOTOR
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