
Harmonica Digital Servo Drive Technical Specifications



March 2004

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Harmonica Catalog Number:	HAR-<u>AXX</u>/<u>YYY</u>IC Version: _ = Standard A = Advanced Current (Amps) Maximum Operating Voltage Communication: _ = RS-232 C = CANopen Feedback: _ = Incremental Encoder R = Resolver I = Interpolated Analog Encoder
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1. Features

1.1 Motion Control Modes

- Current/Torque - up to 14 KHz sampling rate
- Velocity - up to 7 KHz sampling rate
- Position - up to 3.5 KHz sampling rate

1.2 Advanced Positioning Motion Control Modes

- PTP, PT, PVT, ECAM, Follower, Pulse and Direction, Dual Loop
- Fast event capturing inputs
- Fast output compare (OC)

1.3 Advanced Filters and Gain Scheduling

- “On-the-Fly” gain scheduling of current and velocity
- Velocity and position with “1-2-4” PIP controllers.
- Automatic commutation alignment
- Automatic motor phase sequencing

1.4 Fully Programmable

- Third generation programming structure with motion commands
- Event capturing interrupts
- Event triggered programming

1.5 Feedback Options

- Incremental Encoder – up to 20 Mega-Counts (5 Mega-Pulse)
- Digital Halls – up to 2 KHz
- Incremental Encoder with Digital Halls for commutation – up to 20 Mega-Counts
- Absolute Encoder
- Interpolated Analog Sine/Cosine Encoder – up to 250 KHz
 - Internal Interpolation - up to X4096
 - Automatic Correction of amplitude mismatch, phases mismatch, signals offset
 - Encoder outputs, buffered, differential.
- Resolver
 - Programmable 10~15 bit resolution
 - Up to 512 Revolution Per Second (RPS)
 - Encoder outputs, buffered, differential
- Elmo drives provide supply voltage for all the feedback options

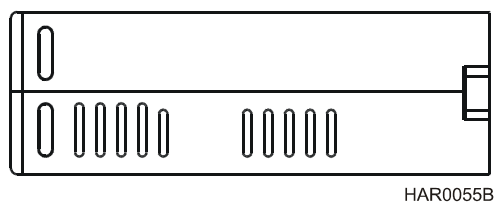
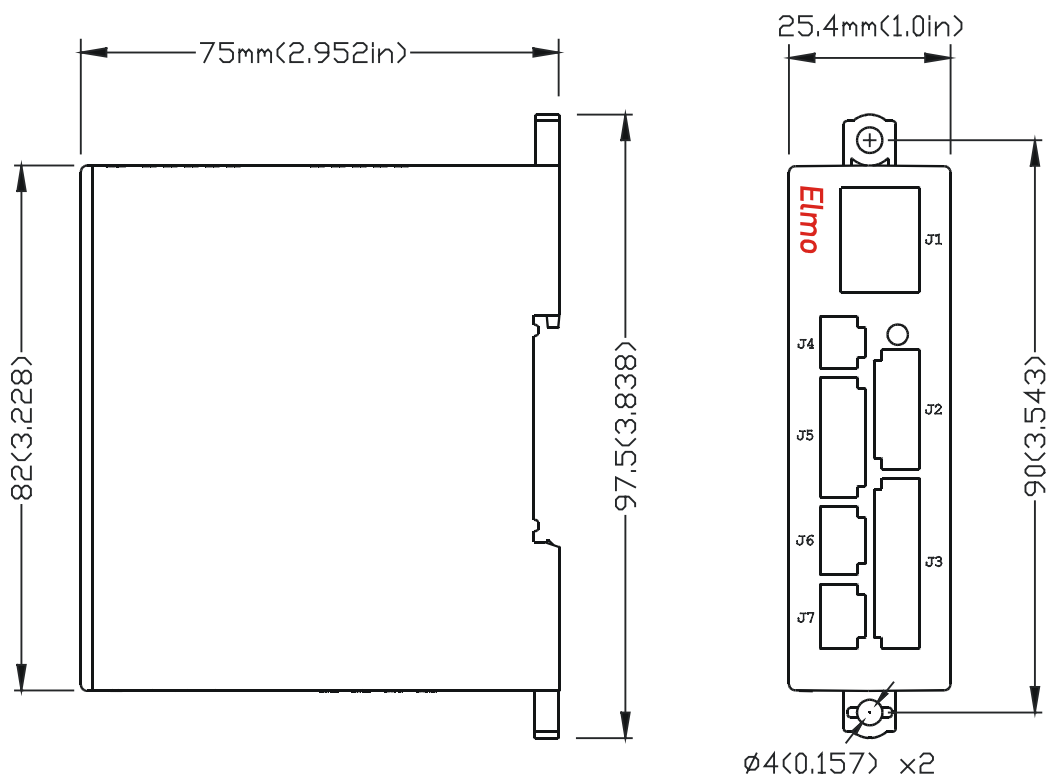
1.6 Input/Output

- Analog Inputs with up to 14-bit resolution
- Programmable digital inputs, optically isolated
 - Inhibit \ Enable motion
 - Software and analog reference stop
 - Motion limit switches
 - Begin on input
 - Abort motion
 - General-purpose
 - Homing
- Fast event capture inputs, optically isolated
- Programmable digital outputs
 - Brake Control
 - Amplifier fault indication
 - General-purpose
 - Servo enable indication
- Buffered and differential outputs of the main encoder with up to 5 MHz pulses
- Emulated output of the resolver or interpolated analog encoder
- Fast output compare (OC), optically isolated

1.7 Built-In Protection

- Software error handling
- Abort (hard stops and soft stops)
- Status reporting
- Protection against
 - Shorts between motor power outputs
 - Shorts between motor power output and power input return
 - Failure of internal power supplies
 - Overheating
 - Over/Under voltage
 - Loss of feedback
 - Following error
 - Current limits

2. Harmonica Dimensions



3. General Specifications

Feature	Unit	5/60	8/60	12/60	2/100	4/100	8/100	12/100	1/200	2/200	4/200	6/200
Minimum Supply Voltage	VDC	10			20				40			
Nominal Supply Voltage	VDC	55			85				180			
Maximum Supply Voltage	VDC	59			95				195			
Maximum Output Power from the Drive	W	250	410	670	210	320	660	1080	210	330	660	1110
Efficiency at Rated Power	%	> 97										
DC (trapezoidal Commutation) Continuous RMS Current limit (Ic)	A	5	8	13.3	2.5	4	8	13.3	1.25	2	4	6.6
Sinusoidal Commutation Continuous RMS Current limit (Ic)	A	3.5	5.7	9.4	1.8	2.8	5.7	26.6	0.9	1.4	2.8	4.7
Peak current limit (RMS)	A	2 x Ic										
RMS output power without heatsink	%	100	50	20	100	50	20	20	100	50	20	20
PWM Switching Frequency	KHz	22 +/-5% default on the motor										
Switching Method		Advanced Unipolar PWM										
Weight		150 grams (5.3 ounces)										
Dimensions		82 x 25.4 X 75 mm (3.2" x1.0" x 3.0")										
Mounting Method		Wall Mount ("Bookshelf") or DIN Rail										
Digital In / Digital Out / Analog In		6 / 2 / 1										

*50V models are no longer available for new designs

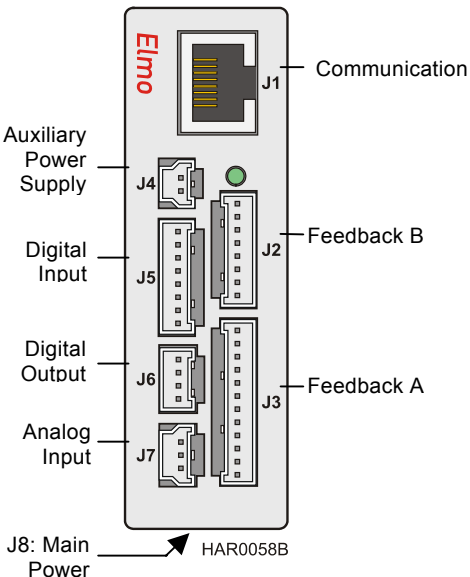
4. Environmental Conditions

Feature	Details
Operating ambient temperature	0° ~ 40° C (32° ~ 104° F)
Storage temperature	-20° ~ +85° C (-4° ~ +185° F)
Humidity	90% maximum non-condensing
Maximum Operating Altitude	10,000m (30,000 feet)
Protection level	IP20

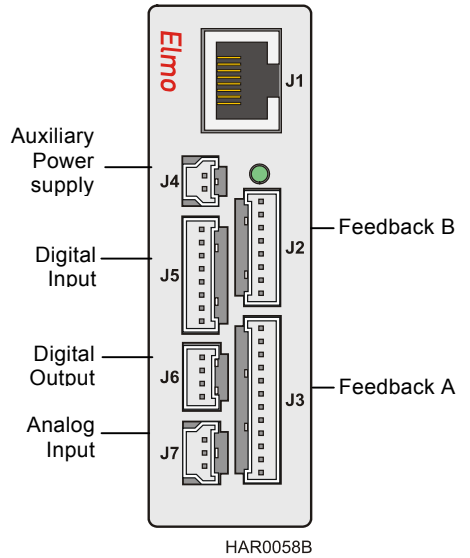
5. Harmonica Connectors

5.1 Connector Types

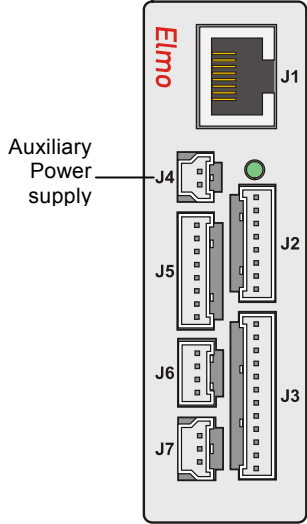
The table below shows the connector panel of the Harmonica. The *Harmonica Cable Starting Kit* (Cat. No. HAR-CABLEKIT) describes each connector cable in great detail.

Pins	Type	Connector Maker & No. / Mating Plug (on Cable)	Port	Connector Location
8	RJ-45	RJ-45 jack / mates with RJ-45 plug	J1	
8	2 mm Pitch	Molex 35363-0800 / mates with 35507-0800	J2	
12	2 mm Pitch	Molex 35363-1200 mates with 35507-1200	J3	
2	2 mm Pitch	Molex 35363-0200 mates with 35507-0200	J4	
8	2 mm Pitch	Molex 35363-0800 mates with 35507-0800	J5	
4	2 mm Pitch	Molex 35363-0400 mates with 35507-0400	J6	
3	2 mm Pitch	Molex 35363-0300 mates with 35507-0300	J7	
7	5.08 mm Pitch Terminal Block	Phoenix MSTBA 2.5/7-G-5.08 with MSTB 2.5/7-ST-5.08	J8	J8: Main Power

5.2 Control and Feedback Connector Specifications

Feature	Details	Connector Location
Product name	Sherlock	
Manufacturer	Molex	
Wire size	24, 26, 28, 30 AWG	
Maximum current	2 A	
Temperature range	-40° to 105° C (-40° to 221° F)	
Plating contact	Tin/Lead (Sn/Pb)	
Maximum voltage	125 V	
Contact resistance	< 20 mΩ	
Withstanding voltage	500 VAC	
Insulation resistance	> 1000 MΩ	
Terminal contact	Phosphor bronze	
UL files	E29179, UL 94 V-0	
Cable connector	Molex 35507-XX00, where XX is the number of leads	
Hand crimper	Molex 63811-1200	
Crimp terminal	Molex 50212	

6. Auxiliary Power Supply (J4)

Feature	Details	Connector Location
Auxiliary power supply	<i>DC source only</i>	 Auxiliary Power supply J1 J4 J5 J6 J7 J2 J3 HAR0058B
Auxiliary supply input voltage	24 V $\pm$ 20%	
Auxiliary supply input power	8 VA (maximum)	

7. Control Specifications

7.1 Current Loop

Feature	Details
Controller type	Vector, digital
Compensation for bus voltage variations	On-the-fly automatic gain scheduling
Motor types	- AC brushless (sinusoidal) - DC brushless (trapezoidal) - DC brush - Linear Motors - Moving coils
Current control	- Fully digital - Sinusoidal with vector control - Programmable PI control filter based on a pair of PI controls of AC current signals and constant power at high speed
Current loop bandwidth	> 2.5 KHz
Current sampling time	<i>Programmable 70 ~ 100 μsec</i>
Current sampling rate	<i>up to 16 KHz</i>

7.2 Velocity Loop

Feature	Details
Controller type	PI
Velocity control	- Fully digital - Programmable PI and FFW control filters - On-the-fly gain scheduling - Automatic, manual and advanced manual tuning
Velocity and position feedback options	- Incremental Encoder - Digital Halls - Interpolated Analog (sin/cos) Encoder (optional) - Resolver (optional)
Velocity command options	- Analog - Internally calculated by either jogging or step Note: All software-calculated profiles support on-the-fly changes.
Velocity loop bandwidth	> 350 Hz
Velocity sampling time	140 - 200 μ sec (x2 current loop sample time)
Velocity sampling Rate	up to 8 KHz

7.3 Position Loop

Feature	Details
Controller type	"1-2-4" PIP
Position command options	- Software - Pulse and Direction - Analog Potentiometer
Position loop bandwidth	> 80 Hz
Position sampling time	280 - 400 μ sec (x 4 current loop sample time)
Position sampling rate	up to 4 KHz

8. Feedback

8.1 Feedback Supply Voltage

Feature	Details
J3 (main encoder) supply voltage	5 V $\pm 5\%$ @ 200 mA maximum
J2 (auxiliary encoder) supply voltage	5 V $\pm 5\%$ @ 200 mA maximum

8.2 Incremental Encoder

Feature	Details
Encoder format	- A, B and Index - Differential - Quadrature
Interface:	RS-422
Input resistance:	Differential: 120 Ω
Maximum incremental encoder frequency:	Maximum absolute: 5 MHz pulses
Minimum quadrature input period (P_{IN})	112 nsec
Minimum quadrature input high/low period (P_{HL})	56 nsec
Minimum quadrature phase period (P_{PH})	28 ns
Maximum encoder input voltage range	Common mode: $\pm 7V$ Differential mode: $\pm 7V$

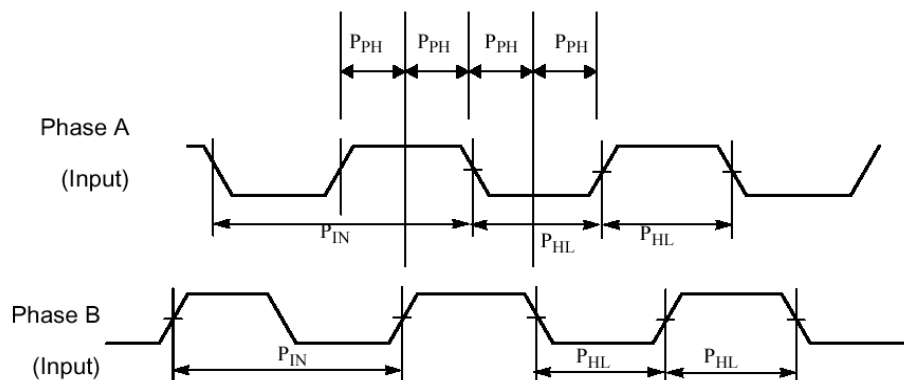


Figure 1: Encoder Phase Diagram

8.3 Digital Halls

Feature	Details
Halls inputs	▪ H_A, H_B, H_C. ▪ Single ended inputs ▪ Built in hysteresis for noise immunity.
Input voltage	Nominal operating range: $0V < V_{In_Hall} < 5V$ Maximum absolute: $-1V < V_{In_Hall} < 15V$ High level input voltage: $V_{InHigh} > 2.5V$ Low level input voltage: $V_{InLow} < 1V$
Input current	Sink current (when input pulled to the common): 3ma Source current: 1.5 ma (designed to also support open collector Halls)
Maximum frequency	$f_{MAX} : 2 \text{ KHz}$

8.4 Interpolated Analog Encoder (Sine/Cosine)

Feature	Details
Analog encoder format	Sine and Cosine signals
Analog input signal level	Offset voltage: 2.2 V – 2.8 V Differential, 1V peak to peak
Input resistance	Differential 120 Ω
Maximum analog signal frequency	$f_{MAX} : 250 \text{ kHz}$
Interpolation multipliers	Programmable: x4 to x4096
Maximum “counts” frequency	20 mega-counts/sec
Automatic errors correction	Signals amplitude mismatch Signals phase shift Signals offset
Encoder outputs	See 8.6

8.5 Resolver

Feature	Details
Resolver format	- Sine/Cosine - Differential
Input resistance	Differential 2.49 K Ω
Resolution	Programmable: 10 ~ 15 bits
Maximum electrical frequency (RPS)	512 revolutions/sec
Resolver transfer ratio	Meets ratio of 0.5
Reference frequency	1/Ts (Ts = sample time in KHz)
Reference voltage	Supplied by the Harmonica
Reference current	up to ± 50 mA
Encoder outputs	See 8.6

8.6 Encoder Outputs

Feature	Details
Encoder output format:	- A, B, Index - Differential outputs - Quadrature
Interface	RS-422
Output current capability:	Driving differential loads of 200 Ω
Available at options	- Buffered outputs of main-input incremental encoder - Emulated encoder outputs of analog encoder - Emulated encoder outputs of the resolver
Maximum frequency	f _{MAX} : 5 MHz pulses/output
Edge separation between A & B	Programmable number of clocks to allow adequate noise filtering at remote receiver of emulated encoder signals
Index (marker):	Length of pulse is one quadrature (one quarter of an encoder cycle) and synchronized to A&B

9. I/O's

The Harmonica has: 6 Digital Inputs 2 Digital Outputs 1 Analog Input

9.1 Digital Input Interfaces

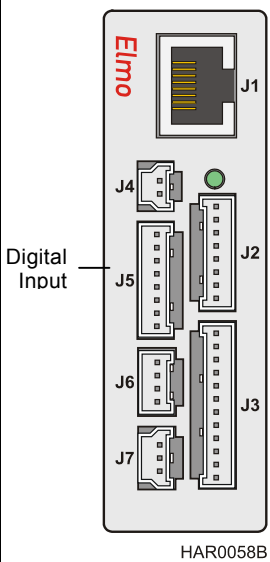
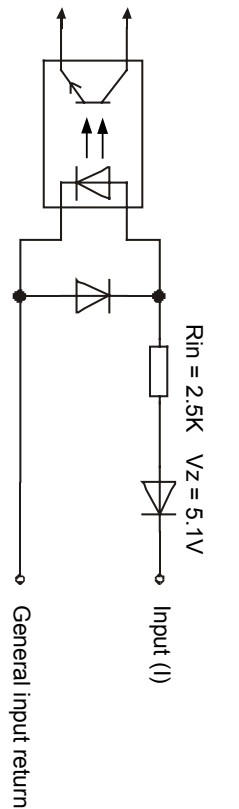
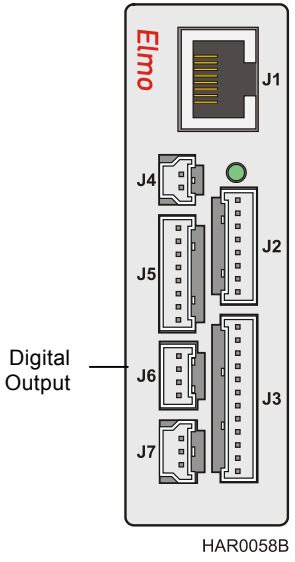
Feature	Details	Connector Location
Type of input	- Optically isolated - Single ended	
Input current	$I_{in} = \frac{V_{in} - 6.5V}{2500\Omega}$ * $I_{in} = 2.2 \text{ mA} @ V_{in} = 12 \text{ V}$	
Input current for high speed inputs	$I_{in} = \frac{V_{in} - 6.5V}{1250\Omega}$ * $I_{in} = 4.4 \text{ mA} @ V_{in} = 12 \text{ V}$	
High-level input voltage	$12 \text{ V} < V_{in} < 30 \text{ V}$, 24 V typical	
Low-level input voltage	$0 \text{ V} < V_{in} < 6.5 \text{ V}$	
Minimum pulse width	$> 4 \times TS$, where TS is sampling time	
Analog input command resolution	12-bit inputs	
I/O inputs	PLC level only	
Execution time (all inputs): the time from application of voltage on input until execution is complete	If input is set to one of the built-in functions – Home, Inhibit, Hard Stop, Soft Stop, Hard and Soft Stop, Forward Limit, Reverse Limit or Begin – execution is immediate upon detection: $0 < T < 4 \times TS$ If input is set to General input, execution depends on program. Typical execution time: $\cong 0.5 \text{ msec.}$	
High-speed inputs - minimum pulse width, in high-speed mode	$T < 5 \mu\text{sec}$ Notes: - Home mode is high-speed mode and can be used for fast capture and precise homing. - High speed input has a digital filter set to same value as digital filter (EF) of main encoder. - Highest speed is achieved when turning on optocouplers.	

Figure 2: Digital Input Schematic

9.2 Digital Output Interface

Feature	Details	Connector Location
Type of output	- Optically isolated - Open collector and open emitter	 HAR0058B
Maximum supply output (Vcc)	30 V	
Maximum output current Io (max) (Vout = Low)	$I_{out} (max) \leq 10 \text{ mA}$	
VOL @ maximum output voltage (low level)	$V_{out} (on) \leq 0.3 \text{ V} + 0.02 * I_{out} (10\text{mA})$	
RL	External resistor RL must be selected to limit output current to no more than 10 mA. $R_L = \frac{V_{cc} - VOL}{I_o(max)}$	
Executable time	If output is set to one of the built-in functions – Home flag, Brake or AOK – execution is immediate upon detection: $0 < T < 4 \times TS$ If output is set to General output and is executed from a program, the typical time is approximately 0.5 msec.	

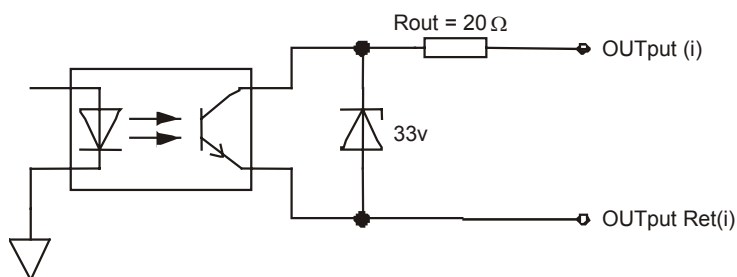
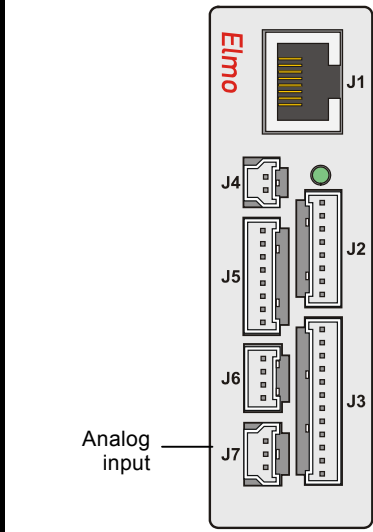
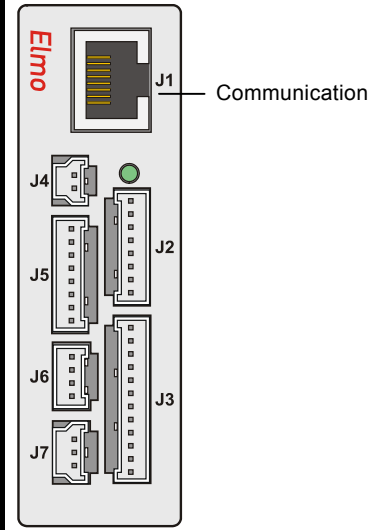


Figure 3: Digital Output Schematic

9.3 Analog Input (J7)

Feature	Details	Connector Location
Maximum operating differential mode voltage	± 10 V	
Maximum absolute differential input voltage	± 16 V	
Differential input resistance	3 K Ω	

10. Communications

Specification	Details	Connector Location
RS-232	Signals: - RxD , TxD , Gnd - Full duplex, serial communication for setup and control. - Baud Rate of 9,600 ~ 57,600 bits/sec.	
CANopen	CANbus Signals: - CAN_H, CAN_L, CAN_GND - Maximum Baud Rate of 1 Mbits/sec. Version: - DS 301 V4.01 Device Profile (drive and motion control): - DSP 402	

11. Pulse Width Modulation (PWM)

Feature	Details
PWM resolution	12-bit
PWM switching frequency on the load	2/ Ts (factory default 22 kHz on the motor)

12. Heatsink Specifications

The following table indicates the RMS output power when operating the Harmonica at nominal DC bus voltage:

Harmonica	5/60	8/60	12/60	2/100	4/100	8/100	12/100	1/200	2/200	4/200	6/200
RMS output power without heatsink (%)	100	50	20	100	50	20	20	100	50	20	20

*50V models are no longer available for new designs

If the input voltage is lower, the RMS output current without a heatsink is higher.

Three types of heatsinks are recommended for ensuring maximum continuous output power of the drive:

- Flat plate heatsink
- Fin heatsink
- L-Shaped heatsink

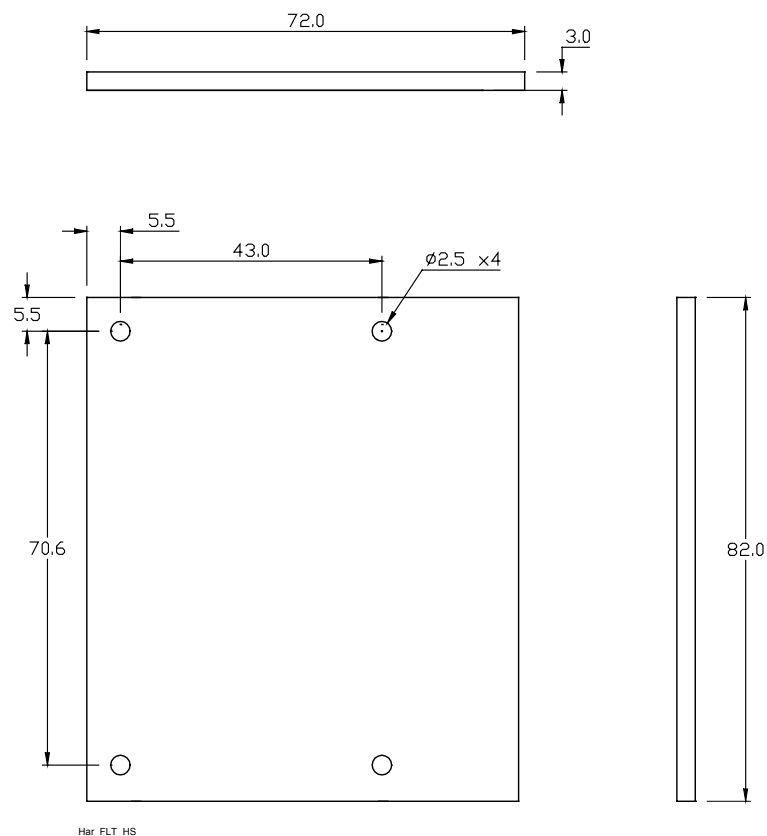
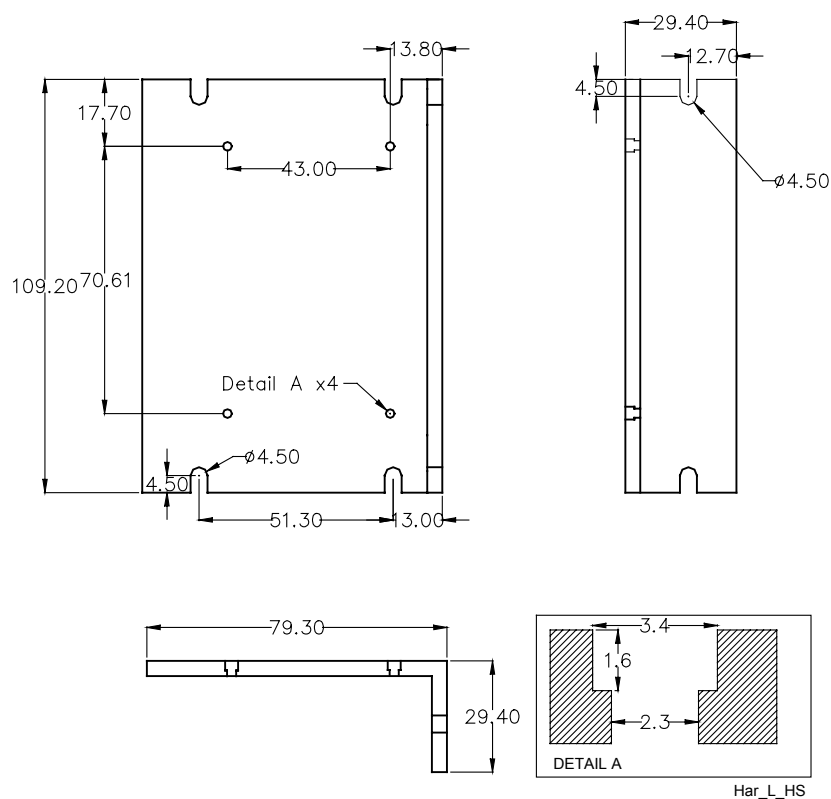
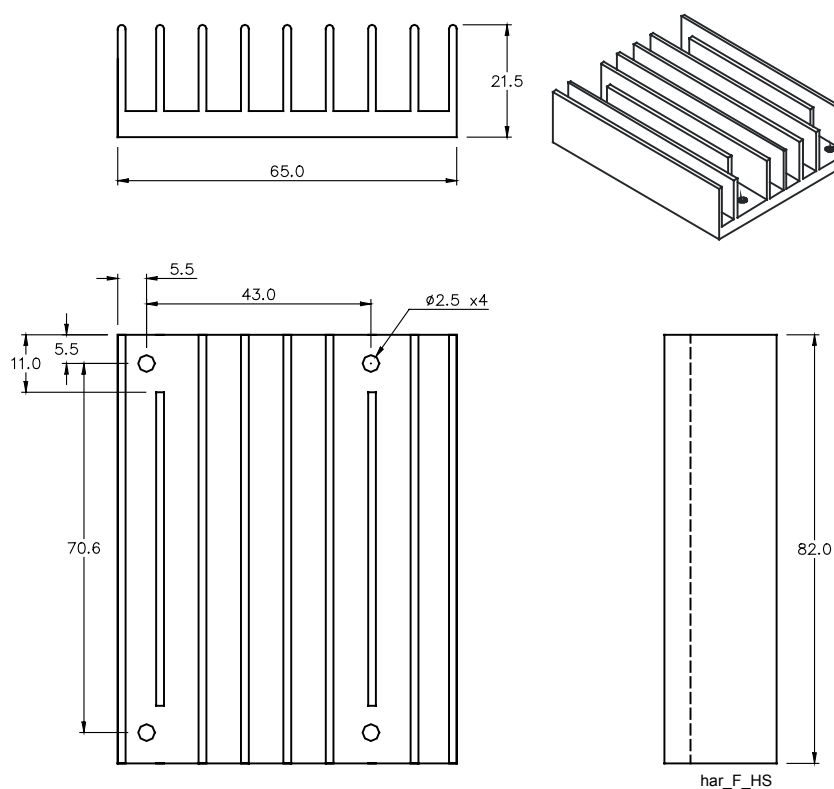


Figure 4: Flat-Plate Heatsink Dimensions



13. Standards Compliance

13.1 Quality Assurance

Specification	Details
ISO 9001:2000	Quality Management

13.2 Design

Specification	Details
MIL-HDBK- 217F	Reliability prediction of electronic equipment (rating, de-rating, stress, etc.)
▪ IPC-D-275 ▪ IPC-SM-782 ▪ IPC-CM-770 ▪ UL508c ▪ UL840	Printed wiring for electronic equipment (clearance, creepage, spacing, conductors sizing, etc.)
In compliance with IEC68	Type testing

13.3 Safety

Specification	Details
Recognized UL508c	Power conversion equipment
In compliance with UL840	Insulation coordination, including clearance and creepage distances of electrical equipment
In compliance with UL60950	Safety of information technology equipment, including electrical business equipment
In compliance with EN60204-1	Low voltage directive, 73/23/EEC

13.4 EMC

Specification	Details
In compliance with EN55011 Class A with EN61000-6-2: Immunity for industrial environment, according to: IEC61000-4-2 / criteria B IEC61000-4-3 / criteria A IEC61000-4-4 / criteria B IEC61000-4-5 / criteria B IEC61000-4-6 / criteria A IEC61000-4-8 / criteria A IEC61000-4-11 / criteria B/C	Electromagnetic compatibility (EMC)

13.5 Workmanship

Specification	Details
In compliance with IPC-A-610, level 2	Acceptability of electronic assemblies

13.6 PCB

Specification	Details
In compliance with IPC-A-600, level 2	Acceptability of printed circuit boards

13.7 Packing

Specification	Details
In compliance with EN100015	Protection of electrostatic sensitive devices