LOGOSOL

Two-Axis Sinusoidal Brushless Servo Controller With Built-In Power Amplifiers

LS-221-BL

Technical Reference

Document No 710220125 / Rev. 1.1 - April, 1999

The information in this data book has been carefully checked and is believed to be reliable, however, no responsibility can be assumed for inaccuracies. All information in this manual is subject to change without notice and does not represent a commitment on the part of the vendor.

FlexWare™ is trademark of Logosol, Inc.

Trademarks are used throughout the manual only as reference to existing common products. If a registered trademark is used without being indicated as such, this does not imply that the name is free.

LS-221-BL Technical Reference
Document No 7102201125 / Rev. 1.1 - April, 1999

Logosol, Inc.
1155 Tasman Drive, Sunnyvale, CA 94089
Tel: (408) 744-0974
Fax: (408) 744-0977
Http://www.logosolinc.com

Contents

1. OVERVIEW

Logosol LS-221-BL is a precision highly integrated 2-axis digital servo controller with built-in power amplifiers. LS-221-BL is specially designed to control 3-phase brushless motors with integrated Hall-sensors and quadrature incremental encoders. The unique **FlexWare™** design allows flexible wiring and assignment of all inputs and outputs to meet specific requirements.

FEATURES

- 2-axis
- Modular design
- ISA bus plug-in board
- DSP technology. PMD MC1231A based
- Sinusoidal commutation
- S-curve profile
- Programmable output current limit/shut down
- Quadrature incremental encoder interface (encoder power supply provided)
- Multi-turn absolute position encoder interface (power and backup supply provided)
- Additional general purpose optoisolated inputs and outputs
- Flexible wiring
- Emergency stop input

TECHNICAL SPECIFICATIONS

Motion Control

Output	
commutation waveform	sinusoidal
PWM phases	3 per axis
PWM resolution	10 bit @ 25KHz
min load inductance	200µH
typical motor power supply voltage range	24÷80 VDC
undervoltage shutdown	18 VDC
overvoltage shutdown	100 VDC
max continuous current per channel	8.5A
max short term current per channel (t < 10 sec)	10A
max continuous current per board	16A
programmable current limit for each channel	2-10A
Encoder	
type	incremental A, B, Z
max pulse frequency	1 MHz
optoisolated encoder inputs	5V/20mA
Hall-sensors	
type	120 degrees
optoisolated Hall-sensor inputs	5V/20mA

Digital I/O lines

16 general-purpose optoisolated digital inputs	24V/10mA
6 of the inputs may serve as high speed position capture strobes	
8 open collector outputs with short circuit protection	
max output voltage	48V

max current per output	1A
max current per board	5A
3 relay controlled 24 V power supplies	
relay type	OMRON G6B
max current	5A/30V DC
contact resistance	30mΩ
mechanical contact reliability	20×10^6

Power Requirements

computer power supply	+5V ± 5% / 1A
	+12V ± 5% /1A
external operating power	24V DC ± 20%
external motor power	24÷80V DC

2. REQUIREMENTS

Logosol LS-221-BL is a plug-in board for a standard ISA bus system. To operate LS-221-BL, the following requirements must be fulfilled.

- ISA bus system.
- One free 8-bit or 16-bit bus slot. LS-221-BL itself requires space for two single PC-boards, though only one bus slot connector is occupied
- A minimum of 512 Kbytes conventional RAM installed
- A free I/O address range x280÷x28F or x2A0÷x2AF, where x may be 0, 1, 2, 3
- Power supply: +5V ± 5% / 1A, +12V ± 5% /1A
- An external operating power: 24V DC ± 20%
- An external motor power in the range: 24÷80V DC (see note)

> Note: Motor power supply **must** be electrically isolated from computer ground and from operating power supply (floating power supply).

- A fan is required when driving high power motors (greater than 48V@3A)

3. INSTALLATION

Note: LOGOSOL assumes no responsibility for any damage occurred to your system or your health, due to improper installation. LS-221-BL is a professional industry application product and is designed to be operated by electronic engineers only. Installation of any hardware in your system requires you to be familiar with the service and maintenance of the personal computer.

Ask a computer service engineer to assist you if you are not familiar with electronics.

Installation Checklist

- Disconnect the power from target system. Never touch the electronics while the power is on. This protects you and your electronics.
- Touch the ground. Touch electrical ground to eventually unload your body from static electricity.
- Setup the board. Select the I/O address with J1 jumper block. Optionally select IRQ line with J2 jumper block. Setup Servo off Mode (J4) and Current Limit Mode (J3).
- Plug in the main power connector CN3. Check power supply – motor power (24÷80V) and operating power (24V). Make sure the emergency stop contact between pins 7 & 8 of CN3 connector is closed.
- Install the board. Plug in LS-221-BL into a free bus slot. Any slot may be used.
- Screw the Board. Fix LS-221-BL with a screw to the chassis. Never switch on the power without LS-221-BL being fixed to the chassis. The board might have tilted within the slot and shortcut the bus with unpredictable results.
- Test the installation. Switch on your system and check whether the board does not influence the normal computer operation. Switch on the LS-221-BL external power supply. Run the application software.

4. BOARD DESCRIPTION

Logosol LS-221-BL is highly integrated 2-axis digital servo controller with built-in power amplifiers designed to control 3-phase brushless motors with integrated Hall-sensors and quadrature incremental encoders. It is intended for high precision and high reliability industrial applications. The board is designed as a plug-in board for PC/AT compatible computers with ISA bus. The unique **FlexWare™** design allows flexible wiring and pin assignment to meet specific requirements and to achieve compatibility with an existing hardware. To attain a high reliability of operation in industrial environments, all inputs and outputs are optoisolated from the computer ground. LS-221-BL is an assembly of a mother-board called Base Module (BM), a plug-in board that caries all input circuits - Input Board (IB), and Interface Wiring (IW) to connect BM and IB to LS-221-BL front panel connector.

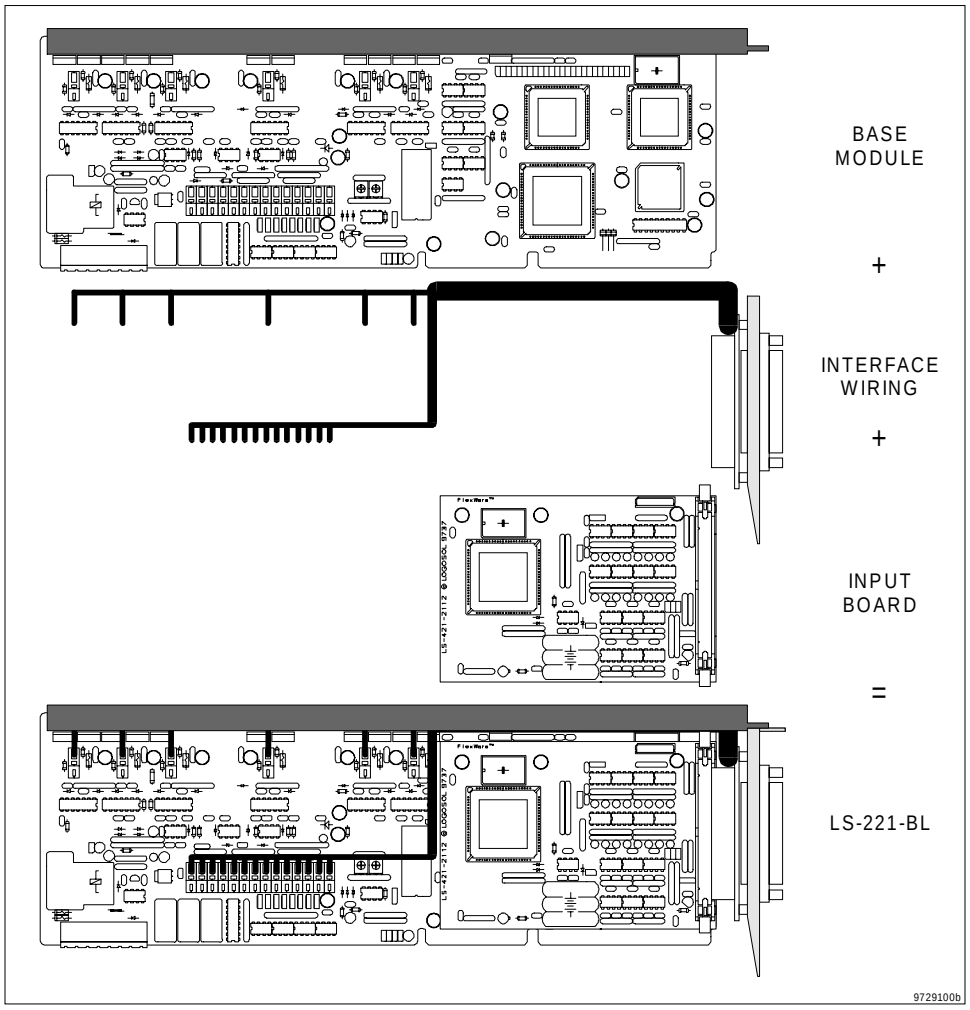


Figure 1: LS-221-BL main components

To deliver a maximum performance and flexibility LS-221-BL is designed using the latest technologies. The onboard 25MHz PMD MC1231A DSP processor guaranties precise and smooth motion control and saves the host computer's time. All input, output and control signals

are processed by ISP (In-System Programmable) chipset to allow fast and easy user-defined customizations.

LS-221-BL controller is equipped with various hardware safety features - emergency stop input, output overload protection, amplifier overcurrent protection, undervoltage and short circuit protection. A dedicated diagnostic logic allows to identify the reason for breaking of the servo loop (amplifier disable).

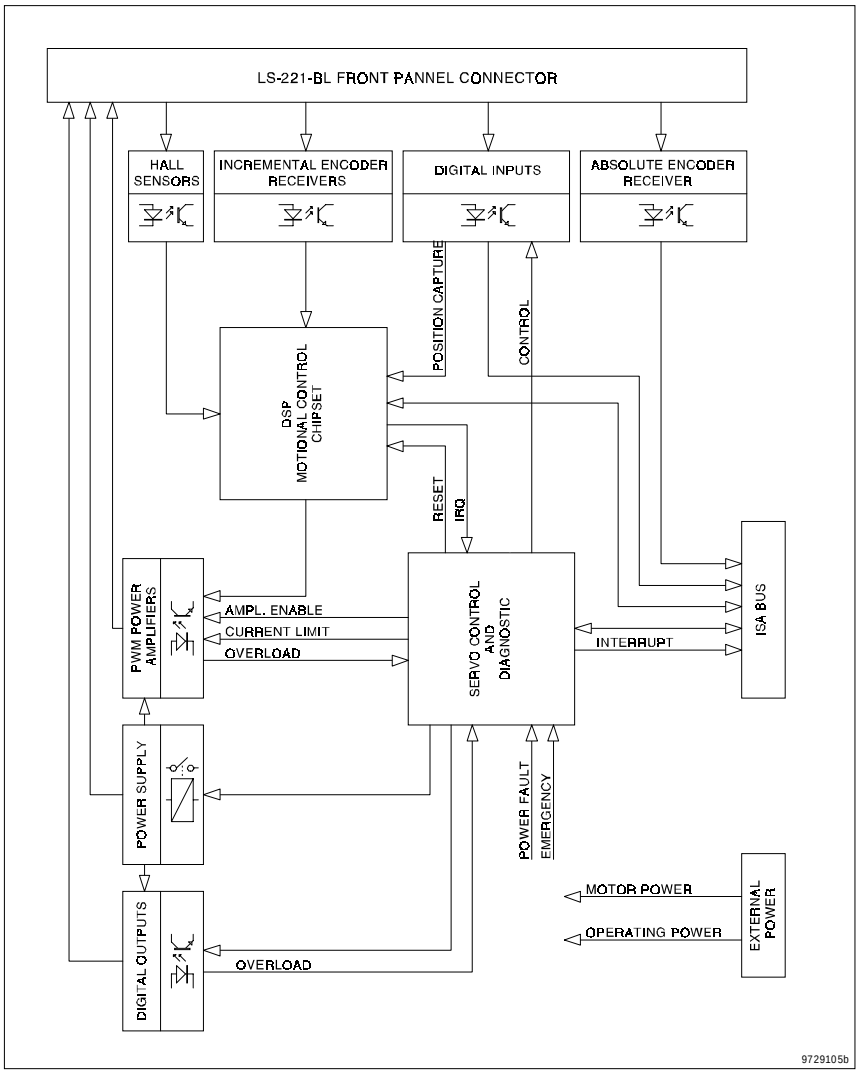


Figure 2: LS-221-BL block diagram

4.1. Memory Map

LS-221-BL is designed as a standard ISA bus peripheral device. To save I/O space, LS-221-BL uses only 16 bytes from the lowest 1024 I/O addresses range. The rest of LS-221-BL registers occupy the space located at offset 0x400, 0x800 and 0xC00. For instance, if LS-221-BL base address is set to 0x280, the following I/O address are in use – 0x280÷0x28F, 0x680÷0x68F, 0xA80÷0xA8F, 0xE80÷0xE8F. Eight base addresses are available, depending on J1 setting – 0x280, 0x1280, 0x2280, 0x3280, 0x2A0, 0x12A0, 0x22A0, 0x32A0. The table below shows LS-221-BL register location relatively to controller base address. The offsets are in hexadecimal.

	READ									WRITE								
	D7	D6	D5	D4	D3	D2	D1	D0		D7	D6	D5	D4	D3	D2	D1	D0	
0	MC1231A DATA REGISTER								0	MC1231A DATA REGISTER								0
1	READY								1	MC1231A COMMAND REGISTER								1
2									2									2
3									3									3
4									4									4
5									5									5
6									6									6
7									7									7
8	IN7	IN6	IN5	IN4	IN3	IN2	IN1	IN0	8									8
9	IN15	IN14	IN13	IN12	IN11	IN10	IN9	IN8	9									9
A	AE	RST	OPT	SPS			CL1	CL0	A	AE	RST	OPT	SPS					A
B	EMG	STP	MPF	OPF	EMGL	STPL	MPFL	OPFL	B									B
C	ADI						MPI		C	ENADI								C
D	OUT7	OUT6	OUT5	OUT4	OUT3	OUT2	OUT1	OUT0	D	OUT7	OUT6	OUT5	OUT4	OUT3	OUT2	OUT1	OUT0	D
E									E	PCS3	PCS2	PCS1	PCS0				APERES	E
F									F									F
400									400									400
401									401									401
402									402									402
403									403									403
404	APE D7	APE D6	APE D5	APE D4	APE D3	APE D2	APE D1	APE D0	404	REQ APE#0								404
405	APE D15	APE D14	APE D13	APE D12	APE D11	APE D10	APE D9	APE D8	405	REQ APE#1								405
406	APE D23	APE D22	APE D21	APE D20	APE D19	APE D18	APE D17	APE D16	406									406
407	APE RDY		BE	OF	OS	BA	PS	CE	407									407
408									408	CURRENT LIMIT #0 (0x0 - 0xF)								408
409									409	CURRENT LIMIT #1 (0x0 - 0xF)								409
40A									40A									40A
40B									40B									40B
40C									40C									40C
40D									40D									40D
40E									40E									40E
40F									40F									40F
807					ID3 = 0	ID2 = 0	ID1 = 0	ID0 = 1	807									807
C07					ID7 = 1	ID6 = 0	ID5 = 1	ID4 = 1	C07									C07

Table 1: LS-221-BL Memory Map

4.2. Base Module

The main part of LS-221-BL servo controller is the Base Module (BM). It carries the motion control processor, PWM power amplifiers, optoisolated digital outputs, and servo control and diagnostic logic. It can be combined with various input boards to create the optimal solution for wide range of motion control tasks. The following diagram shows the layout of the Base Module.

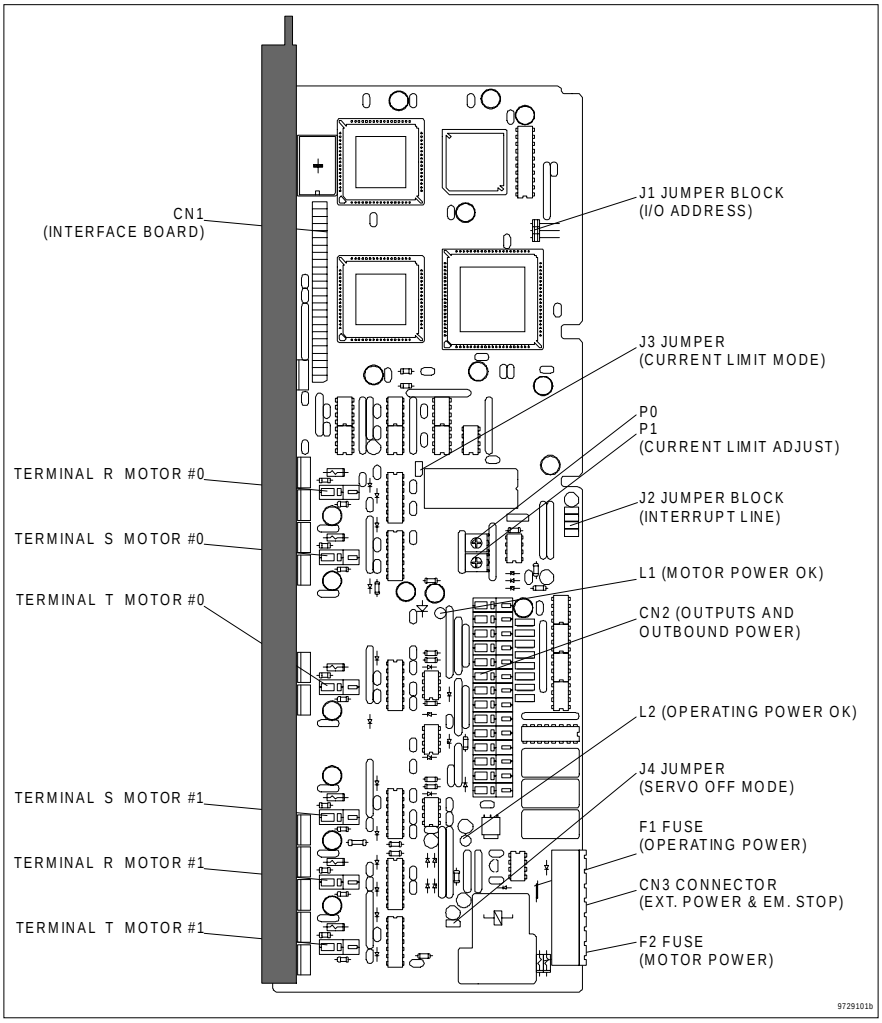


Figure 3: Base Module board layout

BM board is equipped with two LED indicators for fast and easy visual check of the controller status. In order to close the servo loop and enable the power amplifiers both LED must be ON. After the controller is powered and initialised, L1 is ON if the motor power supply is present and if there is no short circuit between any motor terminal and the computer ground or the ground of the operating power. L2 is ON if the operating power is present and none of the digital outputs is overloaded.

4.2.1. Servo Channels

LS-221-BL implements a latest DSP technology for maximum performance and precision. The controller is based on PMD MC1231A DSP motion control chipset. This allows LS-221-BL to perform a smooth and precise control of two servo axes requiring minimum resource from the host processor.

The host computer specifies the acceleration, maximum velocity and final position. A trapezoidal or S-curve profile may be selected. MC1231A uses this information to control the movement by accelerating as specified, until the maximum velocity is reached or until deceleration begins to stop at the specified final position. The deceleration rate is equal to the acceleration rate. MC1231A continuously keeps track of the absolute motor position using the

encoder feedback signal. The encoder delivers two 90^0 phase shifted signals to determine the speed and direction of the motor's motion. At any time during the move, the maximum velocity and/or the target position may be changed, and the motor will accelerate or decelerate accordingly. All trajectory parameters are 32-bit values.

During the motion, on every sampling interval, MC1231A subtracts the actual position (feed back position) from the desired one (profile generator position). The resulting position error is processed by digital filter to produce a motor control command. MC1231A uses a programmable digital Proportional Integral Derivative (PID) filter to compensate the control loop. The motor is held at the desired position by applying a restoring force that is proportional to the position error, plus the integral of the error, plus the derivative of the error. All PID filter coefficients are 16-bit values.

In addition to trajectory generation and servo loop closure the MC1231A chipset provides sinusoidal commutation for 3-phase brushless motors. The commutation portion of the chipset uses as input the motor command signal from servo loop filter. This pre-commutated command is then multiplied by commutation values derived from an internal lookup Sin/Cos table. The commutation angle used in the Sin/Cos table is determined by the position encoder as well as parameters set by the host which relate the specific encoder used to the motor magnetic poles. The encoder index pulse is used to maintain commutation synchronization.

Another feature is the ability to use Hall-sensors for phase initialization. Three Hall-sensors initially determine the motor phasing and sinusoidal commutation begins automatically. The initialization occurs without any motor motion. For motors not supplied with Hall-sensors, a special algorithmic phase-initialization procedure is available. During the algorithmic initialization the motor may move suddenly in any direction. Proper safety precaution should be taken to prevent damage from this movement.

For programming information see the PMD MC1231A chipset manual. The following table shows memory location of the MC1231A registers:

	R/W access	D7	D6	D5	D4	D3	D2	D1	D0
Base Addr + 0	R/W	**MC1231A DATA REGISTER**							
Base Addr + 1	Write	**MC1231A COMMAND REGISTER**							
Base Addr + 1	Read	**READY**							

Table 2: MC1231A register location

4.2.2. Built-in Power Amplifiers

Each LS-221-BL servo channel is equipped with a built-in power amplifier, capable to deliver up to 10A. The amplifiers are designed as three half H-bridges with FET transistors (IRF9540 and IRC530). To achieve a high noise immunity and reliability, the power circuits are optoisolated from the computer ground.

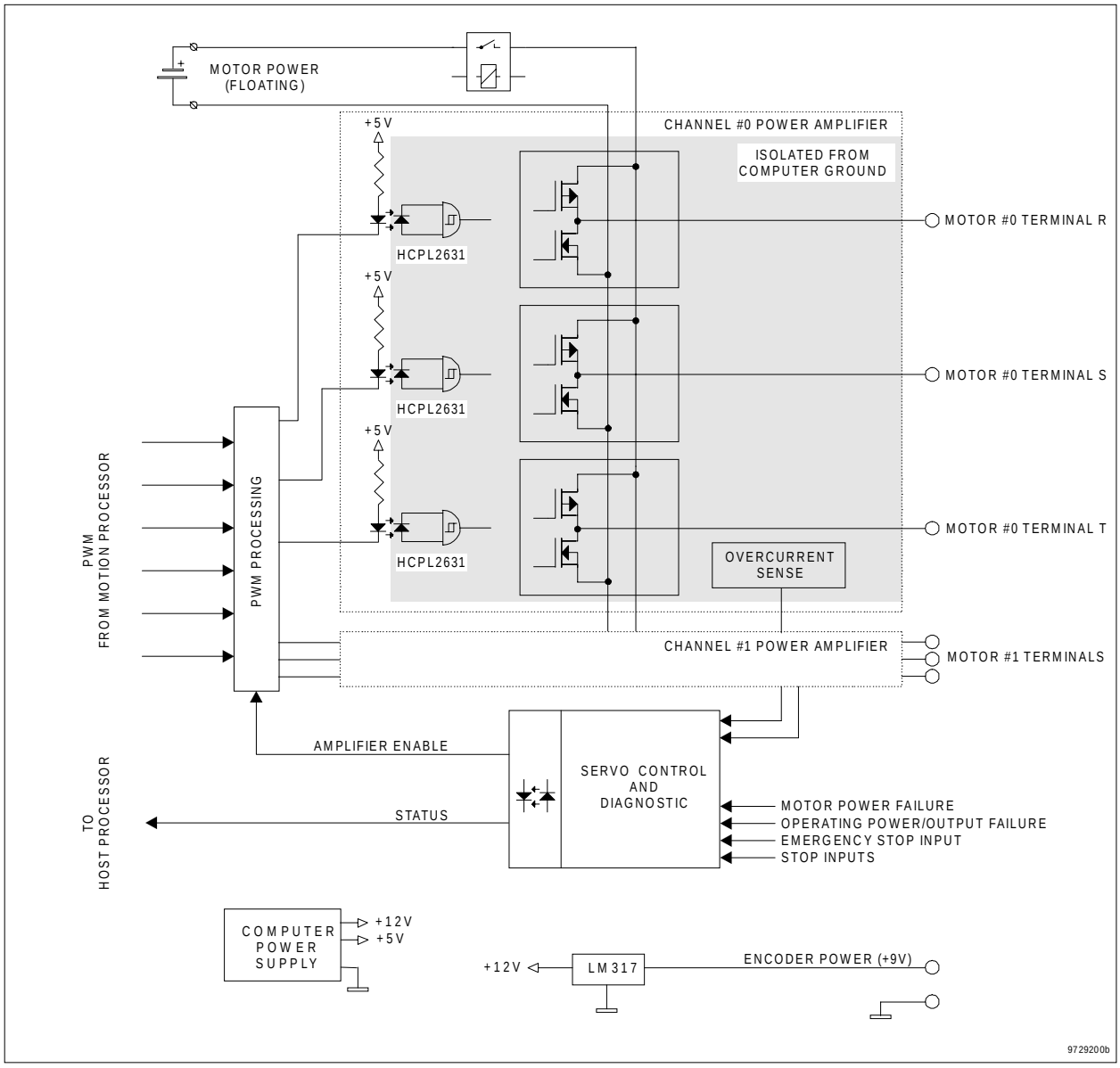


Figure 4: Build-in power amplifiers

PWM signals generated by PMD Motion Processor are formed by special circuit to meet the power bridges requirements. The amplifier enable (AE) is controlled by servo control and diagnostic logic. The amplifiers are immediately shut down in case of emergency - power failure, excess current or output overload, emergency stop. The reason caused amplifiers to disable is latched in special register and is available to the host for diagnostic purpose. If the amplifiers are disabled while the motors run, they can stop in one of two ways depending on J4 jumper setting. With J4 installed, the motors have their windings shorten, which means faster stop, to prevent eventually machine dropping. With J4 open, the motors have their windings open, which causes machine to stop smoothly. If the motors have breaks associated with them, they can be activated automatically immediately after the amplifiers are disabled.

The output current from each half H-bridge is continuously monitored by a protection logic and may be limited to a value adjustable in the range of 2÷10A. The limit for each axis can be programmed individually using a special register. The range 2÷10A is divided into 16 steps. A trimmer-pot (P0, P1) is used for precise adjustment of the selected limit. If the amplifier output is overloaded or even shorted for a moment, the bridge output current is limited to the programmed value. The protection has two modes depending on J3 jumper setting. With J3 jumper installed, if the overloading takes place more than 100 ms, the servo loop will be shut down automatically and the PWM power amplifiers will be disabled. If J3 is left open, the servo loop will remain closed regardless of the overload duration. The output current is limited to the specified value.

See 4.2.4.3 for more information on current limit.

4.2.3. Digital Outputs and Outbound Power

Being a fully integrated servo controller, along with the servo channels, LS-221-BL offers 8 general purpose digital outputs equipped with high voltage, high current FET transistors and three relay controlled power sources. The power sources are named based on their typical application. SPS (System Power Supply) is used basically to power sensors. It is available immediately after the controller is powered and initialised. You can not turn off this power without disabling the servo loop and the digital outputs as well. OPT (OPTional power supply) is general-purpose power source and may be controlled individually. SPS must be ON to enable OPT. OPS (Output Power Supply) is used basically to power motor breaks and various valves and switches. OPS can not be controlled separately. It depends on amplifier enable status and SPS only. If the power amplifiers are enabled, the OPS is present and if the amplifiers are disabled, the OPS is OFF. This is useful for devices that should be shut off automatically when the amplifiers are disabled, for instance motor breaks or other emergency circuits.

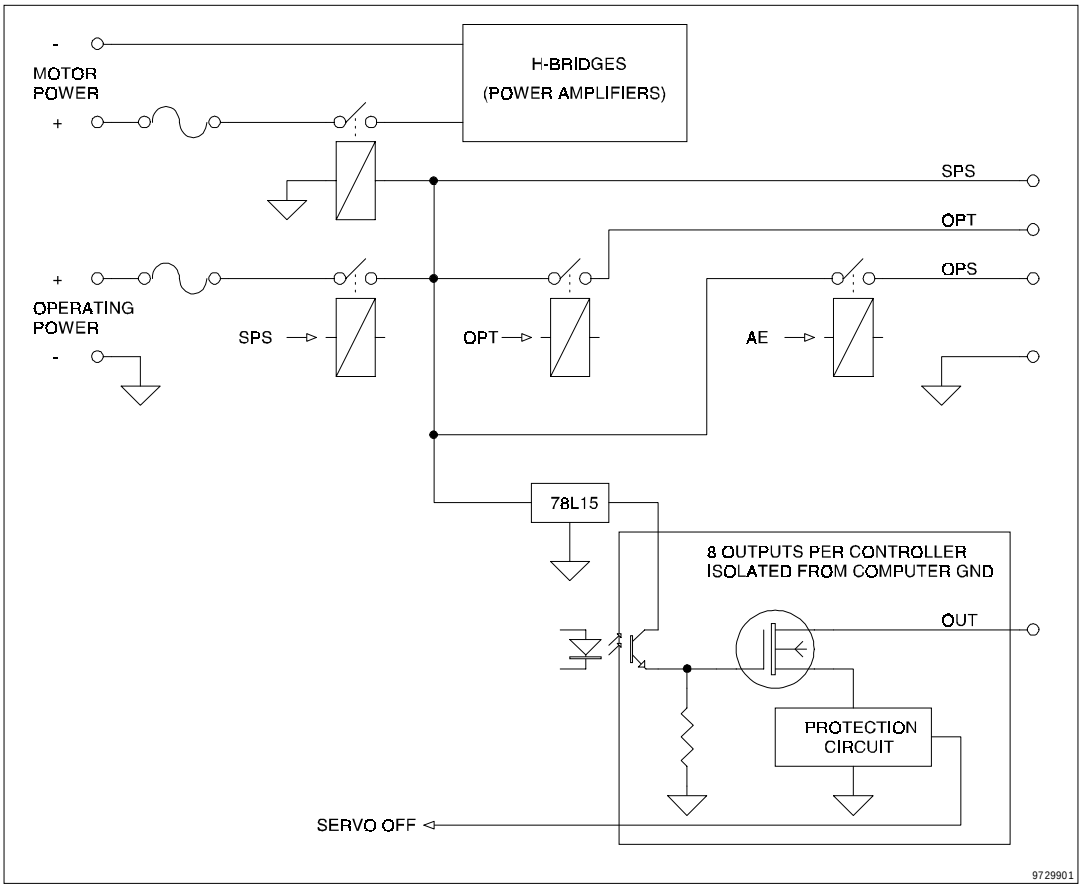


Figure 5: Digital outputs and outbound power sources

The outputs are open collector transistors connected to the ground of the operating voltage. They are optoisolated from the computer ground. All outputs are short-circuit protected. If one of them is overloaded, the protection circuit will shut down all transistor outputs. OPT and SPS relays will not be affected. The servo loop will be turned off automatically (amplifier disable) and this will turn off OPS as well. Once activated, the protection keeps outputs disabled until the reason that caused the overloading is present. The outputs are controlled through the associated registers.

	R/W access	D7	D6	D5	D4	D3	D2	D1	D0
Base Addr + 0xA	R/W	AE	RST	**OPT**	**SPS**			CL1	CL0
Base Addr + 0xD	R/W	**OUT7**	**OUT6**	**OUT5**	**OUT4**	**OUT3**	**OUT2**	**OUT1**	**OUT0**

Table 3: Digital outputs and outbound power registers

To activate an output or a power source, logic one must be written to the corresponding control bit. Activating the emergency stop will turn off SPS and will disable all other power sources and outputs. **For safety reasons, to prevent an accidental turn on after an emergency, SPS is equipped with a special double buffered logic. In order to restore SPS after being shut off by emergency stop, SPS must be cycled off-on. SPS control bit should be first reset to logic zero and after that set to logic one.**

4.2.4. Servo Control and Diagnostic

The servo control and diagnostic logic allows the host to set up the controller and to keep track of the current LS-221-BL status.

4.2.4.1. Motion Processor Reset

After hardware reset or after system power up, MC1231A chipset is reset. To remove the servo chip reset, logic zero should be written to the corresponding RST bit. Writing logic one to the same bit will put MC1231A in reset condition.

	R/W access	D7	D6	D5	D4	D3	D2	D1	D0
Base Addr + 0xA	R/W	AE	**RST**	OPT	SPS			CL1	CL0

Table 4: MC1231A reset control

4.2.4.2. Servo Loop

During normal operation, the LS-221-BL servo loop must be closed. With servo loop closed, the controller constantly reads the current motor position from the encoder and applies the necessary voltage to the motor to keep the desired trajectory or position. In case of emergency this loop must be broken (i.e. the power amplifier must be disabled) to protect the controlled object and/or the controller. With servo loop open, the controller continues to keep track of the motor position but doesn't apply any voltage to the motor. LS-221-BL servo loop is controlled by AE (Amplifier Enable) signal.

	R/W access	D7	D6	D5	D4	D3	D2	D1	D0
Base Addr + 0xA	R/W	**AE**	RST	OPT	SPS			CL1	CL0

Table 5: Amplifier Enable control

To set AE signal a logic one should be written to the corresponding control bit. AE may be reset either by writing logic zero to the same bit, or automatically by servo off condition generated by LS-221-BL protection circuits. **For safety reasons, AE is equipped with the same double buffered logic as SPS to prevent an accidental turn on after an emergency shut down. To restore AE after an emergency, first a logic zero must be written to AE control bit. A subsequent writing of logic one to AE control bit will close the servo loop again and will enable the amplifiers**.

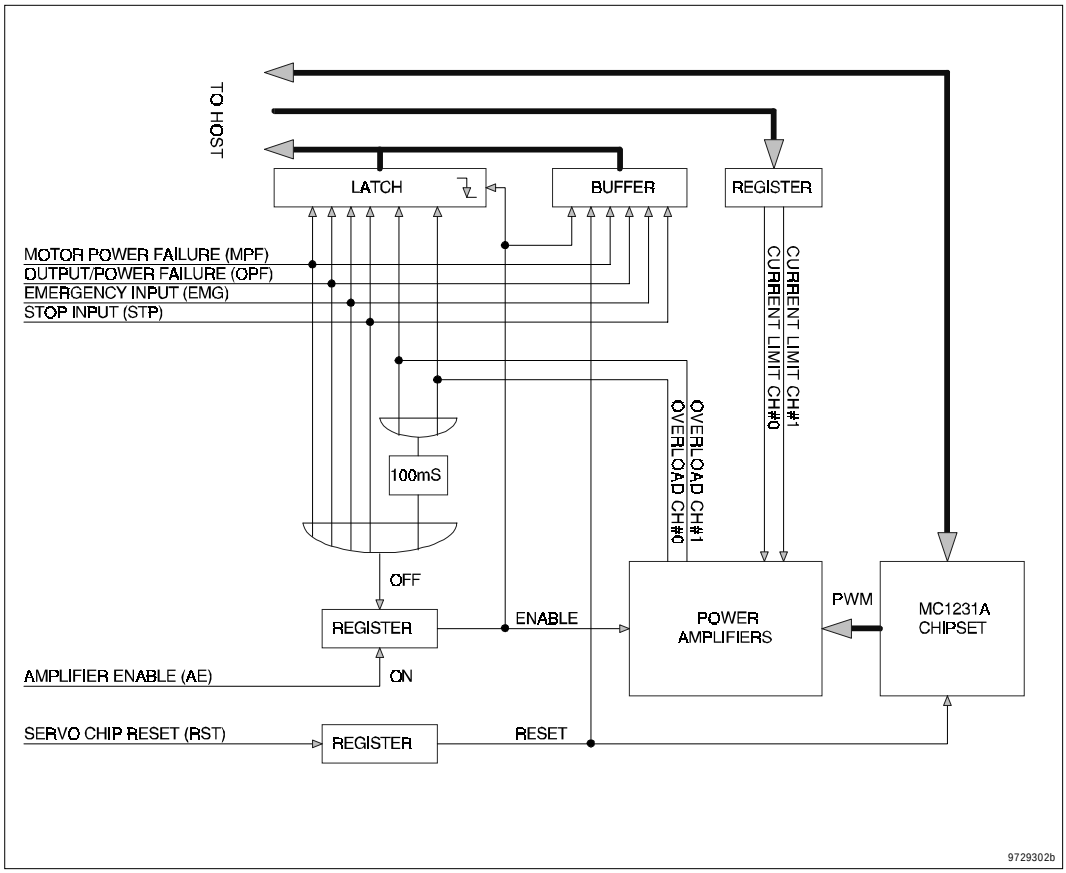


Figure 6: Servo control and diagnostic

There are several sources that can cause servo loop to break.

- **Motor Power Failure (MPF)**

To power the motors, LS-221-BL requires separate power supply isolated from the computer ground and from the operating (24V) power supply as well. If Motor Power is below the undervoltage limit or above the overvoltage limit, MPF is set to logic one and AE is automatically disabled. MPF is also set to logic one in case of leakage between high voltage motor circuits and any of low voltage computer or 24V circuits. A current as low as 0.5mA will trigger the protection. The current MPF value is latched as MPFL at the moment the servo loop is broken.

	R/W access	D7	D6	D5	D4	D3	D2	D1	D0
Base Addr + 0xB	Read	EMG	STP	**MPF**	OPF	EMGL	STPL	**MPFL**	OPFL

Table 6: MPF status

- **Output Overload / Operating Power Failure (OPF)**

The operating power required for the Outputs and Outbound Power Sources must be 24V±20%. If it is out of range, the OPF is set to logic one and AE is automatically

disabled. All digital outputs are short circuit protected. If any of them is overloaded, all outputs are disabled and OPF is set to logic one. To distinguish between the two reasons, OPF should be checked with all outputs reset. In this case only missing or out of range operating power can activate OPF. The current OPF value is latched as OPFL at the moment the servo loop is broken.

	R/W access	D7	D6	D5	D4	D3	D2	D1	D0
Base Addr + 0xB	Read	EMG	STP	MPF	**OPF**	EMGL	STPL	MPFL	**OPFL**

Table 7: OPF status

- **Emergency Stop Input (EMG)**

LS-221-BL is equipped with emergency stop input. To operate LS-221-BL, a normally closed contact must be connected to that input. Opening the contact will immediately disable the amplifiers and all outputs and will shut off the outbound power sources. If the emergency stop is activated, EMG is set to logic one, otherwise is reset to logic zero. EMG is continuously available to the host and the current EMG value is latched as EMGL at the moment the servo loop is broken.

	R/W access	D7	D6	D5	D4	D3	D2	D1	D0
Base Addr + 0xB	Read	**EMG**	STP	MPF	OPF	**EMGL**	STPL	MPFL	OPFL

Table 8: EMG status

- **Stop Inputs (STP) (optional)**

Some of the general purpose inputs or a selected combination of them can be used as an additional emergency stop. This is a custom option and may be installed by user request. By default it is not used. When the option is installed and stop input is activated, STP is set to logic one. Under normal conditions STP is logic zero. STP is continuously available to the host and the current STP value is latched as STPL at the moment the servo loop is broken.

	R/W access	D7	D6	D5	D4	D3	D2	D1	D0
Base Addr + 0xB	Read	EMG	**STP**	MPF	OPF	EMGL	**STPL**	MPFL	OPFL

Table 9: STP status

- **Current Limit (CL)**

When one or more of the power amplifiers reach the programmed current limit the corresponding CL signal is set to logic one. Otherwise CL is logic zero. CL0, CL1 represent the current overload respectively for channel 0, 1. While the servo loop is closed (i.e. AE=1), CL0 and CL1 show the actual states of the current limitation for the corresponding channels. If the servo loop is broken (i.e. AE=0), CL0 and CL1 keep the CL values from the moment the servo was shut down. By reading the register the host can determine overloading of which channel had caused the problem.

	R/W access	D7	D6	D5	D4	D3	D2	D1	D0
Base Addr + 0xA	Read	AE	RST	OPT	SPS			**CL1**	**CL0**

Table 10: CL status

4.2.4.3. Amplifiers Current Control

The output of each amplifier is protected against short circuit or overload. The current delivered to the load is constantly monitored and compared to a limit that can be set individually for each axis. The current may be limited to a value in the range of 2÷10 A with 4-bit precision. Only the four MSB are used. Writing 0x00 to the corresponding register sets the current limit to the lowest level (less than 1A). Writing 0xF0 sets the current limit to the highest level - 10A.

	R/W access	D7	D6	D5	D4	D3	D2	D1	D0
Base Addr + 0x408	Write	**CURRENT LIMIT #0 (0 ÷ 0xF)**							
Base Addr + 0x409	Write	**CURRENT LIMIT #1 (0 ÷ 0xF)**							

Table 11: Current limit registers

If J3 jumper is installed, each time a channel reaches the current limit, the corresponding CL signal is set to logic one. The CL signals are continuously available to the host for diagnostic purpose or for a real time control. If the overloading takes place for more than 100 ms, the servo loop will be shut down automatically and the PWM power amplifiers will be disabled. Special register latches current CL values at the moment the servo loop is broken. By reading the register the host can determine which channel had caused servo off.

If J3 is left open, CL signals are forced to logic zero. The servo loop will remain closed regardless of the overload duration. The output current is limited to the specified value.

4.2.4.4. Interrupt Processing

Reading LS-221-BL Interrupt Status register returns logic one for each event that currently have requested interrupt. Writing logic zero to the Interrupt Mask register allows each event to be individually masked off. By default after power up, Interrupt Mask register is cleared and no interrupts are enabled (except the IRQ from MC1231A, see 4.2.5.2.)

LS-221-BL has two sources that can generate interrupt request (IRQ) to the host as follows:

ADI - Amplifier Disable Interrupt

LS-221-BL is capable to generate interrupt request, each time the amplifiers are disabled. It doesn't matter if the amplifiers are disabled by any of the protection circuits or by the software. Setting the Interrupt Mask enables or disables ADI.

EN ADI = 1, ADI enabled

EN ADI = 0, ADI disabled

MPI – Motion Processor Interrupt

MC1231A motion processor can generate IRQ due to various events. See MC1231A manual for information how to control interrupt requests.

If MC1231A interrupt is enabled and activated, MPI flag in the LS-221-BL Interrupt Status register is set to logic one. MPI is just a flag and can not be masked off using LS-221-BL Interrupt Mask register. MC1231A control register should be used to handle this interrupt.

	R/W access	D7	D6	D5	D4	D3	D2	D1	D0
Base Addr + 0xC	Read	**ADI**						**MPI**	
Base Addr + 0xC	Write	**EN ADI**							

Table 12: IRQ Status and Mask registers

J2 jumper block selects interrupt line to the host. IRQ7, IRQ10, IRQ12, IRQ15 may be used.

4.2.5. Board Identifier

Due to its flexible architecture and ISP (In System Programmable) capability, LS-221-BL allows fast and easy customizations. To provide information for the current controller configuration, LS-221-BL features an 8-bit ID number. Two four-bit read-only registers form the controller ID.

	R/W access	D7	D6	D5	D4	D3	D2	D1	D0
Base Addr + 0x807	Read					**ID3**	**ID2**	**ID1**	**ID0**
Base Addr + 0xC07	Read					**ID7**	**ID6**	**ID5**	**ID4**

Table 13: ID registers

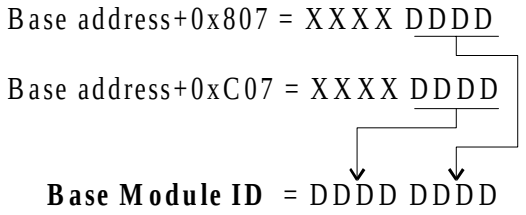


Figure 7: ID number

The ID for the standard LS-221-BL configuration is 0xB3.

4.2.6. Interface Connectors

The Base Module carries two interface connectors available to the user. CN3 is the entry for the external motor and operating power supplies. The emergency stop input is also located here. All digital outputs and outbound power sources are wired to CN2 connector. A block diagram of CN2 together with CN3 is shown below.

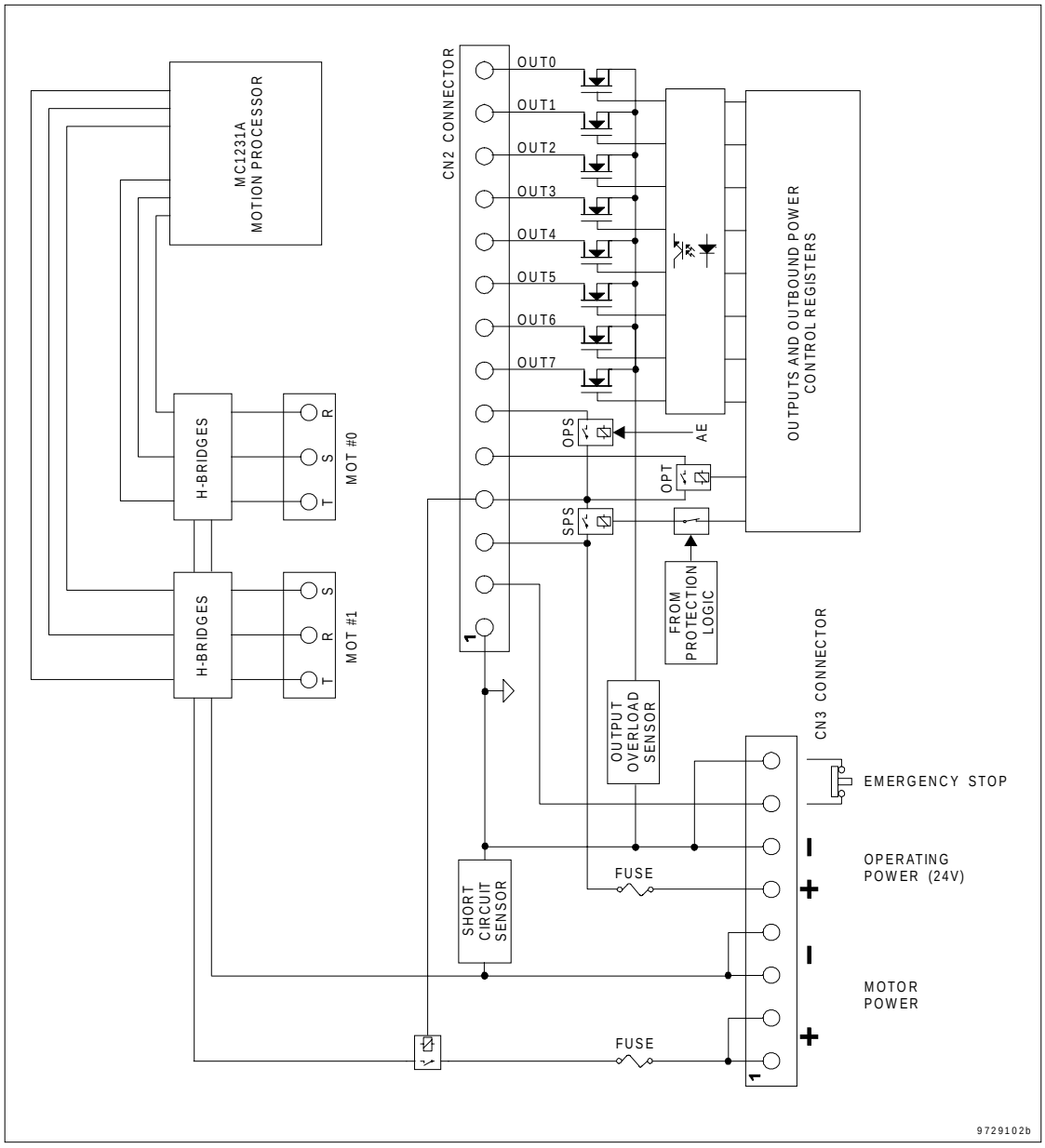


Figure 8: Block Diagram of CN2 & CN3 connectors

4.2.6.1. CN3 Connector (External Power)

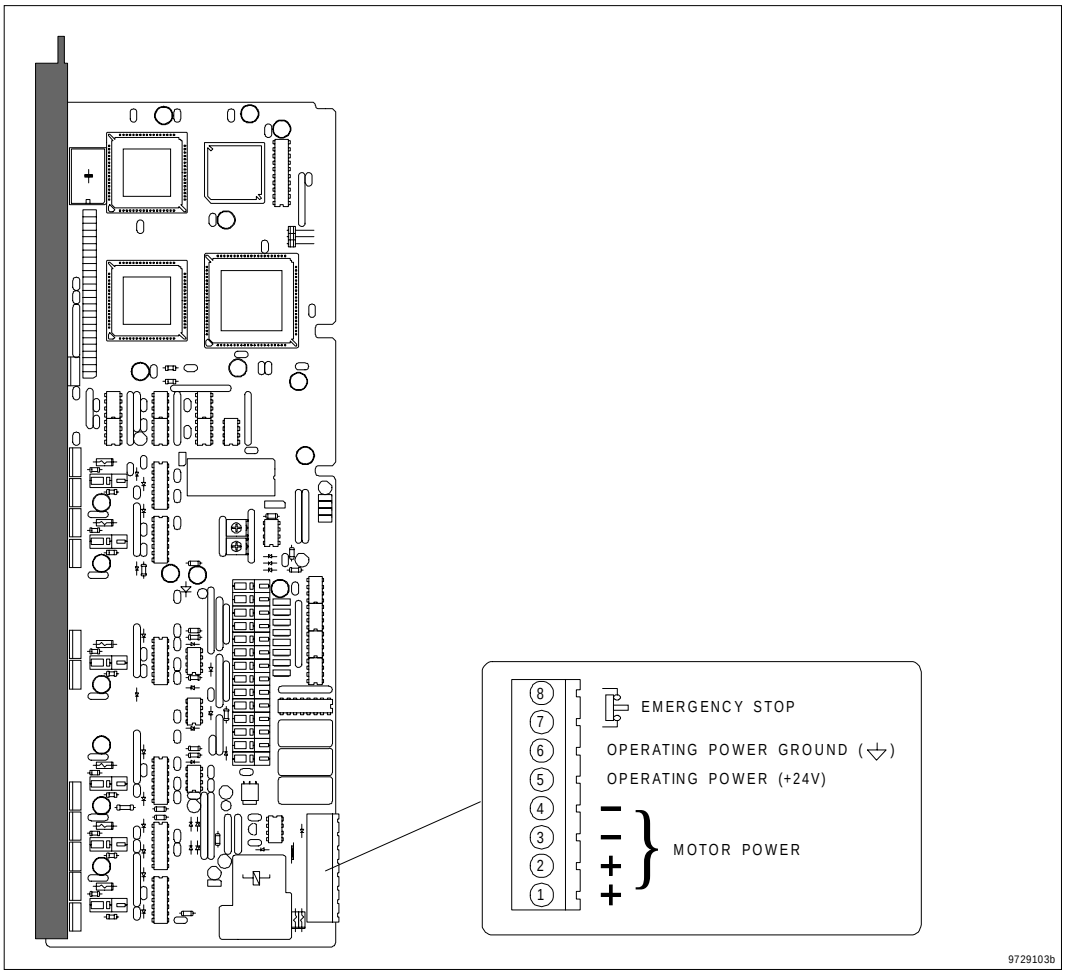


Figure 9: CN3 connector location and pinout

4.2.6.2. CN2 Connector (Outputs & Outbound Power)

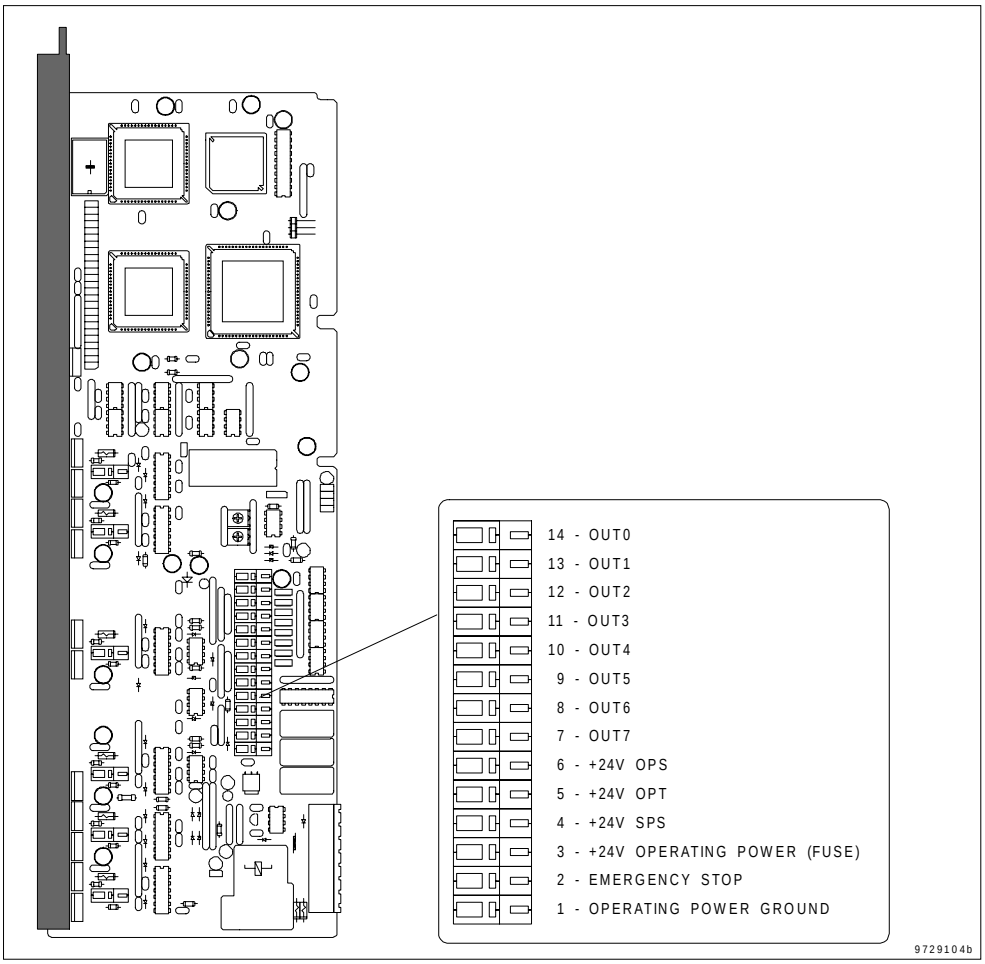


Figure 10: CN2 connector location pinout

4.3. Input Board

LS-221-BL is designed as multipurpose motion controller. To increase controller flexibility, all input circuits are located on a separate board - input board (IB). A flat ribbon cable connects IB to the controller's interface connector, mounted on the front panel.

The front panel connector and the input board may be ordered in different custom designed configurations for specific applications.

The standard LS-221-BL input board is LS-421-2112.

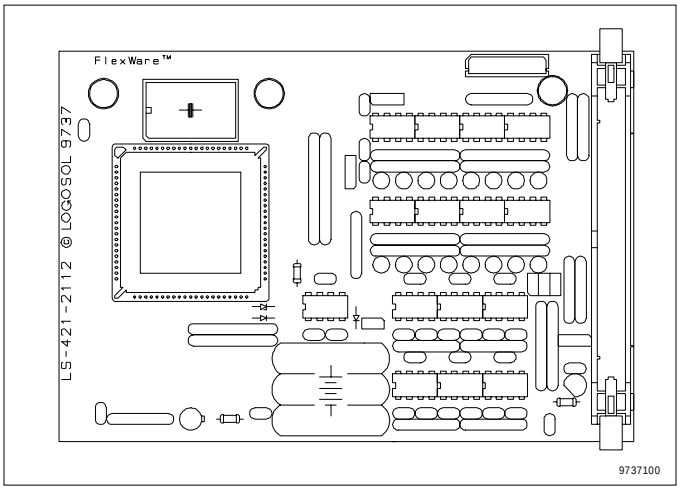


Figure 11: LS-421-2112 input board layout

LS-421-2112 features:

- 16 general purpose digital optoisolated inputs
- 6 optoisolated inputs for Hall-sensors
- Optoisolated interface and power supply for 2 incremental encoders
- 2-channel optoisolated receiver for 2 multi-turn absolute position encoders, power supply and backup battery.

All input lines and encoder signals are processed by ISP (In System Programmable) logic device for maximum flexibility.

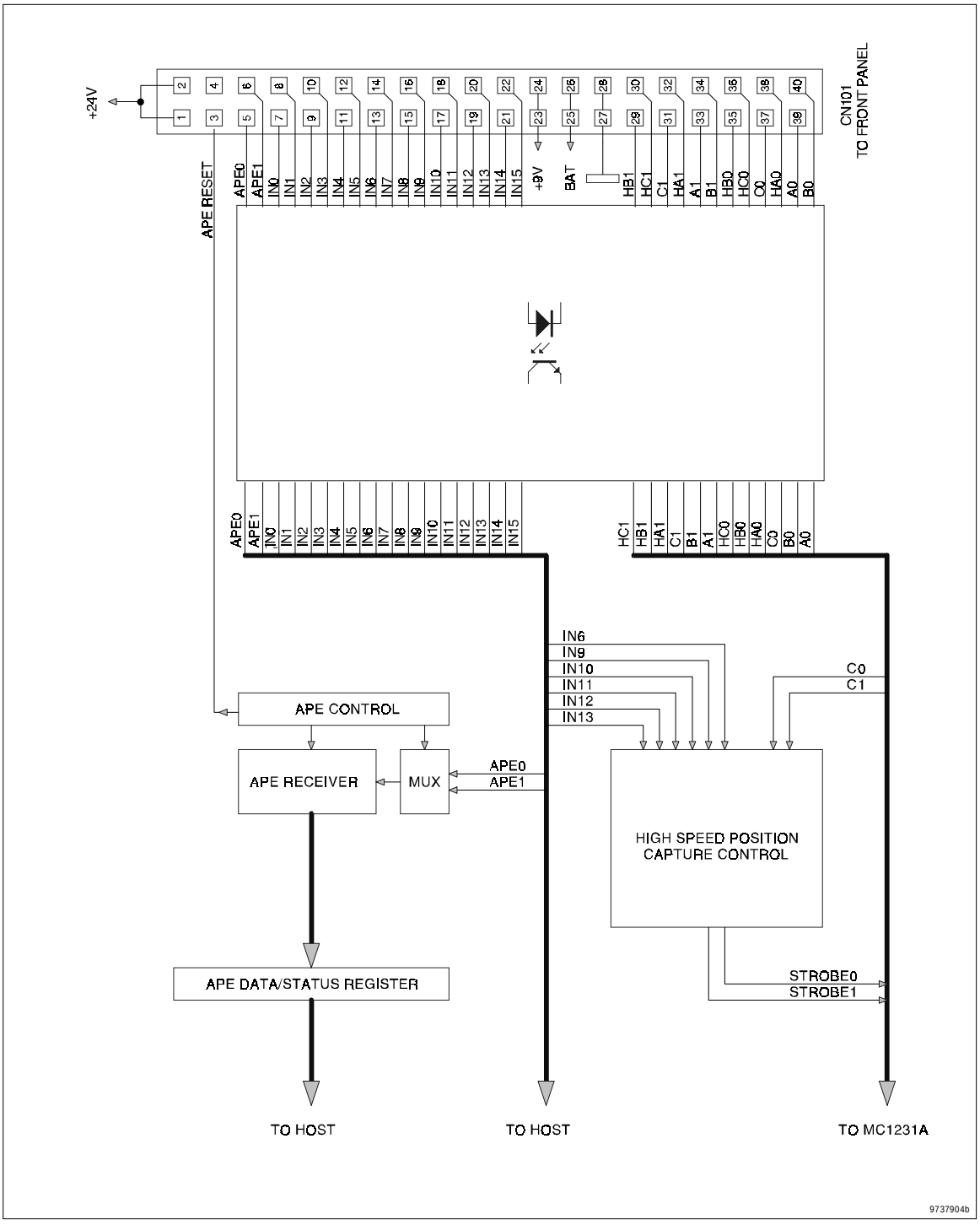


Figure 12: LS-421-2112 Input Board block diagram

4.3.1. Digital Optoisolated Inputs

All 16 inputs IN0÷IN15 may be used as general-purpose inputs, although some of them may have additional functions. Six may serve as strobes for high speed position capturing. APE0 and APE1 are dedicated as inputs for two multi-turn absolute position encoders.

4.3.1.1. General Purpose Inputs

The optoisolated inputs are designed to work with open collector or contact sensors.

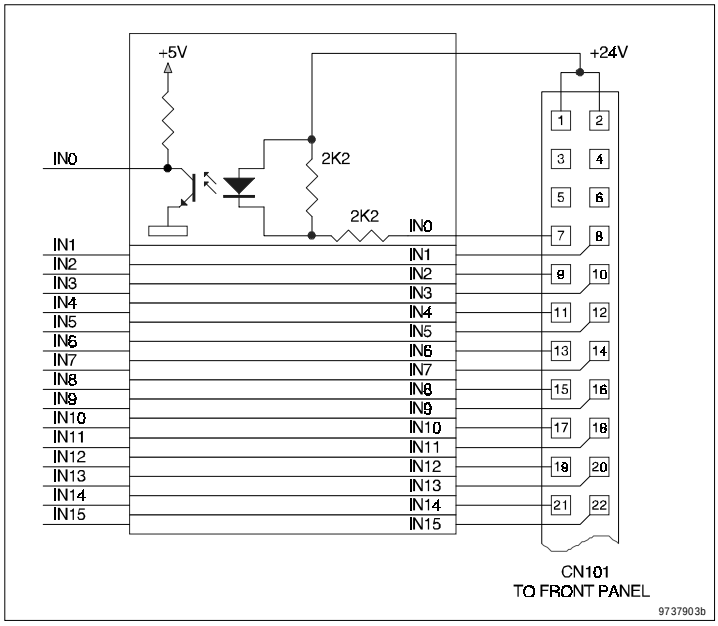


Figure 13: General purpose inputs

Inputs IN0÷IN15 require external +24V power supply. On LS-421-2112 input board, the operation power supply (OPS) is used to power the inputs. The corresponding sensor should be connected between the input and the power source ground. The sensor should be able to sink 10mA @ 24V in order to activate the input.

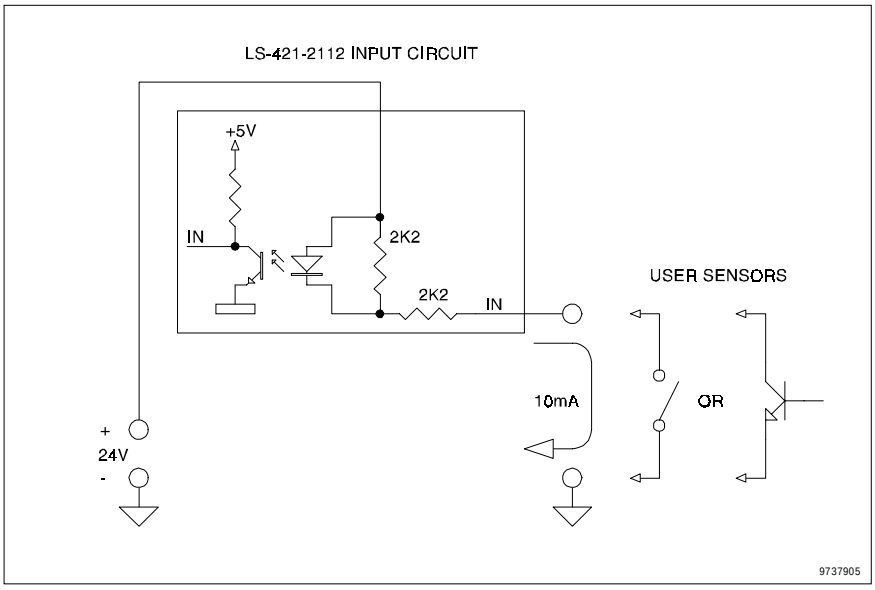


Figure 14: LS-221-BL input connection diagram

APE0, APE1 are designed to work as data inputs for Absolute Position Encoders (APE). Both inputs use +5V power supply. To activate inputs APE0, APE1 load should be able to sink 20mA @ 5V.

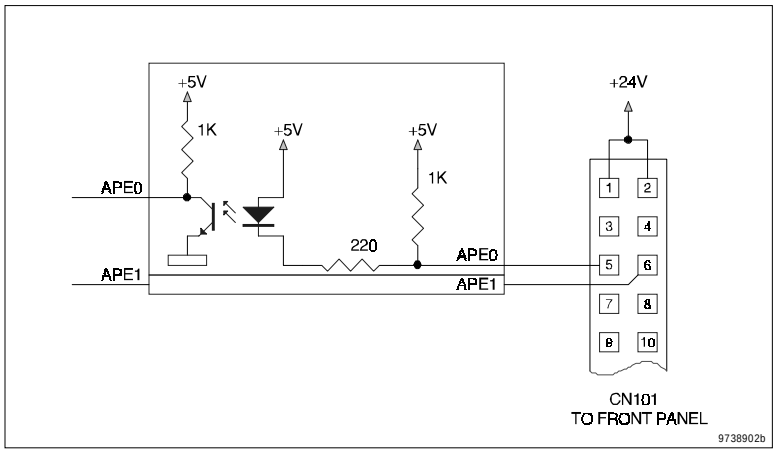


Figure 15: Absolute Position Encoder (APE) inputs

Two eight-bit registers represent IN0÷IN15 state.

	R/W access	D7	D6	D5	D4	D3	D2	D1	D0
Base Addr + 0x8	Read	**IN7**	**IN6**	**IN5**	**IN4**	**IN3**	**IN2**	**IN1**	**IN0**
Base Addr + 0x9	Read	**IN15**	**IN14**	**IN13**	**IN12**	**IN11**	**IN10**	**IN9**	**IN8**

Table 14: Input registers

When input is activated (i.e. the sensor is closed) the corresponding input register bit is set to logic zero. For non-activated inputs register bits are set to logic one.

4.3.1.2. Hall-sensor Inputs

LS-421-2112 is equipped with six (three per axis) dedicated inputs for Hall-sensors. The inputs use +5V power supply. To activate them, load should be able to sink 20mA @ 5V.

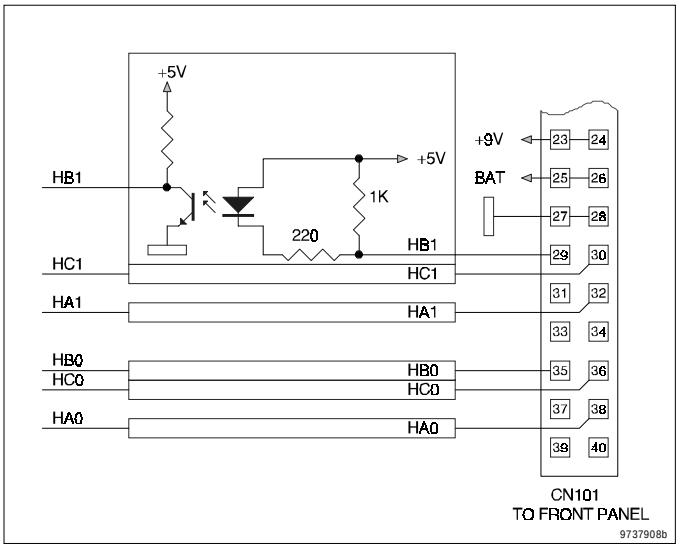


Figure 16: Hall-sensor inputs

The Hall-sensor inputs can not be accessed directly from the host computer. The MC1231A registers should be used to read their status.

4.3.1.3. High Speed Position Capture Inputs

MC1231A DSP motion control chipset is able to record the absolute motor position using encoder index line as strobe. See MC1231A manual for information how to use position capture mode. LS-221-BL is equipped with special logic, which allows replacing the encoder index signal with some of the controller inputs. Writing corresponding number to PCS (Position Capture Select) register selects one of IN6, IN9, IN10, IN11, IN12, IN13 inputs to serve as a strobe.

	R/W access	D7	D6	D5	D4	D3	D2	D1	D0
Base Addr + 0xE	Write	**PCS3**	**PCS2**	**PCS1**	**PCS0**				APE RES

Table 15: PCS control registers

Either low (input is closed to the ground) or high (input is open) level may be selected to trigger the capture. For LS-421-2112 selected strobe input is common for both axes. Row 14 or 15 should be selected during the home procedure. This will allow each axis to capture motor position using its own encoder index signal.

#	PCS3	PCS2	PCS1	PCS0	Channel#0	Channel#1	Active level
0	0	0	0	0	IN6	IN6	Low
1	0	0	0	1	IN6	IN6	High
2	0	0	1	0	IN7	IN7	Low
3	0	0	1	1	IN7	IN7	High
4	0	1	0	0	Reserved	Reserved	-
5	0	1	0	1	Not used	Not used	-
6	0	1	1	0	IN2	IN2	Low
7	0	1	1	1	IN2	IN2	High
8	1	0	0	0	IN5	IN5	Low
9	1	0	0	1	IN5	IN5	High
10	1	0	1	0	IN8	IN8	Low
11	1	0	1	1	IN8	IN8	High
12	1	1	0	0	IN9	IN9	Low
13	1	1	0	1	IN9	IN9	High
14	1	1	1	0	Index#0	Index#1	Low
15	1	1	1	1	Index#0	Index#1	Low

Table 16: Selecting Strobe Inputs

4.3.1.4. Emergency Stop Inputs (optional)

In some customized configurations, one or more of general-purpose inputs may be used as additional emergency stop. The standard version of LS-421-2112 doesn't support this option.

4.3.2. Incremental Encoder Interface

LS-421-2112 input board is designed to work with quadrature incremental encoders with index pulse. Encoders must be equipped with open collector outputs or line drivers capable to sink 20mA@5V. Medium-speed HP2531 optocouplers are used to provide 20mA current loop for increased noise immunity. LS-421-2112 receivers are rated for speeds up to 1,000,000 encoder counts per second.

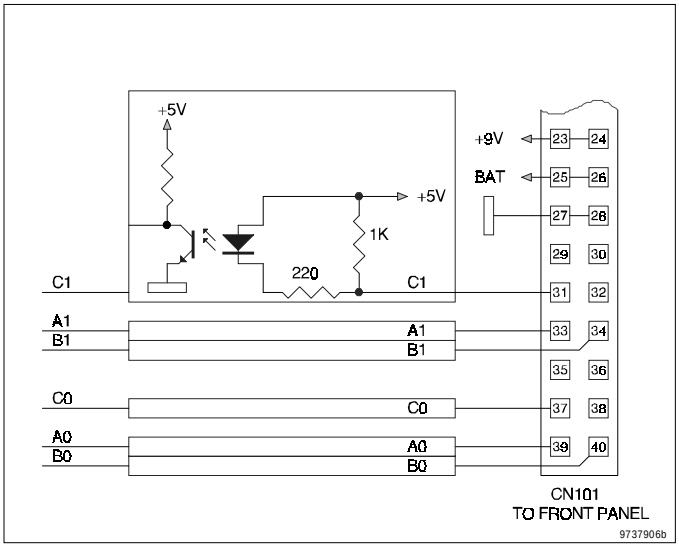


Figure 17: Incremental Encoder interface

To prevent voltage drop across long interface cables, LS-221-BL provides +9V for encoder power. Additional 7805 voltage regulator located close to the encoders is required.

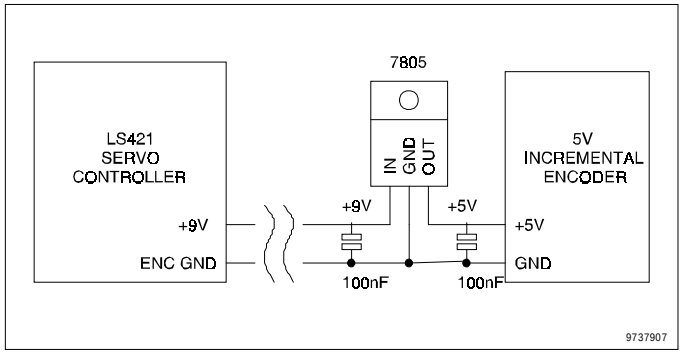


Figure 18: Encoder power supply

See application notes for more information.

4.3.3. Multi-turn Absolute Encoder Receiver

LS-421-2112 is designed to work with two multi-turn absolute position encoders. The following types from Tamagawa Seiki Co are supported:

SA35-11/24bit-LPS-5V

SA56-11/24bit-LPS-5V

SA35/56 series encoder consists of two parts – incremental and absolute. The incremental part works as standard incremental encoder. It should be connected to LS-421-2112 incremental encoder interface. The data from SA35/56 incremental encoder is received and processed by MC1231A motion control chipset. SA35/56 absolute part constantly transmits serial data consisting of 24-bit absolute position and 6-bit status. Manchester code with 3-bit CRC is used. Received data is decoded, checked for errors and stored in 24-bit data register and 6-bit status register, available to the host. There is only one data and status register for both absolute encoders. Receiver works on request. Request from the host selects one of the encoder inputs APE0, APE1 and clears APE data ready flag. Clearing APE ready enables receiver. It acquires one valid data packet and sets APE data ready flag to logic one. Thereafter the receiver enters standby mode and waits for the next request command.

Once APE ready flag is set to logic one APE data and status are valid and may be read by the host. The minimal time to complete the request is 67÷109 μs. In noisy environment this time may increase. If the receiver detects an error, it will discard received data and automatically start new acquiring procedure. In most cases the request will be completed for less than 1 ms. To request absolute position from certain encoder, host should write a dummy data to the corresponding register.

	R/W access	D7	D6	D5	D4	D3	D2	D1	D0
Base Addr + 0x404	Write	**REQ APE#0**							
Base Addr + 0x405	Write	**REQ APE#1**							

Table 17: APE request registers

APE data and status registers are located as follows:

	R/W access	D7	D6	D5	D4	D3	D2	D1	D0
Base Addr + 0x404	Read	**APE D7**	**APE D6**	**APE D5**	**APE D4**	**APE D3**	**APE D2**	**APE D1**	**APE D0**
Base Addr + 0x405	Read	**APE D15**	**APE D14**	**APE D13**	**APE D12**	**APE D11**	**APE D10**	**APE D9**	**APE D8**
Base Addr + 0x406	Read	**APE D23**	**APE D22**	**APE D21**	**APE D20**	**APE D19**	**APE D18**	**D17**	**APE D16**
Base Addr + 0x407	Read	**APE RDY**		**BE**	**OF**	**OS**	**BA**	**PS**	**CE**

Table 18: APE data & status registers

The following is a brief description of the abbreviations used in Table 18. For more information please refer to Tamagawa SA35/56-11/24bit-LPS-5V data sheet.

APE RDY	APE ready flag. If READY=1, data and status are valid. If READY=0, data acquiring is in progress.
APE D23 ÷ D0	Absolute position encoder data
CE	Counter error status
PS	Pre-load status
BA	Battery alarm
OS	Over-speed
OF	Over-flow
BE	Battery error

SA35/56 needs reset after being disconnected or to clear an error (i.e. over-speed, over-flow). To reset encoder, logic one should be written to the corresponding control bit. SA35/56 requires reset signal to be held for at least 4÷5 sec. To enable SA35/56, logic zero should be written to the same control bit.

	R/W access	D7	D6	D5	D4	D3	D2	D1	D0
Base Addr + 0xE	Write	PCS3	PCS2	PCS1	PCS0				**RES**

Table 19: APE reset control bit

Tamagawa SA35/56 multi-turn absolute encoder requires a small external battery to keep track of motor position when the main power is off. A fully charged LS-421-2112 on-board battery is capable to power two SA35 encoders for min 300 hours. During the normal operation the battery is automatically recharged.

4.4. Interface Wiring

LS-221-BL may be equipped with various interface connectors. To allow fast and easy adaptation to user-defined interface and pinout, the interface connector is designed as separate module. It is mounted on the front panel and is connected to the controller with a set of wires (user harness). The LS-221-BL standard interface wiring is shown below.

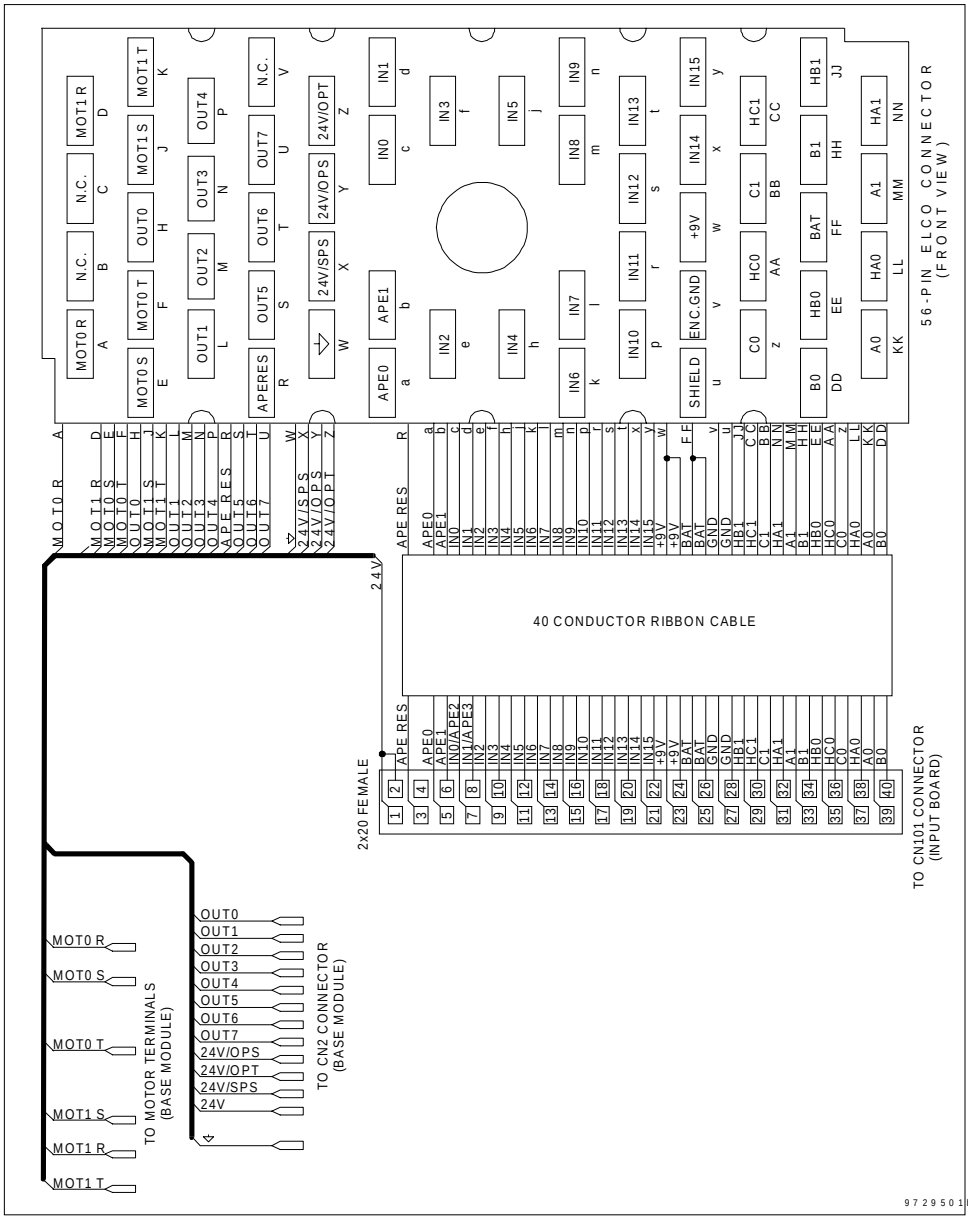


Figure 19: Standard Interface Wiring

4.5. Power Supply

LS-221-BL controller requires two external power supplies - operating power (24V DC) and motor power (24÷80V DC). The motor power supply is used to drive the motors only. The operating power supply is used to power the onboard input and output circuits and, optionally, to power the sensors and other circuits in the controlled system.

> *Important:* **Note that the motor power is floating.** This is required for proper operation of the protection circuits. Otherwise, in case of wrong wiring or a short circuit, controller and/or user electronics may be damaged.

CN3 connector is the entry for the external power supplies. In addition, the emergency stop is connected here. The schematic of a typical power supply for LS-221-BL is shown below:

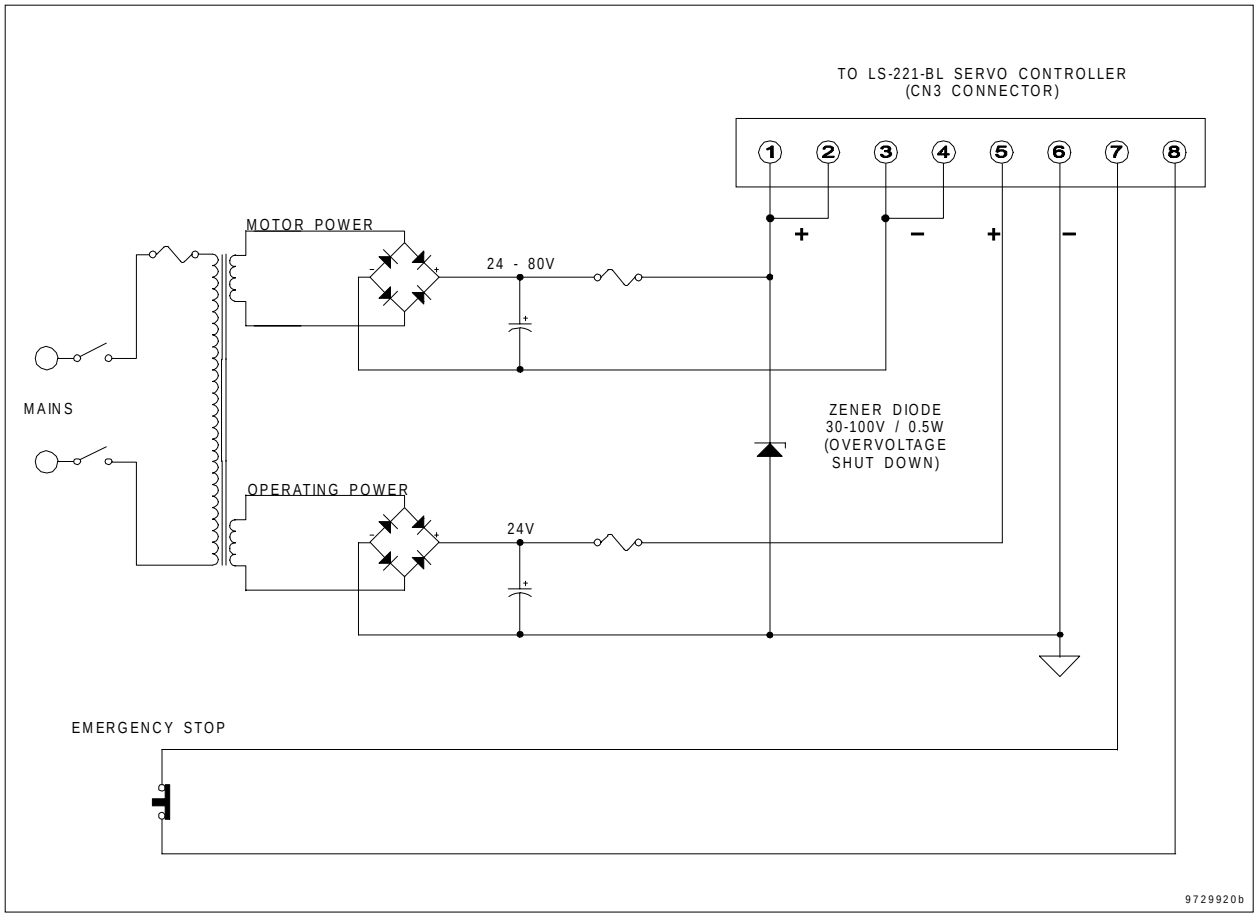


Figure 20: Typical power supply

5. BOARD SETUP

5.1. Base I/O Address

Up to 8 boards may be installed in one computer.

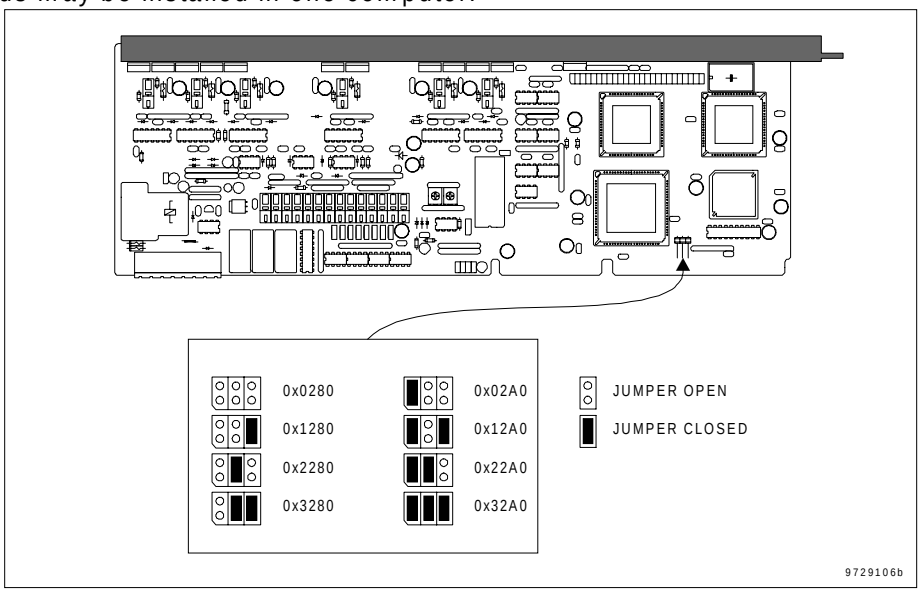


Figure 21: Base I/O Address (J1 jumper block)

5.2. Interrupt Line

There are four hardware interrupt lines available. It is not allowed IRQ line to be shared with another LS-221-BL controller or other device.

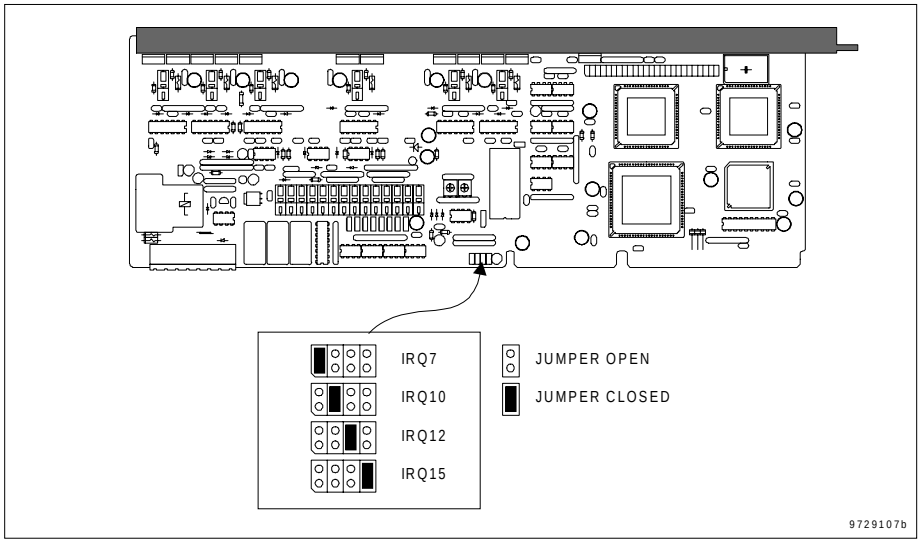


Figure 22: Interrupt line (J2 jumper block)

5.3. Current Limit Mode

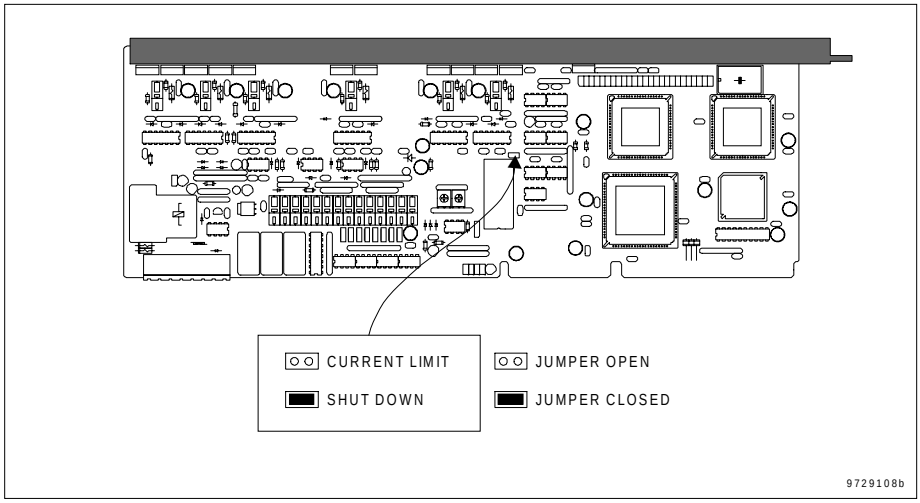


Figure 23: Current Limit Mode (J3 jumper)

5.4. Servo Off Mode

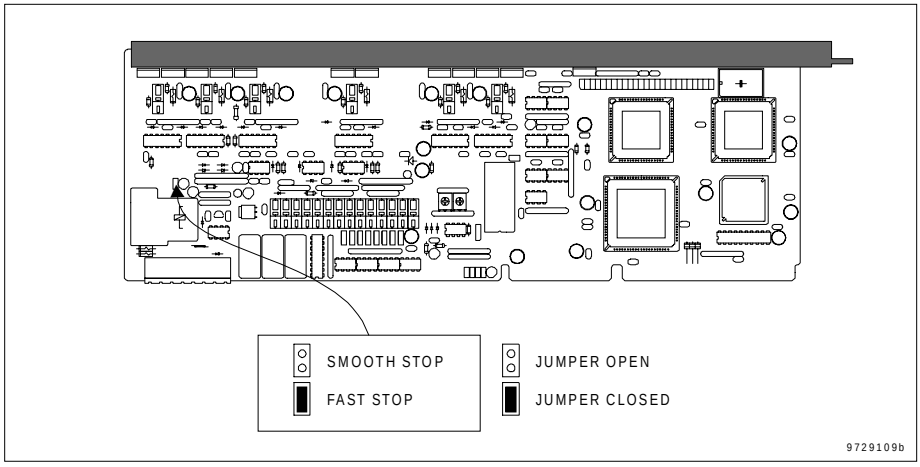


Figure 24: Servo Off Mode (J4 jumper)

6. APPLICATION NOTES

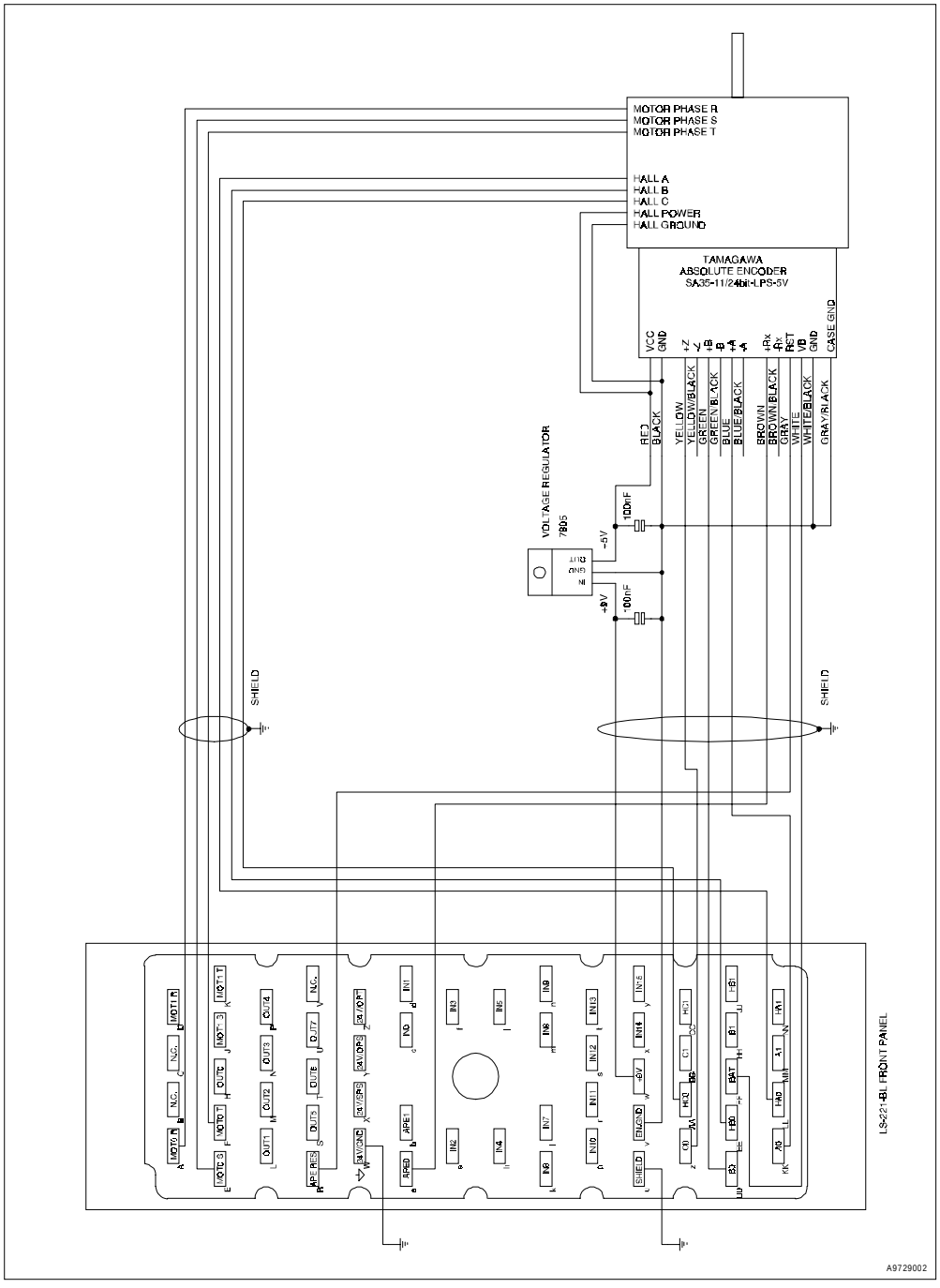
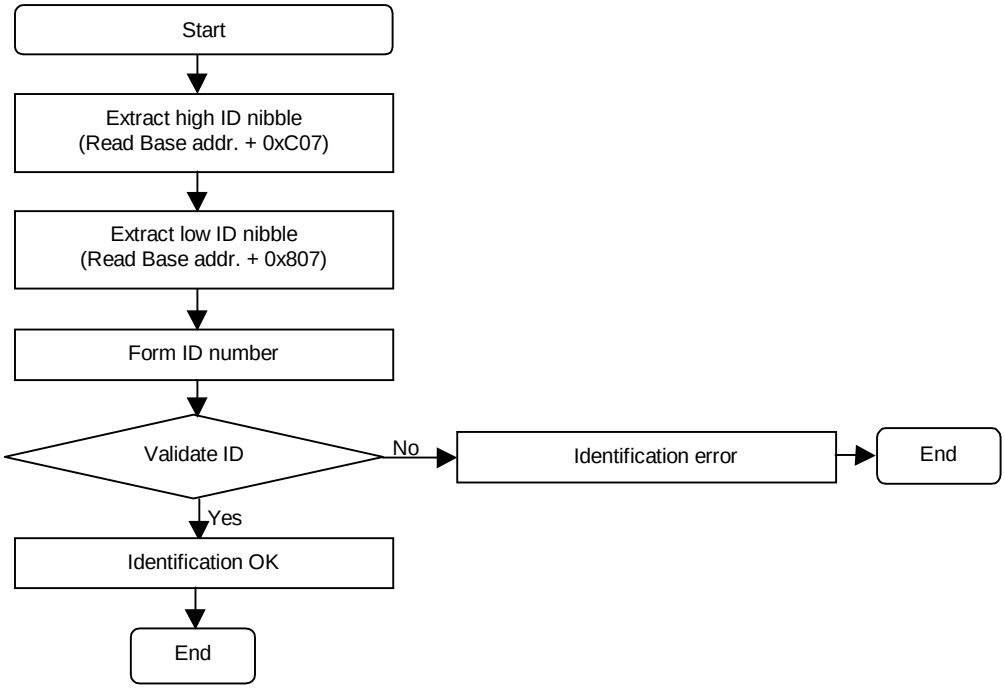


Figure 25: Absolute encoder sample wiring

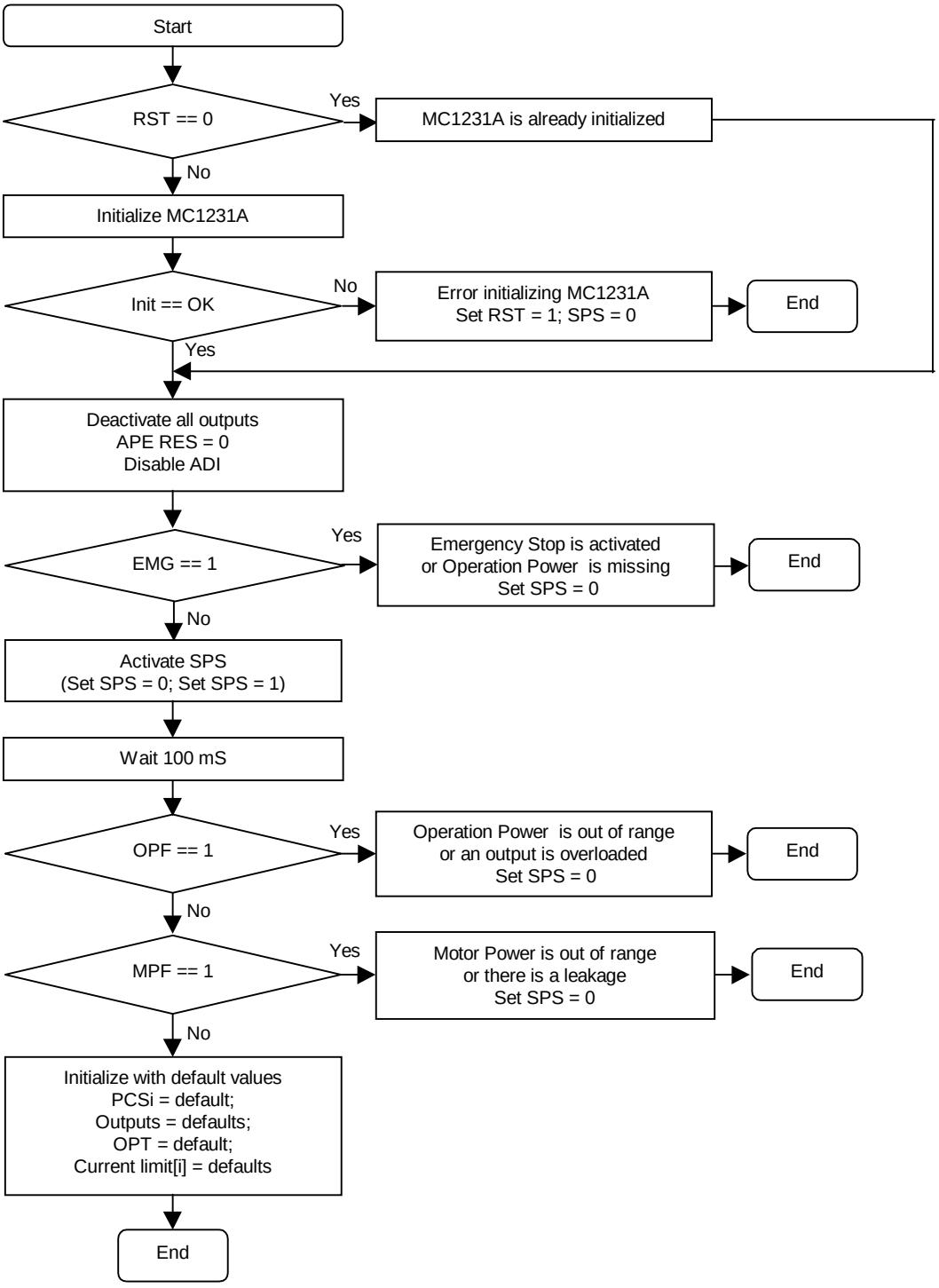
7. BASIC CONTROL PROCEDURES

This section shows algorithm flow charts for some basic control procedures.

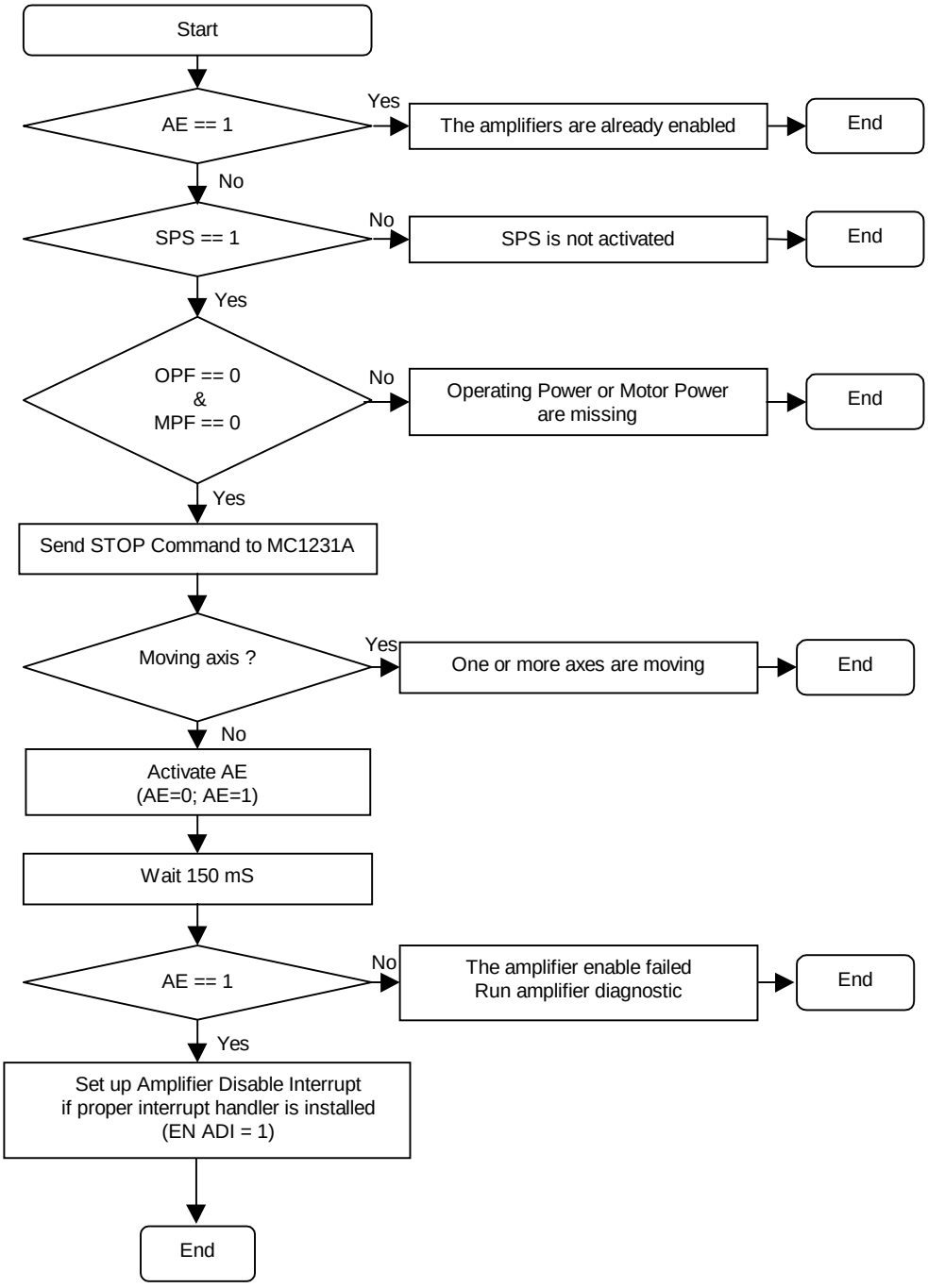
7.1. Board identification



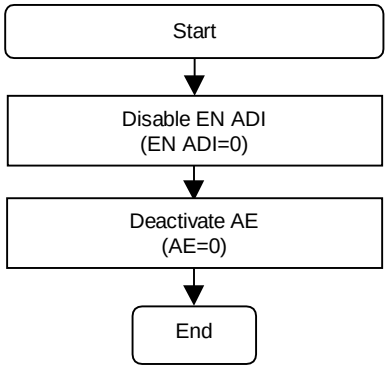
7.2. Board Initialization and Power On



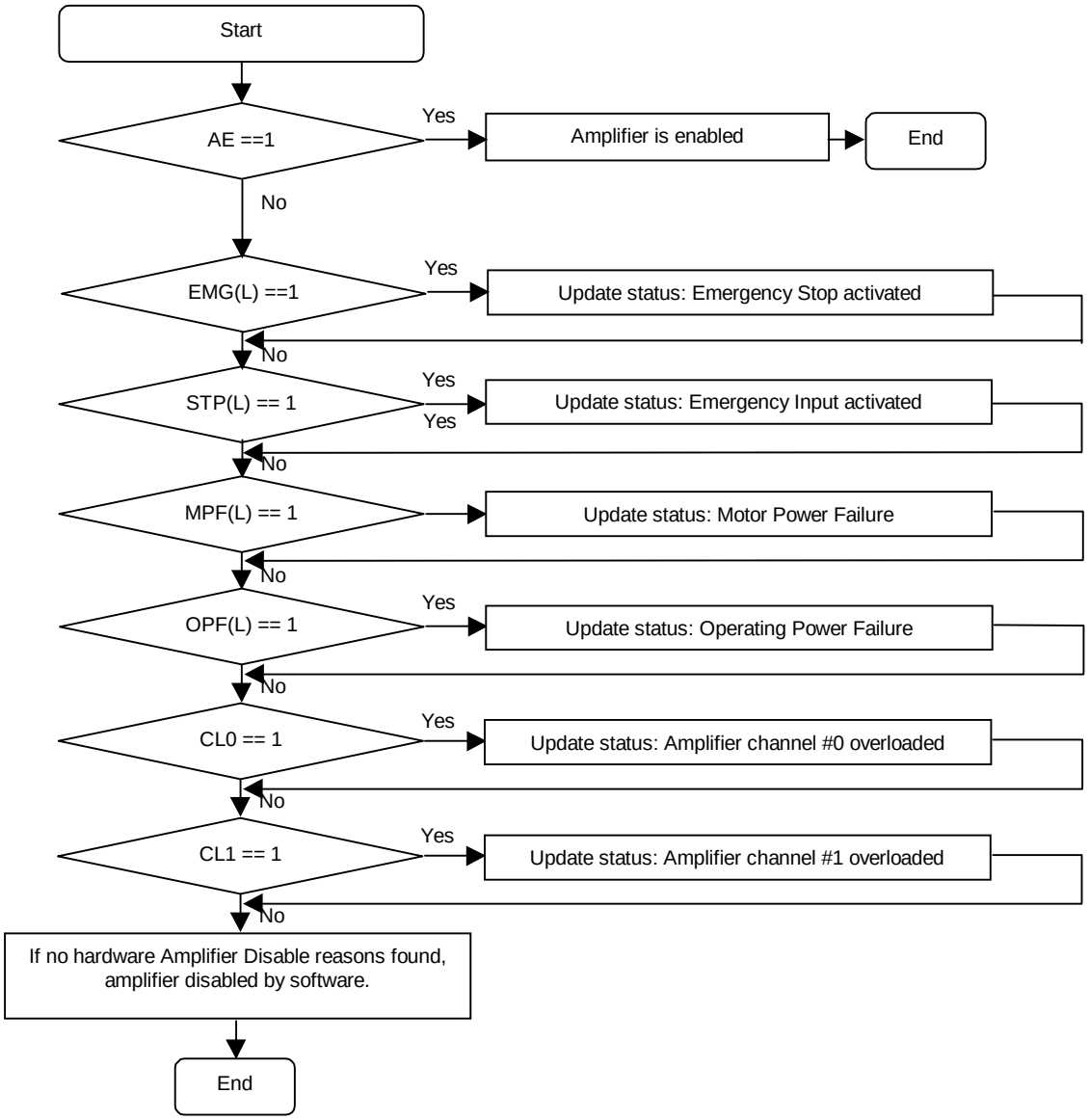
7.3. Enable Amplifiers



7.4. Disable amplifier



7.5. Diagnostic – Finding Out the Reason Caused Amplifier Disable



LOGOSOL

Logosol, Inc.
1155 Tasman Drive
Sunnyvale, CA 94089
USA

Tel: (408) 744 0974
Fax: (408) 744 0977
Http://www.logosolinc.com

Document No 710220125

Printed in USA