Automated Music Punch Controller: AMP-1 v2

Installation and Operating Instructions
(Version 3 Firmware)

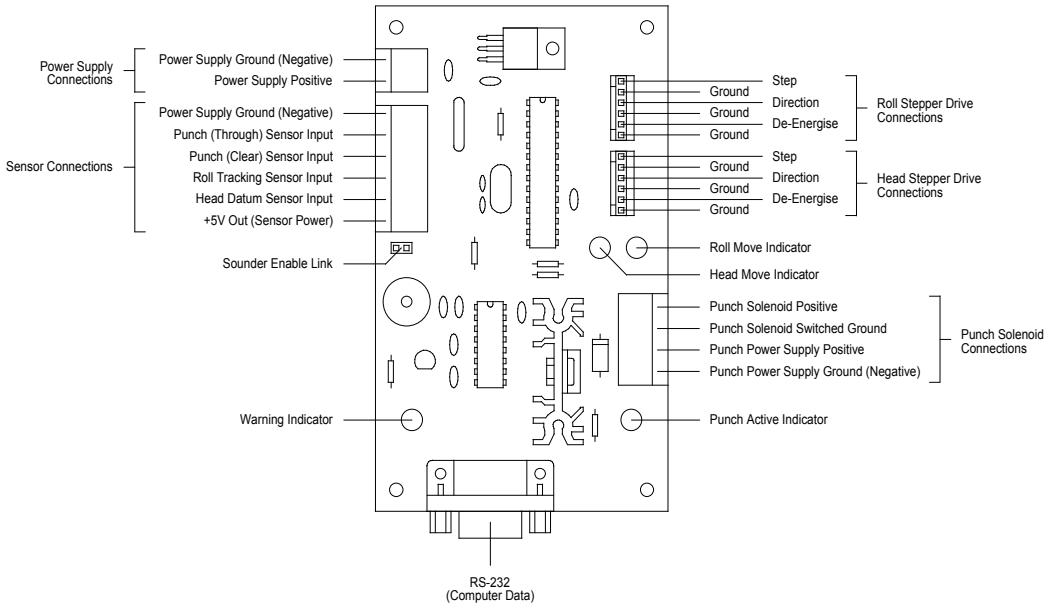
Description

The AMP-1 music roll punch controller is an electronic circuit that provides the interface between an IBM-compatible PC and the stepper motor drives, punch solenoid and feedback sensors of an automated music roll punching machine. The AMP-1 generates accurately timed step pulses that include linear acceleration and deceleration profiles to move two axes at optimal speed into the positions required to punch holes in the production of music rolls for mechanical instruments.

It is intended that the AMP-1 be used in conjunction with the application-specific PC software that it is supplied with. This software, and the use of it, is described in a separate document.

Electrical Installation

The AMP-1 v2 circuit board has connectors for dc power input, feedback sensors, two stepping motor drives, a punch solenoid and serial communications. With the exception of the RS-232 serial port, all connections are via plug in screw terminals. The general layout and connection scheme is shown below:



Power Supply

There are two power inputs to the control circuit: one for the internal logic and one for the punch solenoid.

The internal logic supply requires an input voltage between 7 and 12V (9V optimum) at a current rating of around one hundred milliamps. The AMP-1 has an on-board 5V regulator for its own circuit power and the output of this is also supplied to the sensor connector to provide power for external sensors. The current drawn by these must be taken into consideration when calculating the power supply requirements (see section on sensor inputs). The total loading on the +5V sensor power output must not exceed 0.5A.

The punch solenoid supply input powers the punch solenoid only. If the punch solenoid is being driven by a voltage within the acceptable range for normal board power input, then both loads can be supplied from the same power source. Otherwise, separate supplies should be arranged for the board power and punch solenoid power.

All power supply connections on the circuit board share a common ground connection, which is also the same ground as used by the RS-232 interface.

Stepper Drive Outputs

The motor drive outputs produce pulses suitable for the control of conventional stepper motor drive modules having opto-isolated inputs and using a step-and-direction control scheme. A wide range of drive modules exist, with different voltage, current and step resolution capabilities. Whilst the final choice of drive module is left to the system builder, it is suggested that 'microstepping' drive, capable of a step resolutions in the order of 2,000 microsteps per revolution will allow fine control of position and rapid movement. Drives such as the M542 from Leadshine Technology Co. Ltd (www.leadshine.com) have been found to work well with the AMP-1 in controlling punch machines suitable for organ music of around 30 notes. Step pulses produced by the AMP-1 have a width of 5µs.

The drive de-energise output provided by the AMP-1 can be connected to drives that are capable of turning off the motor power under the control of a remote input. This has no direct effect on punch machine performance, but implementing it will allow the stepper motors to be de-energised and therefore consume less electrical power when they are not in use for a roll punching operation or optionally if an error occurs and the system is waiting for user intervention. If the stepper drives are designed to be energised rather than de-energised on an active input, then it will be necessary to connect the terminals of the stepper drive's energise input between the de-energise pin of AMP-1's 6-pin header and the +5V output from the sensor terminal. In this way, the drive will be activated when the AMP-1's output goes low. Note that in this arrangement, the negative side of the stepper drive input must be connected to the AMP-1 de-energise output.

It is recommended that twisted-pair cables be used to connect the AMP-1 to the stepper drives, using a signal and ground connection in each pair to provide maximum signal integrity and radio frequency noise immunity. Computer network cable (CAT5 UTP) is suitable for this. Each output to the stepper drives can source or sink up to 20mA, which is generally sufficient to drive an opto-coupled drive input.

It may be necessary to include a current-limiting series resistor if the drive inputs do not have these already built in.

Punch Solenoid Output

The punch solenoid is driven by a heavy duty solid state switch, rated at 10A and up to 70V. This switching device is self-protecting and will shut down if its voltage, current or temperature ratings are exceeded. An anti-parallel diode is provided onboard to control the inductive energy released when the solenoid coil is de-energised.

Sensor Inputs

The sensor inputs are 5V TTL and CMOS compatible logic types. There are four sensor inputs utilised:

- Head carriage datum
- Roll tracking
- Punch clear
- Punch through

All sensor inputs are active-low (pulled to ground to activate) and are passively pulled up to +5V by 4k7 Ohm resistors on the AMP-1 circuit board. This means that any sensor inputs that are not connected will be ignored by the system. It is, however, essential that the head datum sensor be connected and highly recommended that all other inputs be utilised to give full protection against machine errors during operation.

The datum sensor detects when the punch head carriage passes a specific point. The AMP-1 uses the signal from this sensor to initially position the punch head and also to make running positional accuracy checks as the machine operates. This input must be driven by the sensor to logic low (ground) when the punch head position is greater than the datum point and high when the position is less than the datum. Any hysteresis in the sensor will not affect overall accuracy, as the datum position is always registered when the carriage is moving in the positive direction only.

The roll tracking input detects if the paper roll or cardboard book material drifts laterally out of tolerance limits. Ideally this would be driven by two sensors at either edge of the roll, connected in an open-collector ‘wire-or’ scheme such that excessive movement in either direction away from the ideal straight line pulls the input to ground, indicating an error condition.

The punch clear input must be pulled low whenever the punch tool is engaged with the roll paper. This input is checked prior to moving either the punch head carriage or the roll and an error will be reported if the sensor connected to it reports that the punch is not clear at this time. This prevents damage to the roll paper if the punch tool fails to return to the clear position when its solenoid is de-energised. Using the punch sensor can also used to speed up punch operation, since it allows the punch energise / release cycle to end as soon as the punch returns to the clear position without needing to wait for the full punch release time.

The punch clear input must be pulled to ground whenever the punch tool is engaged with the roll paper. This input is checked prior to moving either the punch head carriage or the roll and an error will be reported if the sensor connected to it reports that the punch is not clear at this time. This prevents damage to the roll paper if the punch tool fails to return to the clear position when its solenoid is de-energised. Using the punch sensor can also used to speed up punch operation, since it allows the punch energise / release cycle to end as soon as the punch returns to the clear position without needing to wait for the full punch release time.

The punch through input provides a means to warn the user if the punch tool fails to travel fully through the paper when punching a hole is attempted. The use of this input is optional and the AMP-1 will decide at the time of making each hole whether to respond to the input or not. If used, the sensor must be arranged to pull this input to ground whenever the punch tool is not fully through the paper. If punch through detection is not to be used (no punch through sensor fitted), then this input must be unconnected and allowed to float high under the action of the built-in input resistor. In addition to giving more comprehensive fault detection, using this sensor input can further speed up punch operation, since it allows the punch solenoid to be de-energised as soon as the hole has been formed without needing to wait for the full punch energisation time.

Various sensor types can be used with the AMP-1 according to the system builder's preferences, although electro-mechanical switch arrangements should be avoided due to issues of low precision, lifetime wear and contact bounce. Contactless electronic sensor systems such as Hall switches and optical sensors are generally suitable and should have Schmitt-trigger outputs to avoid noise issues at the switching boundary. Examples of suitable optical sensors are the OPB917B and OPB917I manufactured by Optek Technology, Inc (www.optekinc.com). Note that optical sensors will normally require a series resistor for the LED (light emitter) side. Using a 5V supply, a suitable resistor value would be around 270Ω.

The AMP-1's sensor connector includes a +5V output for powering sensors. This output comes from the on-board voltage regulator can supply up to 0.5A to external sensors under normal conditions.

Indicators

There are four indicator LEDs on the AMP-1 to provide status feedback to the user, which are:

- Roll axis moving
- Head axis moving
- Punch solenoid energised
- Warning of system error

Each LED is coloured uniquely to allow easy identification.

Warning Alarm

In the event of an error being detected, the AMP-1 will produce a signal by lighting the warning LED and sounding an audible tone. If the audible tone is not required, it may be disabled by removing the shorting link between the two pins near to the sounder.

Computer Connection

Connection to the host computer is via the RS-232 interface using the standard 9-way D-type connector on the board. A 9-way male-to-female serial extension cable will be required to link the board to the computer. For computers without a built-in RS-232 port, a USB-serial adapter may be used as long as this provides both the RTS/CTS handshake signals in addition to data in/out signals. Some low-cost adapters do not support these additional signals and will not be able to operate the AMP-1 correctly, whereas a good quality adapter will work without problem.