RollSCAN-1 Scanner Controller Answers to Frequently Asked Questions (FAQ's)

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What exactly does the RollSCAN-1 controller do?

The RollSCAN-1 controller is a highly integrated, single-board color scanner controller. Whereas most scanners are designed primarily for page scanning and most scanner controllers are specifically designed for and built into a particular page scanner, the RollSCAN-1 is designed as a highly flexible, general purpose scanning controller. In addition to discrete page scanning, the RollSCAN-1 provides a continuous "streaming" mode of scanning. This "streaming" mode is useful for scanning long, rolled or folded documents such as piano rolls, book music, strip charts or pin-fed continuous forms. Based on one of the newest generation of "scanner-on-a chip" IC's, the RollSCAN-1 integrates all of the electronic functions necessary for a high performance color or monochrome scanner. These functions include:

- Flexible, programmable CCD/CIS timing and clocking circuitry
- Compatible with a wide range of linear mono and color CCD and CIS devices
- Illumination control, timing and drive circuitry (CCFL requires external inverter)
- Complete 12-bit/36-bit (monochrome/color)analog front-end for CCD/CIS
- Pixel-rate digital signal processor
- 512 Kbyte data buffer
- microstepping motor controller and motor drive circuitry
- PC-compatible EPP parallel port interface
- Printer passthrough capability with addition of two external IC's

What are the performance specifications for the RollSCAN-1?

Please refer to the separate "RollSCAN-1 Specifications" document.

Will the RollSCAN-1 board be fully populated or will it be a "kit"?

The RollSCAN-1 controller board will not be a kit. It will be professionally assembled: fully populated with all parts and cleaned of residual flux by a contract circuit board manufacturer. Only a few configuration-dependent resistors and capacitors will be left off. There will be clear instructions in the documentation package describing how to select and install the right component values. The few user-installed parts are very inexpensive discrete components that you can buy at any Radio Shack. There are no user-installed surface-mount parts.

What kind of circuit board is the RollSCAN-1?

General Physical Specifications for the RollSCAN-1 circuit board are as follows:

Size:	Approx. 4" x 6" (pending final layout), mounting holes at corners
Board Thickness:	0.0625 (1/16 inch)
Material:	FR-4 Fiberglass resin
Conductors:	Inner Layers (2,3) – 1.0 oz copper Outer Layers (1,4) – 1.5 oz copper
Outer layer finish:	HASL (Hot Air Solder Level)
Solder Mask:	Yes. Both sides (helps prevent solder shorts)
Screen Printing:	Top side only – component outlines and locators
Layer Stack-up:	Layer 1: signal layer Layer 2: Segmented ground plane Layer 3: Segmented power plane Layer 4: signal layer

Component Mounting:	Top Side (Layer 1) ONLY
Minimum Lead Pitch:	0.019" (TQ100)
Minimum Trace Width:	0.007"
Minimum Trace Spacing:	0.010"
Buried/Blind vias?	None

Will the RollSCAN-1 board be tested? How?

Yes. The costs (and wasted materials) associated with board failures are too high to take the risk of accepting untested boards. The PC board fabrication house will electronically compare the finished blank circuit boards against their net-list. The cost of testing is easily justified as cheap insurance against mounting good components on bad boards. After assembly, all boards will be powered up and given a functional test prior to acceptance from the assembly house. Only boards that pass the functional test will be sent out.

What is the size of the RollSCAN-1 board?

Approximately 4 inches by 6 inches. (Exact size pending completion of layout). See above for more physical details.

What comes with the RollSCAN-1 board?

- Assembled and tested RollSCAN-1 circuit board assembly
- Configurable skeleton driver for Win95/98/Me
- Source code for driver
- Scanner Control DLL, compatible with Visual C++/Visual Basic/ Borland C++
- Source code for scanner control DLL
- Header and definition files for Visual C++ and Visual Basic
- Win32 Piano Roll scanning application – Windows equivalent of Richard Stibbons' CISDEMO/CISTWIN, SCNDEMO/SCNTWIN and MIDDEMO programs, with interpretation of expression perforations
- Source code for Windows scanning application
- Complete schematics of RollSCAN-1
- RollSCAN-1 Theory of Operation
- RollSCAN-1 Programming Guide
- RollSCAN-1 Hardware Interfacing Guide
- Application notes: CIS interfacing, CCD interfacing, stepper motors, paper drive system for continuous forms (piano rolls/organ rolls)
- Reference Designs for CIS and CCD based scanners

All software and documentation will be provided on CD-ROM. All documentation will be in PDF files (Adobe Acrobat-compatible Portable Document Format).

Future enhancements (within 6 months): Windows 2000/NT drivers, TWAIN driver

What do I need besides the RollSCAN-1 board to build a piano roll scanner?

You need to supply a linear image sensor and optical system, an illuminator, a paper transport system (w/optional paper sensor and buttons), a PC with a parallel port, a power supply and a few cables. Typically, the image sensor and optical system will be a CCD/lens combo or an integrated CIS module. *See below for more in the answer to "What about the paper transport system and tracking?"* Illumination can be accomplished many ways, but will typically be either an LED array or a white-light CCFL (Cold Cathode Fluorescent Lamp). If a CCFL is used, you will need to supply a high-voltage inverter (commercially available).

The RollSCAN-1 has on-board power regulation, so power is not critical. A simple rectified and filtered transformer output will do. There are several "wall wart" wall transformers available from a variety of hobby outlets that will suffice. If you need special voltages for your stepper motor and/or illuminator, you will have to provide those, as well.

Since the RollSCAN-1 has its own stepper motor drivers for winding currents of up to 1 ampere, no additional circuitry is required, but you will have to add your own current sensing resistor(s) to the board and provide a motor cable. You will also need cables for the image sensor, illuminator (if separate from the sensor) and PC parallel port. Detailed instructions for making these cables are included in the RollSCAN-1 Hardware Interfacing Guide. All of the parts are readily available from hobby outlets.

What can I do with the RollSCAN-1 if I don't want to write my own software?

A lot!

Right "out of the box", the RollSCAN-1's application software is capable of scanning, archiving, and interpreting piano rolls. All you need to do is provide the right parameters to the configurable driver for your drive and sensor system.

Can I add my own circuitry to the RollSCAN-1?

Yes. There is an array of 0.035" diameter plated holes on 0.1" x 0.1" centers right on the RollSCAN-1 board for prototyping. All of the power supplies and grounds are brought to the edge of this prototyping area. In addition, the RollSCAN-1 Hardware Interfacing Guide shows you a few tricks for attaching your own "sidecar" circuit boards directly to the RollSCAN-1.

How do I connect my computer to the RollSCAN-1 board?

The RollSCAN-1 connects directly to your PC's Parallel Port connector without additional circuitry. EPP (Enhanced Parallel Port), PS/2 (bidirectional), and SPP (Standard Parallel Port) modes are all supported. EPP mode provides the best performance.

My printer uses the only available parallel port. Do I have to disconnect my printer to use the RollSCAN-1?

Not necessarily. With the addition of two IC's – a 74HCT244 buffer and a 74HCT374 buffer/latch – and the appropriate DB25 connectors, you can create a printer passthrough port. Details are provided in the RollSCAN-1 Hardware Interfacing Guide.

Due to the complex hardware compatibility issues associated with passthrough ports, it cannot be guaranteed that the RollSCAN-1 will be compatible with *your specific printer*, but many printers will work with the passthrough port. This capability has not been tested, but is described in National Semiconductor's documentation for the LM9830 chip used on the RollSCAN-1 board.

The alternative is to purchase a second parallel port. Such I/O cards are quite inexpensive and are available for ISA bus, PCI bus, and on PCMCIA cards.

How do I connect a microcontroller to the RollSCAN-1 board?

A single configuration jumper lets you set your host port interface mode to either "parallel port" mode or "microcontroller" mode. In microcontroller mode, the RollSCAN-1 functions are in two-stroke fashion by first writing a register address to an address port, then writing or reading data for that register from a data port. For certain operations (*e.g.*, for loading or retrieving the gain/offset/gamma correction tables), an address-autoincrement mode is supported so that it is not necessary to repeatedly write register addresses to the address port.

Can you connect the RollSCAN-1 board to a laptop computer?

Yes. Via the laptop's parallel port. Parallel port functionality can be added via a PCMCIA card if necessary.

Does any software come with the RollSCAN-1 board?

Yes. See answers to "What comes with the RollSCAN-1 board?" and "What can I do with the RollSCAN-1 if I don't want to write my own software?"

What operating systems does the RollSCAN-1 board support?

Initially, software for the RollSCAN-1 will be provided for Windows 95/98/Me. Later, Windows NT/2000 will be supported.

For maximum portability to other operating systems, great care has been taken to separate out the Windows-specific portions of the code. Source code is kept compatible with the ANSI "C" standard. For non-Windows code, C++ features have been specifically avoided to help ensure maximum cross-platform compatibility. All code is compiler-checked in a non-Windows environment using an ANSI "C" compiler and standard Unix-compatible #include files (stdlib.h, string.h, malloc.h etc.).

What about the paper transport system and tracking?

The RollSCAN-1 Hardware Interfacing Guide and Application Notes make some very specific recommendations with respect to the paper transport system. Building on the excellent work and experience by Spencer Chase, Richard Stibbons and others, as well as drawing from lessons learned the design of printers, production mailing machines and copiers, a very gentle roll transport system is described.

Essential features of the recommended transport system design are:
- minimize the amount of "curl" and "uncurl" that the paper must endure (helps prevent damage to ancient, brittle paper)
- completely eliminate "reverse curl"
- maintain continuous, light paper tension via opposed, lightly energized DC spool drive motors
- bias the spool drive motor currents so there is a VERY SLIGHT tendency for the paper to move in the desired direction
- use a small, center-mounted, stepper motor driven rubber-coated "capstan" roller to control the actual motion of the paper.

Because of the biased tensioning arrangement, very little capstan pressure or torque is required to control the paper motion, resulting in a very gentle but very accurate drive system.

Tracking is not an issue. All tracking is done in software.

How is paper motion coordinated with the scanning?

The RollSCAN-1 tightly couples the stepper motor drive to the scanning logic for accurate motion control.

What kinds of image sensors are supported?

CCD: Linear arrays (monochrome) and Tri-linear (color) arrays are supported up to 16383 pixels in length. Maximum of 5461 pixels if hardware PRNU (Pixel Response Non Uniformity) compensation is desired. Timing and clock signals are compatible with most manufacturer's CCD's

CIS: Single array monochrome (single color LED or CCFL illuminator) and color (R/G/B LED illuminator) and Triple Array color (white light LED or CCFL illuminator) modules are supported. Timing and control signals are compatible with most manufacturer's CIS modules.

Can I control two overlapping CIS modules with just one controller?

Yes, within some limitations. The RollSCAN-1 Hardware Interfacing Guide and Application Notes describe several different approaches to handling overlapping arrays.

What kind of illuminator should I use?

For front illumination, all CIS modules come with their own illuminators – usually an LED or CCFL illuminator. For a CCD, you will need to supply an appropriate illuminator – again, usually an LED array or CCFL illuminator.

For rear illumination, the same options apply, but you must disable the built-in illuminator in CIS modules.

Which is better, frontlighting or backlighting?

It depends upon what you're trying to do. If you want to read the printed text off of word rolls, you'll have no choice but to use front illumination. For measuring and decoding the punches in piano rolls, superior results have been reported for backlighting – but either approach will work. A backlit arrangement is less susceptible to confusion from marks on the surface of the roll, but has trouble with thin, translucent papers. Frontlit systems have no trouble with translucent papers, but are easily confused by pencil marks, printed expression cues and words.

A dual system might provide the most benefit, using backlighting to measure and decode the punch coding and front lighting to capture printed notations on the roll.

What kinds of drive motors can be used?

Spool motors can be DC hobby motors. The capstan motor should be a stepper motor. Specific recommendations for motors and gear/pulley ratios are given in the RollSCAN-1 application notes.

Can't I just use a DC Gearmotor to drive the takeup spool?

It depends. If you are willing to make some basic compromises, you can use a gearmotor as a spool drive.

Since roll paper *never* conforms perfectly to the spool hub, all spool drive systems (including the player pianos and organs themselves!) exhibit a certain amount of "lumpiness" in the paper speed as the takeup spool rotates. Further, as paper accumulates on the takeup spool, the effective hub diameter increases and the paper travel speeds up. Neither problem is severe from a real-time performance point of view, and since ALL player pianos have the same problem, there's no reason to try to improve on it if all you want to do is listen to the music on the roll. The "lumpiness" and speed-up problems are crippling if you're trying to recreate the original punch pattern on the roll.

One of the few limitations of the RollSCAN-1 controller is that it makes no provision for "triggered" scanning. The scanning process must be allowed to free-run. If triggered scanning were available, then you could use a position encoder to measure paper travel and trigger the scanning head at the right positions, eliminating the problem of speed variation. Since triggered scanning is not available, you must make the assumption that the paper speed is stable enough for your purposes if don't want to use a stepper motor.

So, if your goal is Roll-to-MIDI conversion – the DC gearmotor is probably good enough. However, if your goal is archival quality scanning or highly accurate Roll-to-MIDI conversion, then stepper motor drive is recommended.

When is a DC Gearmotor drive spool not appropriate?

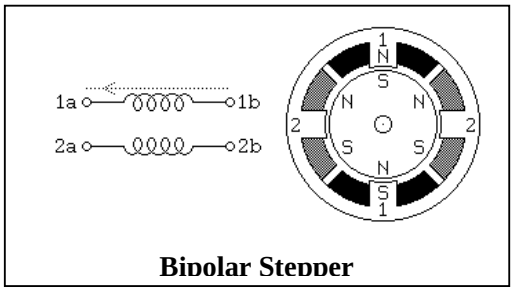
When high-precision is required, as for roll archiving. *See answer to previous question.*

OK. So I have to use a stepper motor. What kind can I use?

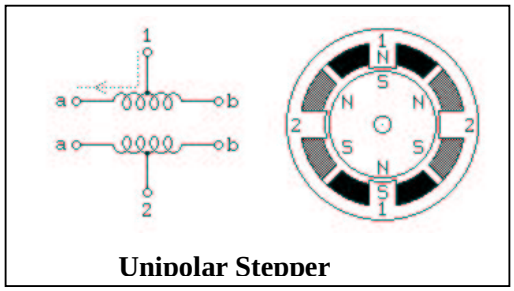
The RollSCAN-1 is configurable for use with both bipolar and unipolar stepper motors with winding currents of up to 1 Ampere. Consult the RollSCAN-1 documentation for sense resistor values and gearing recommendations.

What's the difference between a unipolar stepper and a bipolar stepper?

A bipolar stepper motor has two floating windings, and is often referred to as a "two-phase" motor. A unipolar stepper motor has two center-tapped windings forming (effectively) four windings, with pairs of windings sharing a common power lead. (See illustrations)

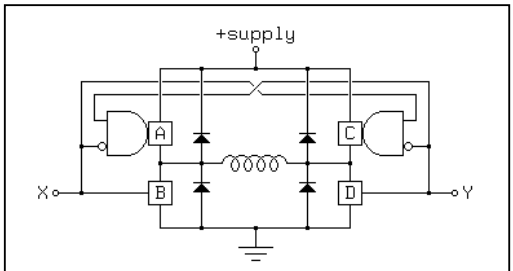


Bipolar Stepper

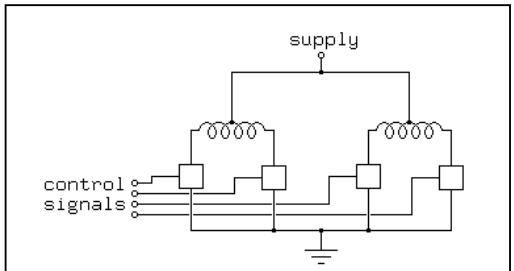


Unipolar Stepper

Drive circuits are different for bipolar and unipolar stepper motors, with bipolar steppers requiring opposite ends of each winding to be driven with an opposite polarity. The common leads (1 and 2) of a unipolar motor are connected to a motor supply. The four winding terminals (a,b,c,d) are driven by simple current sink circuits. (see illustrations)



Bipolar Drive



Unipolar Drive

The RollSCAN-1 controller is compatible with both types of motor

Won't a stepper motor drive be rough on the paper?

Not if the design guidelines are followed. See the answer to *"What about the paper transport system and tracking?"* for more detail.

I just want to do real-time playback. What kind of resolution do I need?

Your required horizontal resolution is dictated by the punch width and spacing. 180 dpi is a nice, safe figure for most applications. Depending upon the software decoding and tracking techniques, horizontal resolutions as low as 70 dpi or so may suffice.

For real-time playback or for Roll-to-MIDI conversion, you only need enough vertical resolution to beat the human temporal perception threshold of about 20 milliseconds. To give the system some margin, we'll assume that 10 millisecond resolution is required. At a ridiculously low speed setting of 3 feet per minute (piano tempo = 30) this works out to about 166 dpi. At a high speed setting of 13 feet per minute, it works out to only 38 dpi.

Actually, for real time scanning, the dpi resolution is irrelevant. The real question is "what is the scanner's sampling rate?" It must be at least as fast as the minimum temporal resolution required. The RollSCAN-1 will easily meet the 10msec requirement for virtually any sensor at virtually any resolution.

I'm interested in accurate roll archiving. What kind of resolution do I need?

See the answer to the previous question for horizontal resolution requirement.

Your vertical resolution requirement for roll archiving is dictated by the need to recalculate the original punch-step interval. Although many punches operated on a 30 punch-per-inch step size, high-resolution rolls were often punched as high as 60 punches to the inch. In order to facilitate back-calculation of the punch-step interval without resorting to exotic mathematical techniques, a vertical resolution of 3 times the punch-step resolution, or 180 dpi, is recommended.

Scanning speed at this vertical resolution will depend upon a number of factors, including the pixel readout rate of the sensor, the number of pixels on the sensor, the scanning mode and pixel depth, among others.

Can I scan wide paper, like 14 7/8" Red Welte rolls or Mills Violano rolls? If so, how?

Absolutely! There are several options available for wide scanning. Probably the simplest method is to use a CCD/lens combo. You could go all the way out to 25" or so with no difficulty and still have more than enough resolution. It is relatively easy to scavenge a complete optical head from out of an older CCD-based scanner (like an HP Scanjet 4 or 5) and keep the lens and folded optical assembly. This will make for a solid, compact, reliable system. All you need to do is move the optical head back a few inches from the roll and re-adjust the focus. One of the reference designs is a scanner of this type.

Another option is to use overlapping CIS modules. Although somewhat more difficult to manage, this is a perfectly viable answer. The RollSCAN-1 Application Notes describe how to do this.

What about REALLY wide paper, like 24"+ organ rolls?

See answer to previous question.

How big is the data buffer on the RollSCAN-1?

About 224 Kbytes. 32 Kbytes of the 256 Kbyte buffer memory is used for storing gain and offset coefficients.