ELM624

Control L to RS232 Interpreter

Description

The Control L or LANC interface is an industry standard for many audio and video devices. It uses a bit serial format that is similar to RS232, but differs enough that devices cannot be directly connected to one another. The ELM624 provides the necessary logic to allow almost transparent transfer between the two systems.

In operation, commands are sent to the ELM624 using an RS232 serial connection, translated to the Control L format, and sent to the controlled device on the LANC port. The resulting responses are then converted to a series of ASCII characters and transmitted back to the controlling serial device.

This integrated circuit was designed to provide a cost-effective way for experimenters to work with the Control L system, so many features typically found in commercial devices, such as RS232 handshaking, variable baud rates, extra buffering of signals, etc. have not been implemented. Responses are kept to a minimum as well (eg. a single question mark is returned for a misunderstood command), but the general principles are demonstrated, and for many applications, this is all that is required.

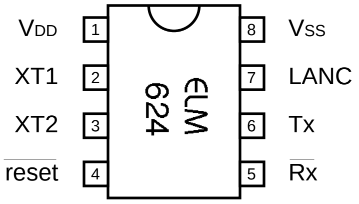
Applications

- Video editors
- Time-lapse recording controllers
- Remote camera controls
- Computer control of A/V equipment

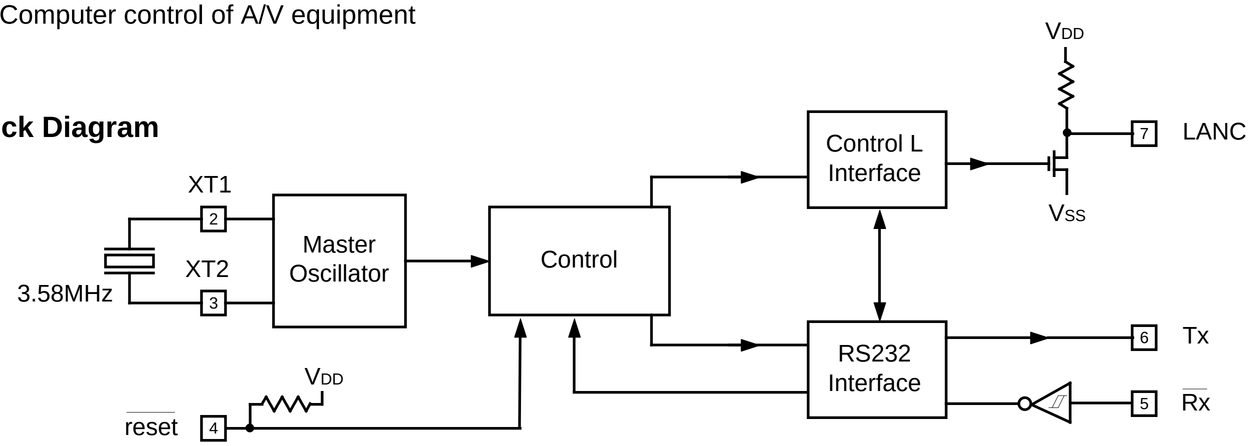
Features

- Low power CMOS design
- High speed RS232 communications
- Configurable with standard AT commands
- ASCII output formatted as standard hex digits
- Minimum of external components required
- Most Control L formats supported
- External reset input for system use
- Crystal controlled for signal accuracy

Connection Diagram
PDIP and SOIC
(top view)



Block Diagram



Pin Descriptions

V_{DD} (pin 1)

This pin is the positive supply pin, and should always be the most positive point in the circuit. Internal circuitry connected to this pin is used to provide power on reset of the microprocessor, so an external reset signal is not required. Refer to the Electrical Characteristics section for further information.

XT1 (pin 2) and XT2 (pin 3)

A 3.579545MHz NTSC television colourburst crystal is connected between these two pins. Crystal loading capacitors (typically 27pF) will also normally be connected between each of the pins and Vss.

$\overline{\text{reset}}$ (pin 4)

This pin can be used to reset the circuit by applying a momentary logic low level to it. If unused, this pin should either be connected to V_{DD}, or left open (as an internal pullup resistor is provided).

$\overline{\text{Rx}}$ (pin5)

The computer's RS232 transmit signal is directly connected to this pin through a single current limiting resistor (typically about 47KΩ). Internal signal inversion and Schmitt trigger waveshaping provide the necessary signal conditioning.

Tx (pin 6)

The RS232 data output pin. Signal level is compatible with most interface ICs, and drive is sufficient to allow interfacing using only a single PNP transistor if desired. See the Example Application section for more details.

LANC (pin 7)

This is the open drain Control L (LANC) interface pin. An internal pullup resistor is provided for a nominal drain load.

V_{SS} (pin 8)

Circuit common is connected to this pin. This is the most negative point in the circuit.

Ordering Information

These integrated circuits are available in either the 300 mil plastic DIP format, or in the 200 mil SOIC surface mount type of package. To order, add the appropriate suffix to the part number:

300 mil Plastic DIP............................... ELM624P   200 mil SOIC.................................... ELM624SM

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Absolute Maximum Ratings

Storage Temperature	-65°C to +150°C
Ambient Temperature with Power Applied	-40°C to +85°C
Voltage on V_{DD} with respect to V_{SS}	0 to +7.5V
Voltage on any other pin with respect to V_{SS}	-0.6V to (V_{DD} + 0.6V)

Note:

Stresses beyond those listed here will likely damage the device. These values are given as a design guideline only. The ability to operate to these levels is neither inferred nor recommended.

Electrical Characteristics

All values are for operation at 25°C and a 5V supply, unless otherwise noted. For further information, refer to note 1 below.

Characteristic	Minimum	Typical	Maximum	Units	Conditions
Supply Voltage, V_{DD}	4.5	5.0	5.5	V	
V_{DD} rate of rise	0.05			V/ms	see note 2
Average Supply Current, I_{DD}		1.0	2.4	mA	see note 3
Input low voltage	V_{SS}		0.15 V_{DD}	V	
Input high voltage	0.85 V_{DD}		V_{DD}	V	
Output low voltage			0.6	V	Current (sink) = 8.7mA
Output high voltage	V_{DD} - 0.7			V	Current (source) = 5.4mA
Internal pullup resistances (see note 4)	300 20	500 30	600 50	KΩ KΩ	Pin 4 ($\overline{\text{reset}}$) Pin 7 (LANC)
$\overline{\text{Rx}}$ pin input current	-0.5		+0.5	mA	see note 5
RS232 Baud Rate		9600		baud	see note 6

Notes:

1. This integrated circuit is produced with a Microchip Technology Inc.'s PIC12C5XX as the core embedded microcontroller. For further device specifications, and possibly clarification of those given, please refer to the appropriate Microchip documentation.
2. This spec must be met in order to ensure that a correct power on reset occurs. It is quite easily achieved using most common types of supplies, but may be violated if one uses a slowly varying supply voltage, as may be obtained through direct connection to solar cells, or some charge pump circuits.
3. Device only. Does not include any load currents.
4. The value of the internal pullup resistance is both supply and temperature dependent.
5. This specification represents the current flowing through the protection diodes when applying large voltages to the $\overline{\text{Rx}}$ input (pin 5) through a current limiting resistance. Currents quoted are the maximum continuous.
6. Nominal data transfer rate. Assumes that a 3.58 MHz crystal is used as a frequency reference. Data is transferred to and from the ELM624 with 8 data bits, no parity, and 1 stop bit (8 N 1).

Communicating with the ELM624

The ELM624 relies on a standard RS232 type serial connection to communicate with the user. All commands are sent to, and responses are received from the ELM624 over this interface. The RS232 data rate is fixed at 9600 baud, with 8 data bits, no parity bit, 1 stop bit, and no handshaking (often referred to as 9600 8N1).

Properly connected and powered, the ELM624 will initially display the message:

ELM624 v1.0 (c)1999

In addition to identifying the version of the IC, receipt of this string is a convenient way for users to be sure that their connections are correct. After displaying this message, the integrated circuit will be ready for a command on the RS232 port, and will wait indefinitely until a valid one is received.

Commands can either be for internally configuring the ELM624, or for passing on to the LANC port. The internal commands are distinguished by always beginning with the characters ‘AT’, while the two Control L bytes are simply a series of four hex digits. See the following sections for further details.

Some other characteristics to note concerning the commands are that extra characters are not permitted (spaces, tabs, etc.), all commands must be terminated with a carriage return character (hex ‘0D’), and the ELM624 is not case-sensitive (so ‘ATZ’ is equivalent to ‘atz’, as is ‘AtZ’).

Understood and executed ‘AT’ commands are signalled by the transmission of the two characters ‘OK’, while any misunderstood commands (syntax errors) are signalled by a single question mark (‘?’) being sent. When Control L commands are executed, correct completion is signalled by the ELM624 transmitting the four status bytes received from the LANC bus (sent as eight hexadecimal digits). To reduce RS232 traffic, all responses are terminated with a single carriage return character, and no line feed character. Some users may wish to have their software insert these linefeed characters to improve readability.

There is a possibility that incomplete data strings could be sent to the ELM624 for one reason or another. To avoid problems in these cases, the ELM624 will automatically time out and abort any incomplete command after about 20 seconds. It will then print a single question mark, and wait for the next command to be sent.

One last note involves the internal priorities assigned to the two busses. In all cases, the RS232 bus takes priority over the LANC bus, and will cause any LANC transmissions to abort if activity is detected on the RS232 bus.

AT Commands

The ELM624 can accept internal configuration commands at any time, in much the same manner that modems do. Any command sent to the ELM624 that begins with the characters A followed by T is considered an internal configuration or ‘AT’ command. These are executed upon receipt of the terminating carriage return character, and acceptance of a command is acknowledged by the printing of the characters ‘OK’.

The factory default settings should be sufficient for most applications, and communications on the LANC port can generally begin without requiring the issuance of any AT commands, but some users may wish to customize settings, such as turning the character echo off, etc.

The following summarizes the ‘AT’ commands that are recognized by the ELM624. Note that the character ‘0’ is the number ‘zero’:

ATC0 and ATC1

These commands specify when the Control L status bytes are to be returned on the RS232 bus. With the C1 command, values are only sent when there is a change from the previous four, while with C0 they are always sent. For most devices, setting C1 will have little noticeable effect, as the LANC responses usually alternate between status and time-code values, thus continually change. The default is C1.

ATD0 and ATD1

These commands determine whether the first two Control L words (0 and 1) are to be duplicated in the next two words (2 and 3). If D0 is selected, duplication will not occur, and words 2 and 3 will be sent as ‘zeros’, while setting D1 will force the words to be duplicated. The default is D1.

ATE0 and ATE1

These commands control whether characters received on the RS232 port are retransmitted (or echoed) back to the host computer. To reduce traffic on the RS232 bus, users may wish to turn echoing off by issuing E0. Default is E1, echo on.

ATRn where ‘n’ is a Hex Digit

This sets the LANC command repeat value. Although commands are only sent from the computer to the ELM624 once, they are sent on the Control L bus multiple times. While the Control L standard requires that commands must be repeated at least four successive times to be valid, the ATR command allows this parameter to be modified for experimentation or non-standard applications. The default value is five (R5), and commands are always sent at least once (R0 is treated as R1).

ATI

This causes the IC to identify itself. It simply sends the power-on string (for a version 1.0 IC, it is ‘ELM624 v1.0 (c)1999’) and returns to the command mode.

ATZ

This combination causes the chip to perform a complete reset as if power were cycled off and then on again. All settings are returned to their default values.

Data Transfer - The LANC Protocol

Any valid four digit hex code that is received on the RS232 port will be converted to Control L format and transmitted out the LANC pin. The ELM624 makes no effort to determine whether the codes are valid or not. After sending the command, all responses received on the port are reported back to the RS232 port using standard ASCII characters for the eight hexadecimal digits that represent the 4 bytes received. Note that control characters are not sent - the hexadecimal digit ‘A’ is transmitted as decimal value 65, not 10.

All transfers on the LANC bus occur at a rate determined by the device being controlled. The camcorder, or other device provides all of the timing or synchronizing pulses for the data transfer, and the ELM624 (in this case) must sense these sync pulses in order to send or receive data. If the controlled device is not providing these pulses for any reason, a ‘NO SYNC’ error will result - check your cables and power supplies.

A Control L ‘data frame’ consists of 8 sequential bytes. Commands to the device (from the ELM624) are sent during the first half of the frame, while the second half (last four bytes) are for feedback from the controlled device. Often, four bytes are not enough to send all of the information, so data is multiplexed over several frames. An example of this is the time codes which contain information on days, hours, minutes and seconds which require several bytes to represent.

The ELM624 does not send a command on the LANC bus until it has received four valid hex digits and a carriage return. The digits are combined in pairs to form the first two words to be sent on the Control L bus and, depending on the ATD option, may also be duplicated and sent on the interface as bytes 3 and 4.

In the Control L standard, the first byte sent usually signifies the type of device being spoken to (eg. 1 for VTR and 2 for camera), as well as an identifying device number. These correspond to the first and second hex digits sent to the ELM624, respectively. The second byte (digits 3 and 4) is the actual command being sent. For example, the four character command string:

1 0 3 4

would normally be interpreted as ‘VTR #0 Play’, as the code for play is 34. Similarly, 1030 would stop the same VTR. Typical control codes follow:

30	Stop	36	Rewind
32	Pause	38	Fast Forward
34	Play	3A	Record
8C	Counter Reset		

The Control L device will respond with a sequence of 4 bytes (8 hex digits). The first byte (two digits) is always a status byte, having typical values as follows:

02	Stopped	03	Fast Forwarding
04	Recording	06	Playing
72	Stopped - at tape beginning		
83	Rewinding		

The next nibble (third digit) is used to identify the meaning of the final two bytes. If the digit is a 1, it generally means that the final two bytes are status bytes, while if it is a 3 the bytes represent minutes and seconds, a 4 is days and hours.

The fourth hex digit (least significant nibble of the second byte) generally gives system status information such as:

b3 - counter memory on
b2 - low battery
b1 - record tab status
b0 - invalid command received

As an example of a typical transmission, assume that the command 1034 (VTR#0 Play) is sent. The response would typically be:

```
0 2 1 2 2 4 5 0
0 2 3 2 4 9 1 1
0 2 4 2 0 1 0 0
```

Many more bytes would be sent, as the time codes are continually varying. Hitting the return key will stop the endless stream of data and place the ELM624 in the command state. The first line above shows that the device is currently stopped (02), that the last four digits will be status (1), and that recording is not allowed due to the tab (2). The status bytes (24 and 50) provide several details such as record switch on (2), no PCM (4), and mono sound (5). Each device is likely to have its own unique interpretation of these bits.

The second line shows that the device is still stopped (02), that the following information will be ss:mm (3), and that recording is not allowed due to the tab (2). The third line states that hh:dd (4) follow. From the ‘3’ and ‘4’ lines, one can deduce that the counter is currently showing 00 days, 01 hours, 11 minutes and 49 seconds. Some counters are simply a linear reading and do not reflect the actual time duration.

After a short time, the following is reported by the ELM624:

```
0 6 1 2 2 4 5 8
0 6 3 2 4 9 1 1
0 6 4 2 0 1 0 0
```

Comparing this to the previous, one can see that the device is now in play mode (06), with a time of 00:01:11:49. The 8 in the last position of the first row indicates that there is a ‘memory mark’ here to show a significant spot on the tape.

It is beyond the scope of this document to detail the Control L standard in any more detail, but hopefully this has been enough to get you started. Be sure to check with your manufacturer for specifics on the model(s) that you are using.

Design Considerations

The ELM624 is an experimenter’s integrated circuit, so it has a few peculiarities that must be considered in any design.

Foremost, one should note that the LANC pin is connected directly to the Control L bus. This presents two areas of concern. One, if the controlled device is powered before the ELM624, there will be a backfeed through the (inherent) LANC pin protection diode into the ELM624 circuitry. This can cause unexplained and possibly erratic operation. Always power the ELM624 circuitry before connecting to the Control L bus.

The other concern related to the LANC pin is the fact that this is a CMOS integrated circuit, and that ‘latch-up’ can occur due to induced currents from external sources. To reduce the possibility, try to keep connecting cables as short as possible, and consider placing a small value resistor (100Ω to 220Ω) in series with this pin.

On the PC side of things, the main consideration with the RS232 interface is the fact that the receive signal is inverted from what would normally be expected. This simplifies the RS232 circuitry, but may cause some confusion. Precautions should also be taken in the circuit design to allow for the possibility that this input may be left floating due to a disconnected serial cable. Typically, this only requires a large-valued resistor between the RS232 TxD pin and Vss, as shown in the Example Application section.

As a final note, one should realize that the ELM624’s RS232 interface does not employ any handshaking signals, so the controlling computer must wait for a response (all responses end with a carriage return character) before issuing the next command. Failure to do so will usually cause the IC to abort whatever action is in progress, as the RS232 Rx signal is given highest priority. Under keyboard control this is unlikely to be a problem, as the character spacing is usually adequate enough to allow the ELM624 to complete any processing before receiving the next ones. Under computer control, however, it is essential that the software waits for a complete response before proceeding with the next command.

Example Application

Figure 1 shows how the ELM624 would typically be connected in a circuit. A very basic RS232 interface is provided, and the Control L connection is unbuffered.

There are two types of Control L or LANC connectors commonly used. One is the mini-DIN type connector (similar to S-VHS or Apple serial port connectors), and the other is the 2.5mm stereo plug type. The mini-DIN is shown below, with a 100Ω resistor in series. As previously mentioned, the resistor is recommended for helping to prevent latch-up and also for protection of the ELM624 from direct shorts to the supply (most Control L connectors provide DC on one of the pins). If a 2.5mm stereo plug is used, the tip is generally the LANC signal, the small ring is often a DC supply, and the sleeve is the circuit common or V_{SS}.

Note that no additional pullup resistance is used in this circuit from pin 7 to V_{DD}, as the ELM624's internal resistance is often sufficient when coupled with pullup resistors in the controlled device. Occasionally this may not be sufficient to provide a full logic swing, however, and an additional resistor (typically 4.7KΩ) may be needed.

Circuit timing is derived from the 3.58MHz reference crystal that is connected to XT1 and XT2 (pins 2 and 3) as shown. These crystals are quite common television types that should not be difficult to obtain.

For connecting to the computer, a simple RS232 interface is used. It is not as elaborate as some, but is sufficient for this purpose. Generally, the RS232 interface is operated in half-duplex mode, with the ELM624 listening to the computer, and then the computer waiting for a response. Since both devices are not likely to be 'talking' at the same time, we are able to 'steal' a bias voltage from the computer for the ELM624 circuitry to use, as shown. A diode provides a return negative from the TxD line that the RxD can use, while a small capacitor provides charge storage. The capacitor size shown should be sufficient in most cases, but if you have trouble with characters being echoed, etc. you might want to increase its size to several µF. The RS232 pin connections shown are for a 25 pin connector. If you are using a 9 pin, the connections would be 2(RxD), 5(SG) and 3(TxD).

That should get you started with the interface. Perhaps with a little programming…

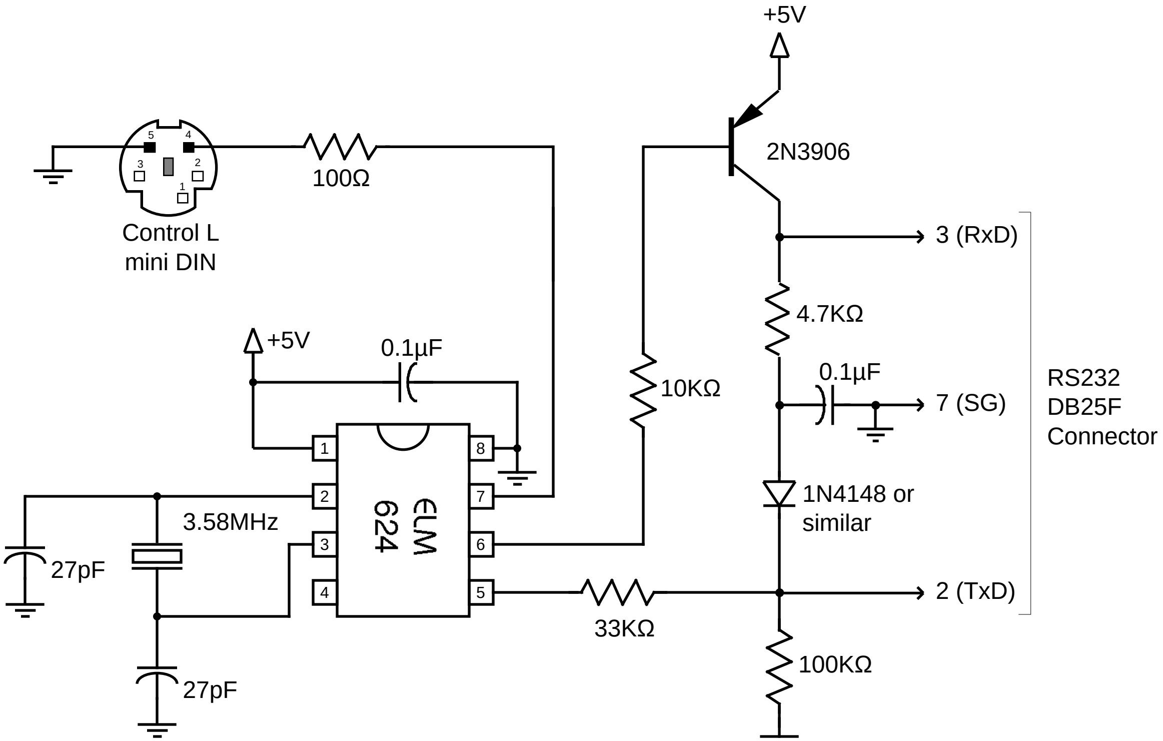

Figure 1. Control L (LANC) to RS232 Interface