ELM327
OBD to RS232 Interpreter

Description

Almost all of the automobiles produced today are required, by law, to provide an interface for the connection of diagnostic test equipment. The data transfer on these interfaces follow several standards, but none of them are directly usable by PCs or smart devices. The ELM327 is designed to act as a bridge between these On-Board Diagnostics (OBD) ports and a standard RS232 interface.

In addition to being able to automatically detect and interpret nine OBD protocols, the ELM327 also provides support for high speed communications, a low power sleep mode, and the J1939 truck and bus standard. It is also completely customizable, should you wish to alter it to more closely suit your needs.
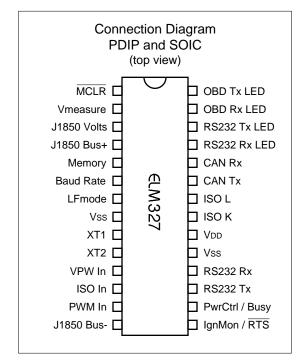
The following pages discuss all of the ELM327's features in detail, how to use it and configure it, as well as providing some background information on the protocols that are supported. There are also schematic diagrams and tips to help you to interface to microprocessors, construct a basic scan tool, and to reduce power consumption.
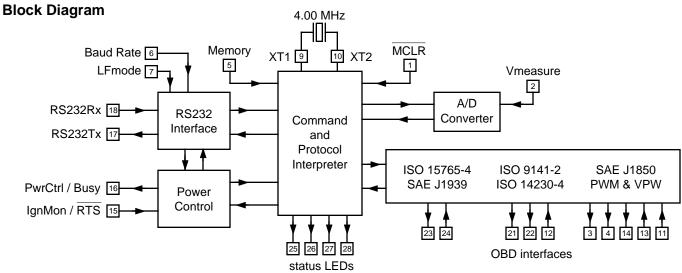
Applications

- Diagnostic trouble code readers
- Automotive scan tools
- Teaching aids

Features

- Power Control with standby mode
- RS232 baud rates to 500 kbps
- Automatically searches for protocols
- Fully configurable with AT commands
- Low power CMOS design

Connection Diagram
PDIP and SOIC
(top view)

	ELM327	
$\overline{MCLR}$		OBD Tx LED
Vmeasure		OBD Rx LED
J1850 Volts		RS232 Tx LED
J1850 Bus+		RS232 Rx LED
Memory		CAN Rx
Baud Rate		CAN Tx
LFmode		ISO L
Vss		ISO K
XT1		VDD
XT2		Vss
VPW In		RS232 Rx
ISO In		RS232 Tx
PWM In		PwrCtrl / Busy
J1850 Bus-		IgnMon / $\overline{RTS}$

Block Diagram

4.00 MHz

Baud Rate [6]
LFmode [7]
Memory [5]
XT1 [9]   [10] XT2
$\overline{MCLR}$ [1]
Vmeasure [2]

RS232Rx [18]
RS232Tx [17]
RS232 Interface

A/D Converter

PwrCtrl / Busy [16]
IgnMon / $\overline{RTS}$ [15]
Power Control

Command and Protocol Interpreter

ISO 15765-4 SAE J1939 [23] [24]
ISO 9141-2 ISO 14230-4 [21] [22] [12]
SAE J1850 PWM & VPW [3] [4] [14] [13] [11]

OBD interfaces

[25] [26] [27] [28]
status LEDs

Pin Descriptions

MCLR (pin 1)

A momentary (>2µsec) logic low applied to this input will reset the ELM327. If unused, this pin should be connected to a logic high (VDD) level.

Vmeasure (pin 2)

This analog input is used to measure a 0 to 5V signal that is applied to it. Care must be taken to prevent the voltage from going outside of the supply levels of the ELM327, or damage may occur. If it is not used, this pin should be tied to either VDD or VSS.

J1850 Volts (pin 3)

This output can be used to control a voltage supply for the J1850 Bus+ output. The pin normally outputs a logic high level when a nominal 8V is required (for J1850 VPW), and a low level for 5V (for J1850 PWM), but this can be changed with PP 12. If this switching capability is not required for your application, this output can be left open-circuited.

J1850 Bus+ (pin 4)

This active high output is used to drive the J1850 Bus+ Line to an active level. Note that this signal does not have to be used for the Bus- Line (as was the case for the ELM320), since a separate J1850 Bus- drive output is provided on pin 14.

Memory (pin 5)

This input controls the default state of the memory option. If this pin is at a high level during power-up or reset, the memory function will be enabled by default. If it is at a low level, then the default will be to have it disabled. Memory can always be enabled or disabled with the AT M1 and AT M0 commands.

Baud Rate (pin 6)

This input controls the baud rate of the RS232 interface. If it is at a high level during power-up or reset, the baud rate will be set to 38400 (or the rate

that has been set by PP 0C). If at a low level, the baud rate will always be 9600.

LFmode (pin 7)

This input is used to select the default linefeed mode to be used after a power-up or system reset. If it is at a high level, then by default messages sent by the ELM327 will be terminated with both a carriage return and a linefeed character. If it is at a low level, lines will be terminated by a carriage return only. This behaviour can always be modified by issuing an AT L1 or AT L0 command.

VSS (pin 8)

Circuit common must be connected to this pin.

XT1 (pin 9) and XT2 (pin 10)

A 4.000 MHz oscillator crystal is connected between these two pins. Loading capacitors as required by the crystal (typically 27pF each) will also need to be connected between each of these pins and circuit common (VSS).

Note that this device has not been configured for operation with an external oscillator – it expects a crystal to be connected to these pins. Use of an external clock source is not recommended. Also, note that this oscillator is turned off when in the Low Power or 'standby' mode of operation.

VPW In (pin 11)

This is the active high input for the J1850 VPW data signal. When at rest (bus recessive) this pin should be at a low logic level. This input has Schmitt trigger wave shaping, so no special amplification is required.

ISO In (pin 12)

This is the active low input for the ISO 9141 and ISO 14230 data signal. It is derived from the K Line, and should be at a high logic level when at rest (bus

Pin Descriptions (continued)

recessive). No special amplification is required, as this input has Schmitt trigger wave shaping.

PWM In (pin 13)

This is the active low input for the J1850 PWM data signal. It should normally be at a high level when at rest (ie. bus recessive). This input has Schmitt trigger wave shaping, so no special amplification is required.

J1850 Bus- (pin 14)

This active high output is used to drive the J1850 Bus- Line to an active (dominant) level for J1850 PWM applications. If unused, this output can be left open-circuited.

IgnMon / $\overline{RTS}$ (pin 15)

This input pin can serve one of two functions, depending on how the Power Control options (PP 0E) are set.

If both bit 7 and bit 2 of PP 0E are '1's, this pin will act as an Ignition Monitor. This will result in a switch to the Low Power mode of operation, should the signal go to a low level, as would happen if the vehicle's ignition were turned off. An internal 'debounce' timer is used to ensure that the ELM327 does not shut down for noise at the input.

When the voltage at pin 15 is again restored to a high level, and a time of 1 or 5 seconds (as set by PP 0E bit 1) passes, the ELM327 will perform a 'Warm Start' and return to normal operation. A low to high transition at pin 15 will in fact restore normal operation, regardless of the setting of PP 0E bit 2, or whether pin 15 was the initial cause for the low power mode. This feature allows a system to control how and when it switches to low power standby operation, but still have automatic wakeup by the ignition voltage, or even by a pushbutton.

If either bit 7 or bit 2 of PP 0E are '0', this pin will function as an active low 'Request To Send' input. This can be used to interrupt the OBD processing in order to send a new command, or as previously mentioned, to highlight the fact that the ignition has been turned off. Normally kept at a high level, this input is brought low for attention, and should remain so until the Busy line (pin 16) indicates that the ELM327 is no longer busy, or until a prompt character is received (if pin 16 is being used for power control).

This IgnMon input has Schmitt trigger wave shaping. By default, pin 15 acts as the $\overline{RTS}$ interrupt input.

PwrCtrl / Busy (pin 16)

This output pin can serve one of two functions, depending on how the Power Control options (PP 0E) are set.

If bit 7 of PP 0E is a '1' (the default), this pin will function as a Power Control output. The normal state of the pin will be as set by PP 0E bit 6, and the pin will remain in that state until the ELM327 switches to the Low Power mode of operation, when the output changes to the opposite level. This output is typically used to control enable inputs, but may also be used for relay circuits, etc. with suitable buffering. The discussion on page 70 ('Modifications for Low Power Standby Operation') provides more detail on how to use this output.

If bit 7 of PP 0E is a '0', pin 16 will function as a 'Busy' output, showing when the ELM327 is actively processing a command (the output will be at a high level), or when it is idle, ready to receive commands (the output will be low).

By default, bit 7 of PP 0E is '1', so pin 16 provides the Power Control function.

RS232Tx (pin 17)

This is the RS232 data transmit output. The signal level is compatible with most interface ICs (the output is high when idle), and there is sufficient current drive to allow interfacing using only a PNP transistor, if desired.

RS232Rx (pin 18)

This is the RS232 receive data input. The signal level is compatible with most interface ICs (when at idle, the level should be high), but can be used with other interfaces as well, since the input has Schmitt trigger wave shaping.

Vss (pin 19)

Circuit common must be connected to this pin.

VDD (pin 20)

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

Pin Descriptions (continued)

reset signal is not required. Refer to the Electrical Characteristics section for further information.

ISO K (pin 21) and ISO L (pin 22)

These are the active high output signals which are used to drive the ISO 9141 and ISO 14230 buses to an active (dominant) level. Many new vehicles do not require the L Line – if yours does not, you can simply leave pin 22 open-circuited.

CAN Tx (pin 23) and CAN Rx (pin 24)

These are the two CAN interface signals that must be connected to a CAN transceiver IC (see the Example Applications section for more information). If unused, pin 24 must be connected to a logic high (VDD) level.

RS232 Rx LED (pin 25), RS232 Tx LED (pin 26), OBD Rx LED (pin 27) and OBD Tx LED (pin 28)

These four output pins are normally high, and are driven to low levels when the ELM327 is transmitting or receiving data. These outputs are suitable for directly driving most LEDs through current limiting resistors, or interfacing to other logic circuits. If unused, these pins may be left open-circuited.

Note that pin 28 can also be used to turn off all of the Programmable Parameters, if you can not do so by using the normal interface - see pages 54 and 55 for more details.

Unused Pins

When people only want to implement a portion of what the ELM327 is capable of, they often ask what to do with the unused pins. The rule is that unused outputs may be left open-circuited with nothing connected to them, but unused inputs must be terminated. The ELM327 is a CMOS integrated circuit that can not have any inputs left floating (or you might damage the IC). Connect unused inputs as follows:

Pin	1	2	5	6	7	11	12	13	15	18	24
Level	H	H*	H*	H*	H*	H*	L*	L*	H	H	H

Note that the inputs that are shown with an asterisk (*) may be connected to either a High (VDD) or a Low (VSS) level, but the level shown is preferred.

Ordering Information

These integrated circuits are 28 pin devices, available in either a 300 mil wide plastic ('skinny') DIP format or in a 300 mil (7.50 mm body) SOIC surface mount type of package. We do not offer an option for QFN packages.

To order, add the appropriate suffix to the part number:

300 mil 28 pin Plastic DIP.............................ELM327P   300 mil 28 pin SOIC....................................ELM327SM

Absolute Maximum Ratings

Storage Temperature....................... -65°C to +150°C

Ambient Temperature with
Power Applied.....................................-40°C to +85°C

Voltage on VDD with respect to VSS..... -0.3V to +7.5V

Voltage on any other pin with
respect to VSS........................... -0.3V to (VDD + 0.3V)

Note:

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

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 current, I_{DD}	normal		12		mA	ELM327 device only - does not include any load currents
	low power		0.15		mA	
Input logic levels	low	V_{SS}		0.8	V	Pins 5, 6, 7, and 24 only
	high	3.0		V_{DD}	V	
Schmitt trigger input thresholds	rising		2.9	4.0	V	Pins 1, 11, 12, 13, 15 and 18 only
	falling	1.0	1.5		V	
Output low voltage			0.3		V	current (sink) = 10 mA
Output high voltage			4.4		V	current (source) = 10 mA
Brown-out reset voltage		4.11	4.33	4.55	V	
A/D conversion time			9		msec	see note 3
Pin 18 low level pulse duration to wake the IC from Low Power mode		128		-	µsec	
IgnMon debounce time		50	65		msec	
AT LP to PwrCtrl output time			1.0		sec	
LP ALERT to PwrCtrl output time			2.0		sec	

Notes:

1. This integrated circuit is based on Microchip Technology Inc.'s PIC18F2480 device. For more detailed device specifications, and possibly clarification of those given, please refer to the Microchip documentation (available at http://www.microchip.com/).

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. This is the time between when the AT RV command is received, and when the voltage reading response begins.

AT Command Summary

OBD Commands

AL	Allow Long (>7 byte) messages
AR	Automatically Receive
AT0, 1, 2	Adaptive Timing off, auto1*, auto2
BD	perform a Buffer Dump
BI	Bypass the Initialization sequence
DP	Describe the current Protocol
DPN	Describe the Protocol by Number
H0, H1	Headers off*, or on
MA	Monitor All
MR hh	Monitor for Receiver = hh
MT hh	Monitor for Transmitter = hh
NL	Normal Length messages*
PC	Protocol Close
R0, R1	Responses off, or on*
RA hh	set the Receive Address to hh
S0, S1	printing of Spaces off, or on*
SH xyz	Set Header to xyz
SH xxyyzz	Set Header to xxyyzz
SP h	Set Protocol to h and save it
SP Ah	Set Protocol to Auto, h and save it
SR hh	Set the Receive address to hh
SS	use Standard Search order (J1978)
ST hh	Set Timeout to hh x 4 msec
TA hh	set Tester Address to hh
TP h	Try Protocol h
TP Ah	Try Protocol h with Auto search

ISO Specific Commands (protocols 3 to 5)

FI	perform a Fast Initiation
IB 10	set the ISO Baud rate to 10400*
IB 48	set the ISO Baud rate to 4800
IB 96	set the ISO Baud rate to 9600
IIA hh	set ISO (slow) Init Address to hh
KW	display the Key Words
KW0, KW1	Key Word checking off, or on*
SI	perform a Slow (5 baud) Initiation
SW hh	Set Wakeup interval to hh x 20 msec
WM [1 - 6 bytes]	set the Wakeup Message

J1850 Specific Commands (protocols 1 and 2)

IFR0, 1, 2	IFRs off, auto*, or on
IFR H, S	IFR value from Header* or Source

CAN Specific Commands (protocols 6 to C)

CEA	turn off CAN Extended Addressing
CEA hh	use CAN Extended Address hh
CAF0, CAF1	Automatic Formatting off, or on*
CF hhh	set the ID Filter to hhh
CF hhhhhhhh	set the ID Filter to hhhhhhhh
CFC0, CFC1	Flow Controls off, or on*
CM hhh	set the ID Mask to hhh
CM hhhhhhhh	set the ID Mask to hhhhhhhh
CP hh	set CAN Priority to hh (29 bit)
CRA	reset the Receive Address filters
CRA hhh	set CAN Receive Address to hhh
CRA hhhhhhhh	set the Rx Address to hhhhhhhh
CS	show the CAN Status counts
CSM0, CSM1	Silent Monitoring off, or on*
D0, D1	display of the DLC off*, or on
FC SM h	Flow Control, Set the Mode to h
FC SH hhh	FC, Set the Header to hhh
FC SH hhhhhhhh	Set the Header to hhhhhhhh
FC SD [1 - 5 bytes]	FC, Set Data to [...]
PB xx yy	Protocol B options and baud rate
RTR	send an RTR message
V0, V1	use of Variable DLC off*, or on

J1939 CAN Specific Commands (protocols A to C)

DM1	monitor for DM1 messages
JE	use J1939 Elm data format*
JHF0, JHF1	Header Formatting off, or on*
JS	use J1939 SAE data format
JTM1	set Timer Multiplier to 1*
JTM5	set Timer Multiplier to 5
MP hhhh	Monitor for PGN 0hhhh
MP hhhh n	" " and get n messages
MP hhhhhh	Monitor for PGN hhhhhh
MP hhhhhh n	" " and get n messages

AT Command Summary (continued)

General Commands

<CR>	repeat the last command
BRD hh	try Baud Rate Divisor hh
BRT hh	set Baud Rate Timeout
D	set all to Defaults
E0, E1	Echo off, or on*
FE	Forget Events
I	print the version ID
L0, L1	Linefeeds off, or on
LP	go to Low Power mode
M0, M1	Memory off, or on
RD	Read the stored Data
SD hh	Save Data byte hh
WS	Warm Start (quick software reset)
Z	reset all
@1	display the device description
@2	display the device identifier
@3 cccccccccccc	store the @2 identifier

Programmable Parameter Commands

PP xx OFF	disable Prog Parameter xx
PP FF OFF	all Prog Parameters disabled
PP xx ON	enable Prog Parameter xx
PP FF ON	all Prog Parameters enabled
PP xx SV yy	for PP xx, Set the Value to yy
PPS	print a PP Summary

Voltage Reading Commands

CV dddd	Calibrate the Voltage to dd.dd volts
CV 0000	restore CV value to factory setting
RV	Read the input Voltage

Other

IGN	read the IgnMon input level

Note: Settings shown with an asterisk (*) are the default values