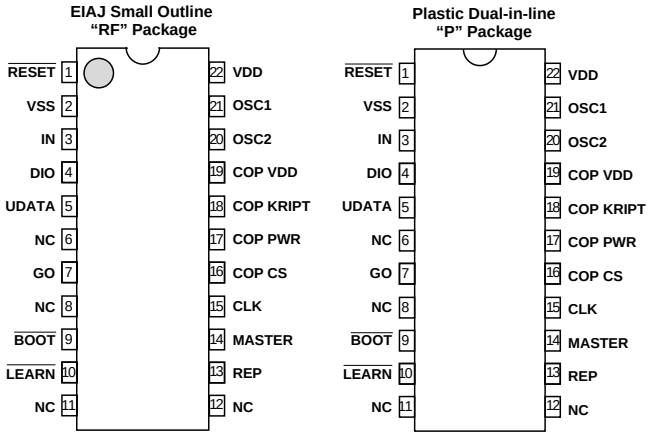
Rolling Code Decoder
A SureLok™ Security Product

FEATURES

- **Unique Master Transmitter for Each System**
- **Up to Five (5) Learnable Other Transmitters Per Decoder**
- **Each Transmitter has a Unique Key**
- **Secure Transmitter Self-Learning**
- **Separate Transmitter Synchronization**
- **Automatic Compensation for Differences in Component Timing**
- **Master Transmitter Applications**
  - **— Authorize self-learning**
  - **— Higher user priority**
  - **— Privileged Access**
- **Functions Accessible Through Serial Port**
  - **— 64 bits of nonvolatile user storage**
- **Interfacing**
  - **— Serial outputs (clock, data)**
  - **— Optional handshake (GO)**
  - **— Valid signal indicator (REPEAT)**
  - **— Master transmitter indicator**
- **Serial Output Information**
  - **— Desired and Delayed function**
  - **— Transmitter identification**
  - **— Configuration information**
- **22-pin SOIC and PDIP**

PIN CONFIGURATION



D0022 ILL A01.3

PIN NAMES

$\overline{\text{RESET}}$	Hardware Reset Input
VSS	Ground Reference
IN	Decoder Input
DIO	Data To/From Coprocessor
DELAY	Delayed Function Output
UDATA	User Data I/O
NC	No Connect
GO	Handshaking (Optional)
$\overline{\text{BOOT}}$	Cold Reset Input
$\overline{\text{LEARN}}$	Self-Learning Select
REPEAT	Valid Signal Indicator
MASTER	Master Transmitter
CLK	Coprocessor/user Clock
COP CS	Coprocessor Select
COP PWR	Coprocessor Power
COP KRIPT	Coprocessor Control
COP VDD	Coprocessor Power
OSC1-2	Oscillator Timing
VDD	Supply Voltage

OVERVIEW

The XL110 is a low cost remote control decoder for use in security systems. It makes use of revolutionary rolling code technology, offering an unprecedented level of security in remote control systems. Typical applications include vehicle security and access control systems.

The decoder is designed to be used with XL106 based transmitters and uses the XL106 as a coprocessor.

Outputs from the decoder are provided through a synchronous serial interface. A user microprocessor requires only two lines to service this serial interface, freeing up valuable I/O pins for other purposes. The 32 bit serial output word includes a flag indicating delayed function operation, up to 4 bits of function information (for a total of 15 functions) and a transmitter identification number form 0 to 5. For configuration of the user's microcontroller up to 24 bits can be relayed to the controller though the remote control system.

EXEL Microelectronics, Inc.
2150 Commerce Drive • San Jose, CA 95131
PHONE 408 432-0500 • FAX 408 432-8710 • Internet www.exel.com

D0022 4/96
DVPTD 6931-05

The user microcontroller can also execute an IFF (Identification Friend or Foe) operation through this port, making it possible to implement authentication systems with a minimum of additional hardware.

The XL106 is used as a nonvolatile storage and decoding device. Direct access to the XL106 coprocessor can be arranged from outside, making it possible for an external microcontroller to use the coprocessor as nonvolatile storage, and for the user to program the coprocessor on the PC board.

The XL110 decoder contains sophisticated error checking algorithms to ensure that only valid transmissions are decoded. Sophisticated synchronization checking ensures that the user can remain totally unconcerned with synchronization issues. Extensive history evaluation provides maximum protection against “code grabbing” and other unauthorized code generation technologies. Automatic baud rate compensation ensures that the system will remain operational despite variations in timing component values.

APPLICATIONS

Applications of the XL110 include: vehicle security systems, gate and garage door openers, burglar alarm systems, remote control units, and central locking systems.

GENERAL DESCRIPTION

The XL110 integrated circuit is a remote control decoder for use in high security remote control applications such as vehicle security and access control systems.

In remote control operation, a high degree of security is provided by 56 bit non-repetitive codes. The XL110 is designed to function with transmitters based on XL106. An external XL106 is used with the XL110 as coprocessor for decoding and nonvolatile storage. The coprocessor is a custom IC, a fact that considerably enhances the key storage and learning operation.

The Surelok™ rolling code system provides greatly enhanced security by being immune to attacks by code scanners and code grabbers and even against more sophisticated analytical attacks.

A serial output, consisting of communications and clock lines, provides communication with the system controller. A synchronous protocol is employed. Though the serial interface, the user can also gain access to four 16 bit words in the coprocessor EEPROM.

The Surelok encoders provide flexibility and ease of use, and require an absolute minimum of peripheral circuitry. Considerable savings can be realized in most circuits, as circuit board space requirements and labor costs are significantly reduced. This decoder provides the designer with system flexibility while retaining the economic advantages of the Surelok system. Programmable decoders, tokens and transmitters make the process of configuring matching systems extremely fast and simple, while maintaining the highest possible level of security.

EXEL supplies Surelok evaluation and demonstration kits, containing documentation, software, a programming probe and samples of the integrated circuits as well as transmitters and receivers. These kits can be used to assess the operational aspects of the devices. EXEL also supplies production hardware and software.

FUNCTIONAL DESCRIPTION

The XL110 is designed for use with an external system controller. Its configuration allows the user to exploit the versatility and security of the Surelok range while requiring only two of his valuable I/O pins.

Serial Interface

The key to the XL110 decoder's operation is the serial interface. The decoder relieves the system controller of the load of monitoring the input, verifying the integrity of received signals, verifying their origin, decoding function information and interfacing with the nonvolatile storage medium where keys and synchronization information are kept.

The serial output interface consists of a clock line (CLK) and a data line (UDATA). The system controller has to watch the CLK line every 25 ms or less. If this line is high, the controller should check to see if UDATA is also high. If this is the case, a valid signal has been received by the decoder, and information about that signal follows within 25 ms after that. All clocking is done by the XL110.

The system controller has direct access (through the serial interface) to four 16 bit words of user EEPROM in the XL110's coprocessor. System configuration, identifying information and other user parameters can be stored in this memory, and will be retained even in the absence of a power supply. The controller can also do an IFF operation and initiate learning through the same interface.

If the system controller wants to initiate communications with the XL110, it has to configure DDATA as an input for up to 125 ms, while monitoring DDATA and the clock line. All communication between the controller and the XL110 is clocked by the CLK output of the XL110. DDATA should normally be forced low.

The 32 bit output word is preceded by a 3 bit header, and contains the following information:

- Four bits of function information
- Four bits indicating delayed function mode - activated when a transmitter button has been activated for an extended period
- A four bit transmitter identifier - the memory block used by that transmitter. The master transmitter is identified by a value of 0.

The function capability can be used where a single receiver is used to control several other circuits. A typical example is a single controller controlling a security gate, an alarm system and a garage door. Delayed mode operation is ideal for the implementation of panic buttons, where inadvertent output activation is undesirable.

REPEAT - Valid signal indicator: 75 ms pulses will appear at regular intervals on this output as long as a valid code is being received. The valid signal indicator can be used to implement systems where the duration of the transmitter activation is important - a car window winder is a good example. The user would depress the transmitter button until the desired position is reached, and then release the button. REPEAT should not be used without a preceding valid code signal, as grabbed signals will also activate REPEAT.

MASTER output: One of the transmitters acts as a master transmitter. When this transmitter is used, the serial output is activated in the normal way. Information is contained in the output to indicate that the master transmitter has been used. In addition, the MASTER output is activated. This output may be used to provide special levels of privilege to a single user. The master transmitters parameters are stored in a special location where it will normally not be written over during learning. The master transmitter can hence be used for learning authorization. Master transmitter learning authorization must only be implemented through the serial interface.

Decoder Operation

The decoder operates in independent mode - each transmitter uses a unique key. Separate synchronization information is also maintained for each transmitter. Function information, based on the button that has been used for transmitter activation, is made available at the output.

SECURITY CONSIDERATIONS

Remote control via RF or IR is popular for many applications, including the control of automatic garage doors and vehicle security systems. Conventional remote control systems are based on unidirectional transmission and offer very limited security. More sophisticated devices based on bidirectional transmission are also available. However, because of high cost and certain practical disadvantages, especially the requirement for two receivers, bidirectional communication is not widely used in commercial remote control.

The popular unidirectional transmission systems currently have two very important security shortcomings: The codes they transmit are usually fixed and the number of possible code combinations is relatively small. Either of these shortcomings can lead to unauthorized access. Such unauthorized access can be obtained by scanning through all the combinations or by a code grabber. A code grabber records a transmission for retransmission at a later stage to gain access. Because frequencies are usually fixed in a specific country and the ease of making a code grabber, the code grabbing principle is widely recognized as a very serious threat to current remote control systems.

Greatly improved security without cost increases (or possibly even with cost reductions) can be realized by using the Surelok series of rolling code devices. The encoders feature a complex rolling code algorithm that uses a 64 bit key to scramble a 32 bit transmission word. The rolling code mechanism prevents code capturing, since a different code will be used with every transmission. A nonlinear scrambling process is used, making it impossible to calculate the key, even if numerous transmissions are captured and analyzed. This provides the highest possible level of security.

The 32 bit random portion of the transmission code provides for more than 4,000,000,000 combinations and thus prevents scanning (a complete scan would require around 12 years!).

It is impossible for someone without the 64 bit key to predict the next word in the sequence of transmission words. The 64 bit keys can be pre-programmed but cannot be read out of the EEPROM. This read protection ensures that codes will remain secret to anyone but the programmer. This system is far superior to current DIP systems, where the code being used is freely visible and can be easily duplicated onto another transmitter.

Every key will result in a unique sequence of over 65,000 values in the set of 2^{32}, (over 4000 million) possible sequences of the transmission word (32 bit random portion). This means that, once a code has been transmitted, it will not be used-again for more than 65,000 transmissions. Likewise, a matching Surelok decoder will never accept any previous codes again over several lifetimes of a typical system.

The risk of accidentally activating a decoder with another key is practically nonexistent (less than one in billions of operations).

This high level of security is becoming available at prices comparable to obsolete fixed code systems through special hardware and algorithm design techniques along with full custom integrated circuit implementation on state of the art silicon processes.

ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Rating	Unit
V_{DD}	Supply voltage	-0.3 to 6.5	V
V_{IN}	Input voltage	-0.3 to VDD +0.3	V
V_{OUT}	Output voltage	-0.3 to VDD +0.3	V
T_{STG}	Storage temperature	-55 to +125	°C
T_{LSOL}	Lead soldering temp	300	°C
V_{ESD}	ESD rating	2000	V

D0022 PGM T01.1

Note: Stresses above those listed under "ABSOLUTE MAXIMUM RATINGS" may cause permanent damage to the device.

RECOMMENDED OPERATING CONDITIONS

Symbol	Item	Rating	Unit
V_{DD}	Supply voltage	4.5 to 5.5	V
T_{AMB}	Operating temperature	-40 to 85	°C

D0022 PGM T02.1

DC ELECTRICAL CHARACTERISTICS

Ta = -40°C to 85°C, V_{DD} = 5V ± 10% unless otherwise specified

Symbol	Parameter	Min	Typ	Max	Unit
I_{CC}	Operating current		2.8		mA
V_{IH}	Input H voltage	2.25			V
V_{IL}	Input L voltage			0.75	V
I_{OL}	Output sink current*			10	mA
I_{OH}	Output source current*	N/A		N/A	

*Open collector outputs

D0022 PGM T03.1

AC ELECTRICAL CHARACTERISTICS

Ta = -40°C to 85°C, V_{DD} = 5V ± 10% unless otherwise specified

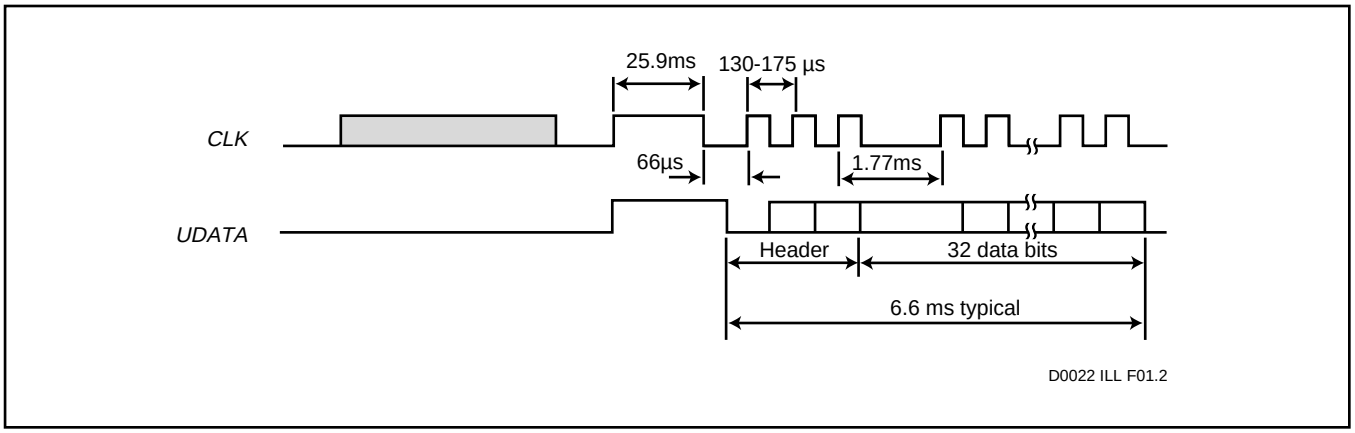
Symbol	Parameter	Min	Typ	Max	Unit
F_{OSC}	Operating frequency		1		MHz
T_{RESET}	Reset activation	50			µs
T_{DPWR}	Delay from power on		100		ms
T_{PWM}	Input bit period	0.4		3.6	ms
F_{IPR}	Input data rate	280		2500	bps
T_{TCO}	Transmission comp to output	115		160	ms
T_{OW}	Output word duration		33		ms
T_{CA}	Communication access			160	ms
T_{CH}	Communication header		25.9		ms
T_{HC}	Header to clock		78		µs
T_{CI}	Communication Input		5.5		ms
T_{CO}	Communication output		6.6		ms
T_{CCP}	Communication clock period	120		180	ms
T_{CC}	Communication command		2.5		ms
T_{HD}	Communication header to data		1.77		ms
T_{RD}	Read delay		56		ms
T_{ID}	IFF delay		69		ms
T_{LEARN}	Learn activitation time*	1			s

D0022 PGM T04.1

* Learn can also be entered reliably with either of the following procedures
1. Pull RESET and LEARN low. Release LEARN 20ms after RESET
2. LEARN must be held low until REPEAT is high for 50ms, while all function outputs are low.

Note: All typical values are dependant on the operating frequency.

DECODER PROTOCOL



Decoder outputs are always preceded by a 25.9 ms header pulse on both CLK and UDATA. The user's controller will normally keep UDATA low and sample CLK every 25 ms or less. If it finds CLK high, UDATA will be configured as an input and sampled. If UDATA is found high, it is an indication of a pending decoder output. If it is found low, UDATA must immediately be pulled low again and the controller may proceed with other duties, sampling again within 25ms.

Data bits are clocked out sequentially by the rising edge of the CLK signal. The bit period varies from 130 to 175 µs. UDATA is high asserted — a high state indicates a 1.

The following tables depict the data formats as a three bit header followed by eight nibbles, each containing four bits. Bits are transmitted from left to right (i.e. the left hand most bit first). XXXX indicates "don't care" bits, the value of which is unpredictable and meaningless.

The first three bits identify the type of operation taking place, while the following 32 bits contain information about the operation function information, the identity of the transmitter, and whether or not the transmitter has entered delayed mode.

Valid Transmission Received

010	XXXX	XXXX	XXXX	XXXX	XXXX	Ident	Delay	Function

D0022 PGM T05.1

A transmission has been correctly decoded, and its synchronization has been found valid. Normal function activation (e.g. arming/disarming operations) should always be done on this type of transmission.

Ident indicates the memory block used by the transmitter's parameters — 0 for the master transmitter, and 1 to 5 for the user transmitters. *Delay* is 0000 or 1111, depending on whether or not the transmitter has entered Delayed Function mode. Function is a four bit function code, dependent on the buttons used to activate the transmitter.

Repeated Transmission Received

001	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	Delay	Function

D0022 PGM T06.1

A transmission has been correctly decoded, and its synchronization has been found invalid (i.e. it is a repetition of a previously-used code). This output string can be used to operate window winders or other devices requiring an indication of the duration of the user's transmission. It should never be used without being preceded by a "valid transmission received" code, as a code grabber will cause the decoder to issue "repeated transmission received" output codes. Such output codes may also appear during learning operations or re-synchronization.

Command mode

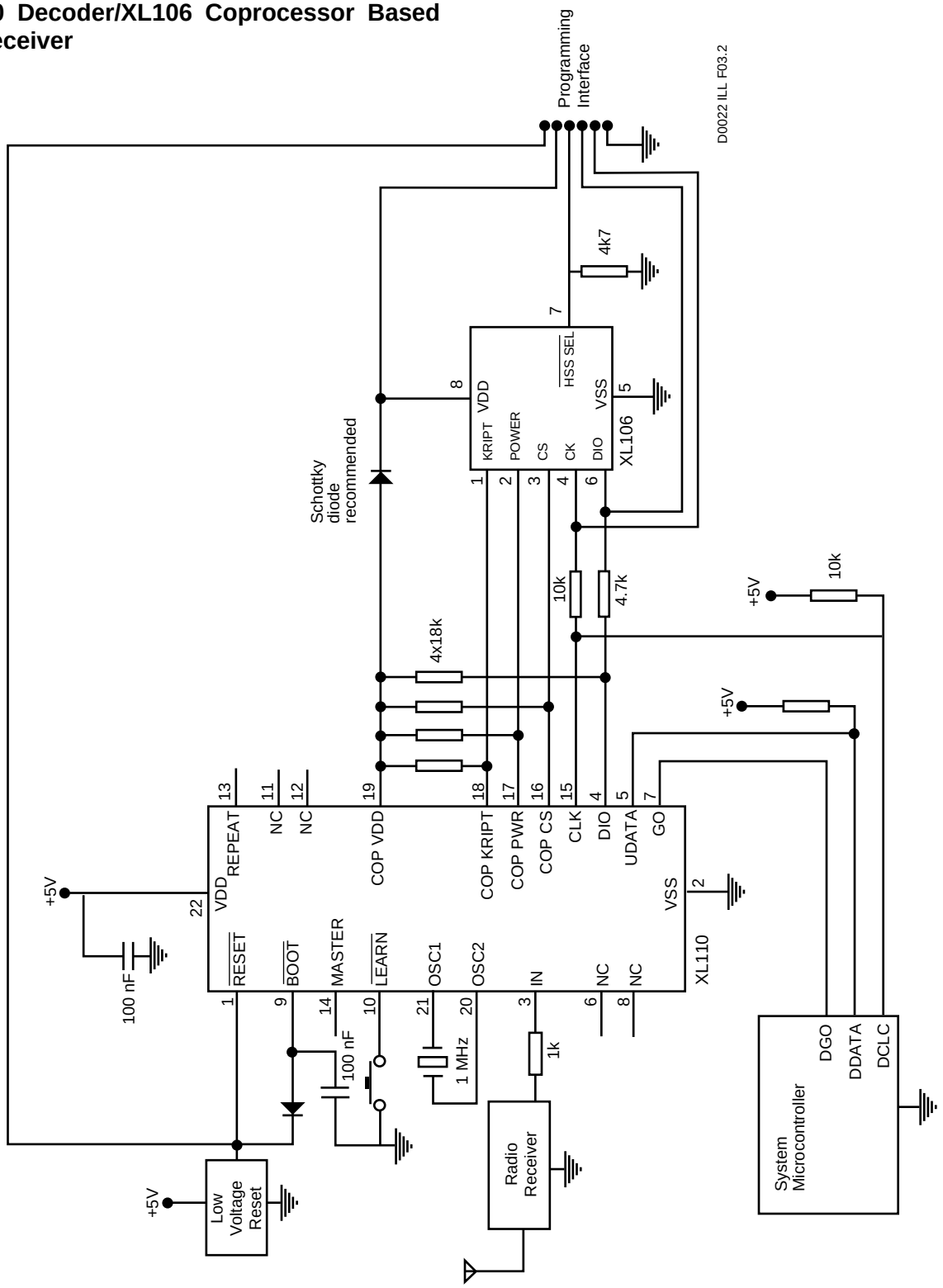
001	XXXX	XXXX	$Data_5$	$Data_4$	$Data_3$	$Data_2$	$Data_1$	$Data_0$

D0022 PGM T07.1

A transmission of which the last 32 bits are all 0 has been received. The first 24 bits of the transmission are made available to the system controller for configuration purposes. The bits are transmitted in reversed order — the first bit received by the decoder appears at the end of the output word.

APPLICATION EXAMPLE

XL110 Decoder/XL106 Coprocessor Based RF Receiver



Pin Functions

Pin	Name	Description	Type
1	$\overline{\text{RESET}}$	Hardware reset input	I1
2	V_{SS}	Ground reference	—
3	IN	Decoder Input	B2
4	DIO	Coprocessor data I/O	B2
5	UDATA	User Data I/O	B2
6	NC	—	—
7	GO	Handshaking (optional)	—
8	NC	—	—
9	$\overline{\text{BOOT}}$	Startup capacitor	I2
10	$\overline{\text{LEARN}}$	Self learning select	I2
11	NC	—	—
12	NC	—	—
13	REPEAT	Valid signal indicator	O3
14	MASTER	Master transmitter	O3
15	CLK	Coprocessor/user clock	O3
16	COP CS	Coprocessor select	O3
17	COP PWR	Coprocessor activation	O3
18	COP KRIPT	Coprocessor control	O3
19	COP V_{DD}	Coprocessor power	C
20	OSC2	Oscillator timing	—
21	OSC1	Oscillator timing	—
22	V_{DD}	Supply voltage	—

D0022 PGM T08.1

Key to I/O types

I = Input
B = Bidirectional (open drain output)
O = Open drain output
C = CMOS output
1 = 500 kΩ pullup resistor
2 = 70μA pullup. Approximately equivalent to 70 kΩ pullup resistor
3 = Protection diode to V_{DD}. Reverse biased for normal operation

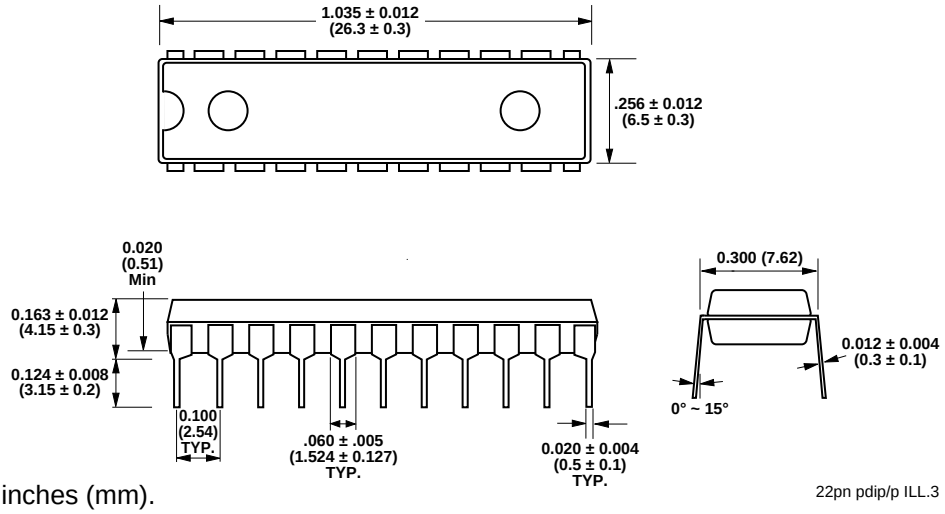
Specified currents and resistances are nominal, and are subject to -50% and +100% variation.

Notes:

- GO must be connected to V_{SS} if not used.
- All pins labelled NC must be left unconnected externally.

PACKAGE DIAGRAMS

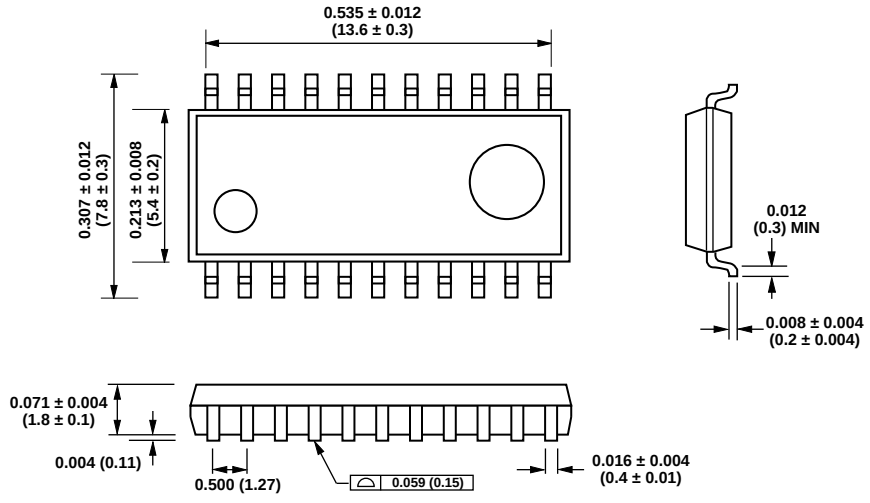
Plastic Dual-in-line (Type “P”) Package (PDIP)



All dimensions in inches (mm).

22pn pdip/p ILL.3

EIAJ Small Outline (Type “F”) Package (SOIC)



22pn SOIC ILL.1

All dimensions in inches (mm).

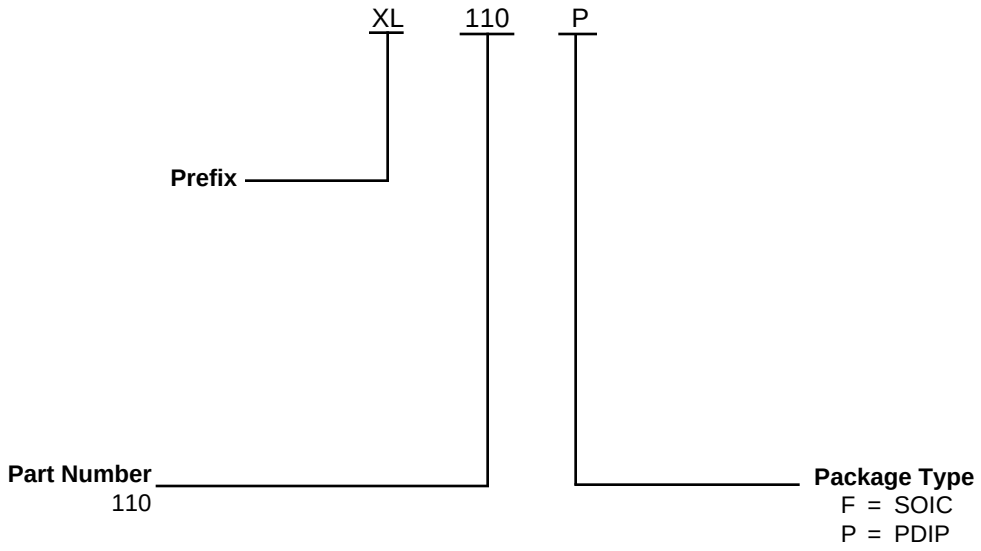
ORDERING INFORMATION

Standard Configurations

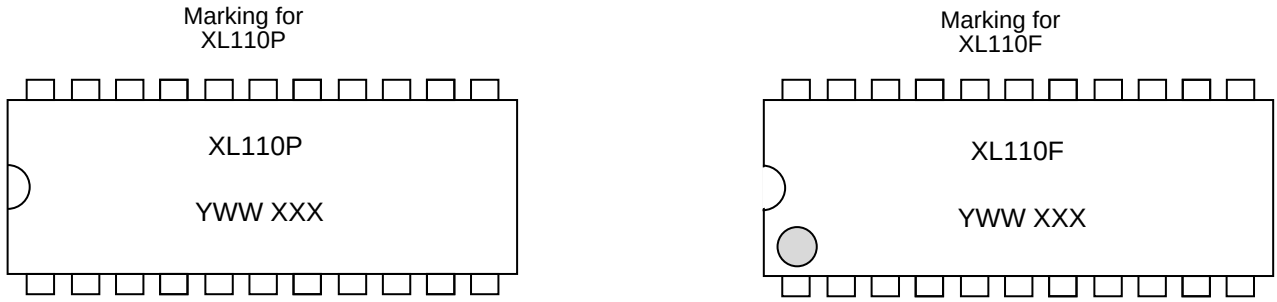
Prefix Type	Part Type	Package Type
XL	110	P, F

D0022 PGM T09.1

Part Numbers:

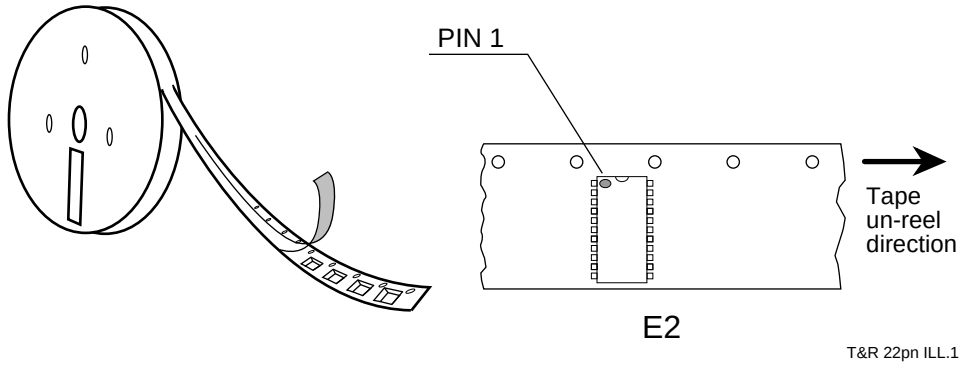


MARKING INFORMATION



TAPE AND REEL (EMBOSSED) INFORMATION

Surface mount devices, which are normally shipped in antistatic plastic tubes, are also available mounted on embossed tape for customers using automatic placement systems. The following diagram provides general information regarding the direction of the IC's. Tape "E2" shall be designated with PIN 1 at the trail direction.



Quantity per reel: 1,000 parts

NOTICE

EXEL Microelectronics, Inc. reserves the right to make changes to the products contained in this publication in order to improve design, performance or reliability. EXEL Microelectronics, Inc. assumes no responsibility for the use of any circuits described herein, conveys no license under any patent or other right, and makes no representation that the circuits are free of patent infringement. Charts and schedules contained herein reflect representative operating parameters, and may vary depending upon a user's specific application. While the information in this publication has been carefully checked, EXEL Microelectronics, Inc. shall not be liable for any damages arising as a result of any error or omission.

EXEL Microelectronics, Inc. does not recommend the use of any of its products in life support applications where the failure or malfunction of the product can reasonably be expected to cause failure of the life support system or to significantly affect its safety or effectiveness. Products are not authorized for use in such applications unless EXEL Microelectronics, Inc. receives written assurances, to its satisfaction, that: (a) the risk of injury or damage has been minimized; (b) the user assumes all such risks; and (c) potential liability of EXEL Microelectronics, Inc. is adequately protected under the circumstances.

Surelok™ is a trademark of EXEL Microelectronics, Inc.

D0022 4/96
DVPTD 6931-05