Unistep LabMaster Series

ICL

INFRARED COMMUNICATION LINK

USER MANUAL

USER MANUAL

1. INTRODUCTION

The ICL module is a full-duplex infrared modem circuit module that facilitates wireless asynchronous communication between two PC's. It works with the existing PC serial ports and only requires an external DC power source and a serial cable. On-board RS-232 transceiver circuit carries out the conversion of the RS-232 signals and makes the ICL circuit transparent to the application controlling the serial port. The infrared link is established by FSK modulation of an infrared light beam by an IR LED and the reception by a PIN diode. Full-duplex transmission is achieved by using two separate pairs of frequencies. The ICL circuitry has a good complement of test points, configuration options, and indicators to assist the learning, tuning, and troubleshooting process.

1.1 About this Document

This user manual is based on the ICL Module Rev 1.0 and covers the ICL Control Panel program version 1.0.

1.2 ICL Module Features

- On-board RS-232 transceiver
- DB9 socket for connecting to the PC serial port
- Transmission speeds up to 14.4 BAUD
- Infrared receiver stage with variable gain and high-pass filtering
- Separate carrier frequency pairs for "Originate" and "Answer" modes of operation
- Visual indicators for power, carrier detect, and data
- "Transponder" loopback mode for operation with a single PC
- Reverse polarity input power protection
- On-board 5.0 V regulator
- Configuration jumpers for testing and tuning without a PC
- External input terminals for using a square-wave signal for precise PLL receiver tuning
- Test points for tuning, analysis of operation, and troubleshooting
- Fully socketed IC's for ease of repairs and maintenance

1.3 Package Contents

Please make sure that you have the following items in the ICL package:

1. The ICL Module (1)
2. Plastic light guide sleeve for the IR receiver PIN diode
3. ICL-XX-AM Version only: PCB support posts (4)
4. This User Manual
5. Software and documentation distribution disk
6. Circuit Diagram.

1.4 Installation

Plastic light guide sleeves:

The plastic light guide sleeve should be inserted on the PIN diode D2. This sleeve shields the IR PIN diode from ambient lighting and from the radiation that always leaks from the on-board IR transmitter diode. Without the sleeve, the ICL module will not be able to perform at its normal speed and sensitivity.

2. CIRCUIT DESCRIPTION

2.1 Schematic Diagram

Full circuit diagram is included in the ICL package, alongside this user manual. You may find it useful to keep the circuit diagram open while reading the following sections about the details of circuit operation.

2.2 RS-232 Interface

U1 IC along with the J2 connector takes care of the RS-232 interface signal translation from bipolar RS-232 signals to 5V digital logic signals. U2 has a built-in charge-pump circuit to generate the +10 V and –10 V levels required for the out-going RS-232 signals.

Signal	Dir	Pin	Description
CD	Out	J2-1	Carrier Detect signal, indicating that the ICL is receiving an infrared carrier signal
Rx Data	Out	J2-2	Data received with the infrared signal
Tx Data	In	J2-3	Data to be transmitted on the infrared beam
DTR	In	J2-4	Data Terminal Ready signal, used to turn on the infrared carrier beam
GND	--	J2-5	Signal Ground
DSR	Out	J2-6	Data Set Ready signal, tied to the +10 V rail
RTS	In	J2-7	Request To Send, shorted back to the CTS signal
CTS	Out	J2-8	Clear To Send, obtained from the RTS signal
RI	Out	J2-9	Ring Indicator signal, not supported by the ICL circuitry

2.3 Infrared Transmitter

U4 precision timer circuit is configured as a free-running oscillator to generate the carrier signal that modulates the IR beam from the D6 IR LED. Oscillator signal is gated by the DTR signal, so that there is no IR transmission until the application program asserts the DTR signal. To obtain the correct polarity, the second amplifier inside the U2 IC inverts the DTR signal from the RS-232 transceiver before it is applied to the reset input of U4.

The jumper JP2 is used to force the transmitter to continuous transmission during testing and adjustment. Position the shorting jumper as follows:

JP2-1	Test position for continuous transmission
JP2-2	Normal operation under DTR signal control

The time constant that determines the oscillation frequency is set by the serial combination of R27, R28, and R29 resistors and the parallel combination of the C17 and C18 resistors. With the switch S1-1 open, the time constant is longer and this selects the "Originate" pair of transmit frequencies. Closing the S1-1 shorts R29 and selects the higher "Answer" pair of transmit frequencies.

During normal operation, the incoming data stream causes the oscillator to switch between the two frequencies by turning the Q2 FET transistor on and off, which, in turn, connects and disconnects the C17 capacitor. When capacitor is connected to ground via Q2, the time constant is longer, so the lower of the frequency pair (Mark) is generated. When the capacitor is disconnected, the higher frequency (Space) is generated. Adjustment of the two frequencies is not independent, since the R27 trimpot adjusts them both.

Generation of a carrier signal that changes its frequency between two different levels to represent binary data is known as the FSK (Frequency-Shift Keying) modulation. This is the modulation scheme used in most commercial slow-speed modems.

D5 LED indicates data transmission by blinking for each transmitted data bit. Since the blinking period is the same as the duration of the logic 1 bits, it may be harder to observe at higher transmission speeds.

JP1 selects the source of the FSK modulation as follows:

Position	Source of FSK Modulation
JP1-1	"Mark" or Logic 1
JP1-2 ✶	Data bits to be transmitted (Normal/default position)
JP1-3	Loop back of received data bits (Transponder mode)
JP1-4	"Space" or Logic 0
JP1-5	External modulation signal

In the normal operating position 2, data coming through the J2 connector is fed to the transmitter circuit. When the JP1 is in position 3, data received from the IR receiver section is fed back to the transmitter. This enables the ICL module to work as a "transponder" in a loop back configuration to retransmit the data just received from the IR channel.

Positions 1 and 4 are used for forcing the FSK generator to Logic 1 (Mark) or Logic 0 (Space) frequencies, respectively, for testing and tuning purposes. Position 5 allows applying an external square wave modulation signal via J3 for more precise tuning of the Phase-Locked-Loop (PLL) FSK demodulator of the receiving ICL module.

Finally, Q3 transistor is used to modulate the carrier onto the IR beam emitted by the D6 IR transmitter diode.

2.4 Infrared Receiver

Voltage variations generated across the IR PIN diode, D2, are fed to the AC amplifier built with the U2a op-amp. C7 and R5 form a high-pass filter to remove the effects of the ambient light and the fluorescent room lighting. The gain of the amplifier can be adjusted with the R7 trimpot to obtain the best signal for FSK demodulation stage that follows. C9 is used to block the DC component of the output voltage and only pass the AC portion.

2.5 FSK Demodulator

The FSK demodulator is built around the U3 PLL demodulator integrated circuit. The circuit locks onto the signal fed into the input pin 2, and produces two outputs: LD (Lock Detect) and DO (Data Output). The LD (Lock Detect) output is used as the *Carrier Detect* (CD) signal, because it indicates that the demodulator has locked onto a valid carrier signal within its capture range. The other output, DO, is the Data Output that has the demodulated serial data bits.

These output signals are taken directly to the RS-232 transceiver circuit, where DO becomes the Rx Data signal and LD becomes the CD (Carrier Detect) signal.

The center frequency of the PLL circuit is set by C13 capacitor and the serial combination of R14, R15, and R16. Once again, S1-4 is used to select "Originate" or "Answer" center frequency of operation. When S1-4 is closed, R16 is shorted out, therefore the higher (or "Answer") center frequency is chosen.

S1-2 and S1-3 are used to adjust the PLL loop filter characteristics for proper demodulation of the FSK signal when "Originate" or "Answer" pairs are chosen.

2.6 Power Input

This section of the circuit includes the reverse-voltage protection diode (D1), 5 V regulator (U5), and the power indicator LED (D8). C1 and C2 provide filtering and high frequency stability to the regulator circuit. With the JP3 open, a DC supply voltage between 8 V – 15 V can be used to power the ICL module.

If the only power source available is a 5V logic power supply, then the JP3 jumper can be shorted to bypass the regulator and feed the circuit directly from the 5 V DC source.

CAUTION: Shorting the JP3 jumper for 5 V operation also bypasses the reverse polarity protection diode and removes the protection against accidental application of reverse-polarity power sources.

3. CONFIGURATION & TUNING

NOTE: Since two ICL modules are required to establish an IR link for normal operation, test and adjustment procedure makes use of two modules to simplify the adjustment procedure. For a simple data link, it's only required to match the frequencies of the two ICL modules to each other, and the value of exact frequencies of operation does not matter within the normal operating range of the circuits. We recommend, however, that the ICL modules be carefully and precisely tuned to the assigned frequencies for good interoperability between them, and for the maximum range and speed of operation.

This procedure assumes that a pair of ICL modules is being adjusted for mutual operation.

3.1 Configuring the Mode

It is necessary at this point to assign one ICL module to be the "*Originate*" modem and the other ICL module to be the "*Answer*" modem. This is necessary to make sure that the modules are using the correct frequency pairs to transmit and receive. Just like any other full-duplex modem, the ICL module has to use different frequency pairs for transmitting and receiving to maintain the separation between the two channels.

This mode assignment is done with the S1 DIP-switch bank as follows:

Switch	Originate	Answer
S1-1	Off	On
S1-2	Off	On
S1-3	On	Off
S1-4	On	Off

3.2 Tuning the Infrared Transmitter

The procedure below uses the on-board facilities of the ICL module for testing and fine-tuning, without requiring a PC. Note that two ICL modules are required for the tuning process.

The specifications for the operating frequencies are listed in Table 5.1 Please consult this table while following the tuning procedures.

1. Connect a frequency counter to the test point TP5 to measure the frequency of the carrier signal.
2. Place the JP2 shorting jumper to position 1. This will make sure that the FSK generator is continuously enabled.
3. Set the first ICL modem to "Originate" mode and the second ICL modem to "Answer" mode with the S1-1 switch as follows:

   Originate S1-1 Off
   Answer S1-1 On

4. Place the JP1 shorting jumper to position 4 to transmit the "Upper/Space" frequency.
5. Using trimpot R27, carefully adjust the frequency to the "Transmit Upper/Space" frequency as indicated in Table 5.1.

6. Place the JP1 shorting jumper to position 1 to transmit the "Lower/Mark" frequency.
7. Measure and note this "Lower/Mark" frequency.
8. Calculate the *Center Frequency* as follows:

$$f_c = (f_U+f_L)/2$$

9. If the calculated *Center Frequency* is not within ± 100 Hz of the value indicated in Table 5.1, go back and repeat steps 4 – 9.

3.3 Tuning the Infrared Receiver

In order to tune the receiver section of the ICL modem, another ICL modem is required. This second ICL modem must already be tuned to the correct operating frequencies. Infrared signals transmitted by this second ICL modem will be used to tune the receiver of the first modem.

1. Make sure the second ICL is transmitting continuously (Place JP2 to position 1)
2. Connect the TTL-level square-wave output of a signal generator to J3-1 of the second modem. Make sure the ground of the signal generator is connected to J3-2.
3. Make sure the light filter sleeve is placed over the D2 PIN diode of the ICL module being tuned.
4. Set the signal generator frequency to about 20 Hz.
5. Place the IR transmitter of the second ICL module directly opposite the receiver at a distance of about 6-8 inches.
6. Set the amplifier gain trimpot of the receiving ICL R7 to its midpoint position.
7. Adjust R14 until the CD indicator LED (D4), turns on steadily, and the Rx Data LED (D3) follows the blinking of the Tx Data LED (D5) of the transmitting ICL.
8. Turn the R14 trimpot in one direction until either PLL loses lock (CD goes off or starts flickering), or until the Rx Data LED stops following the frequency shifts, whichever comes first. Note the position of the trimpot.
9. Now turn the R14 trimpot in the other direction until either PLL loses lock, or the Rx Data LED stops following the frequency shifts. Note the position.
10. Set the R14 trimpot to the mid-point of the two positions you noted in the preceding two steps. This should give satisfactory operation up to a transmission rate of about 4800 BAUD without a precise center frequency setting for the PLL. (A more precise setting of the center frequency would make 14.4 kBAUD operation possible).

4. FUNCTIONAL TESTING

4.1 Basic Functionality

To carry out the basic functionality test, a PC with a serial port, running a terminal emulation or a serial communication program is required. The procedure below assumes that the ICL Control Panel program is being used for this purpose.

1. Confirm that the ICL modules are in normal operating configuration:
   a) "Originate" and "Answer" modes must selected properly on both Modules. (One must be *Originate* the other must be *Answer*).
   b) JP1 jumper must be in position 2 for data transmission.
   c) JP2 jumper must be in position 2 for FSK generator control by DTR signal.
   d) DC Power is being supplied to the modules and the power LED is on.
2. Connect the two ICL modules to the serial ports of their respective PC's.
3. Place the two ICL modules so that the IR diodes are facing each other at a distance of about 6 inches.
4. Start the ICL Control Panel program on the two PC's.
5. Make sure the light filter sleeves are still on the PIN diodes (D2).
6. Select 300 BAUD operation and *No Parity* as a safe starting point.
7. Make sure that the COM port is set correctly on both programs.
8. Open the Serial Port and turn on the DTR signal.
9. Observe that the CD LED on the remote ICL and the CD indicator on the remote Control Panel program are both on.
10. Select the *Terminal* operation mode.
11. Type a character in to the *Transmit Window* on one PC and make sure it appears on the *Receive Window* of the other PC. If you do not see this happen, then this is the time to do troubleshooting and see what might have been done wrong.
12. Type a character in to the *Transmit Window* on the other PC and make sure it appears on the *Receive Window* of the first PC.
    Note: Please keep in mind that the two channels are completely independent and it is possible to have communication in one direction and not in the other direction.

4.2 Extended Operation

Further experimentation with the ICL circuit is possible by changing or modifying the following variables to increase the transmission speed and/or the maximum communicating distance between the two ICL modules:

- **Receiver amplifier gain**

  Using R7, receiver amplifier gain can be adjusted for operating with fewer errors or over longer distances.

- **Filtering or reduction of ambient light**

  Since the ICL circuitry does not have a very elaborate filter stage, ambient light, especially fluorescent light, has an adverse effect on the tracking of the PLL FSK decoder stage. Reduction of the ambient light improves circuit performance

- **Positioning of the transmit and receive LED's**

  Filter sleeve on the PIN diode and the radiation pattern of the IR transmitter LED increases the directional sensitivity of the ICL system and results in a rather narrow angle of operation. The distance between the units and the correct positioning of the units have a strong effect on the performance, especially at longer distances.

- **Center frequency of the PLL circuit**

  The tuning procedure explained in section 3.3 is good for slower transmission speeds, but may not work very well at 9.6 and 14.4 kBAUD rates. For more precise tuning, it is recommended that the tuning be carried out with a 10 kHz modulation signal. The signal should be a TTL-level square wave with a precise 50% duty cycle. Tuning is done by observing the DO signal at the receiver (TP4) with an oscilloscope and adjusting the PLL center frequency to obtain a square wave with a 50% duty cycle.

- **Redesigning the FSK and PLL circuits for different operating frequencies**

  The frequency-determining components of the ICL module are not soldered to the board but inserted into single-pin contacts to facilitate easy replacement. The FSK generator and the PLL decoder sections can be redesigned for higher frequency of operation to support higher data transmission rates.

- **Increasing the infrared transmission power output**

  The infrared power output from the D6 IR LED is controlled by the current-limiting resistor, R31. The value of this resistor can be decreased for increased power output. The default operating point for the IR LED is chosen well below the maximum rating of D6, so there is quite a bit of room for improvement.

4.3 Transponder Mode

You can make one ICL reflect back the received data by placing the JP1 jumper to position 3. In this mode the data received and recovered from the incoming signal is shorted to the transmitter circuit and sent back on the other channel.

5. SPECIFICATIONS

RS-232 Interface DB-9F socket, DCE configuration
Modulation Frequency FSK with the following pairs:

Mode	Pair	Name	Frequency [kHz]	Center Freq. [kHz]
Originate	Transmit	Lower / Mark	12.2	14.8
//	//	Upper / Space	17.4	
//	Receive	Lower / Mark	26.6	32.2
//	//	Upper / Space	37.8	
Answer	Transmit	Lower / Mark	26.6	32.2
//	//	Upper / Space	37.8	
//	Receive	Lower / Mark	12.2	14.8
//	//	Upper / Space	17.4	

Table 5.1 - ICL Operating Frequencies

Transmission Rate 14.4 kBAUD Max
Supply Voltage 5.0 or 8.0 – 15 V DC
Power Consumption 60 mA typical, 70 mA max

6. CONTROL PANEL PROGRAM

The Control Panel application is a companion program for the ICL modules to provide the following basic functionality:

- Serial port and ICL Modem control functions
- Monitoring line errors
- Automatic character transmission facilities for testing and experimentation
- A chat-like terminal application for sending characters and text
- Data loopback
- Statistical measurements for throughput and error measurements

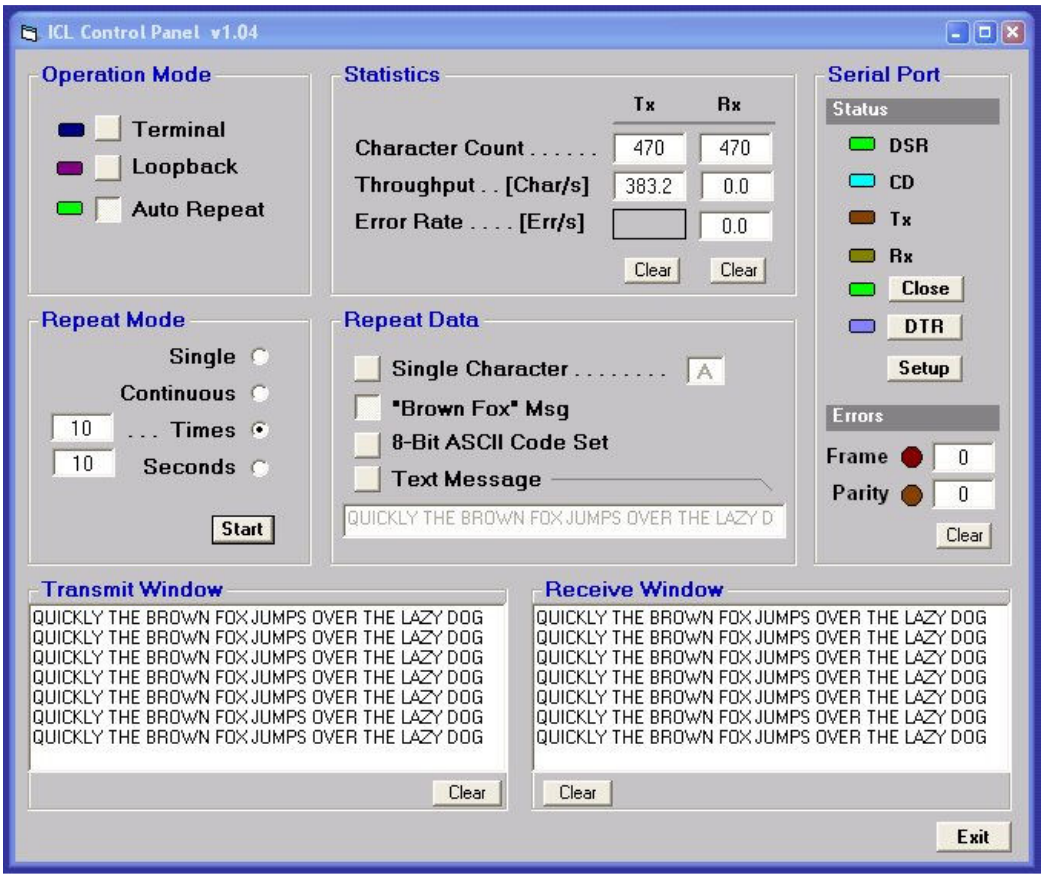

Fig. 6.1 Control Panel Main Screen

6.1 Serial Port and Modem Control

The controls and indicators in this group are contained inside the "Serial Port" frame on the main screen. The following are the indicators and the controls:

DSR Indicator

Shows the status of the DSR (Data Set Ready) signal. The DSR signal is asserted as soon as the ICL module is powered up.

CD Indicator

Shows the status of the CD (Carrier Detect) signal. The CD signal is asserted by the ICL modem whenever the receiver is able to receive and lock onto an in-coming infrared carrier signal within the capture range.

Tx Data Indicator

This indicator blinks on every time a character frame is transmitted.

Rx Data Indicator

This indicator blinks on every time a character frame is received.

Com Port Open/Close Control

This control button is used to open or close the selected com port. The caption on the button is "Open" before the com port is opened. When the button is pressed, the com port is opened, the indicator turns on, and the caption on the control button changes to "Close". Pressing the button after this closes the com port and discards any data that may still be in the input or output buffers.

DTR On/Off Control

The DTR (Data Terminal Ready) control button turns the DTR signal on or off. ICL module uses the DTR signal to turn on the infrared carrier signal.

Com Port Setup Control

Pressing the *Setup* button opens up another form where the com port, its speed setting and the parity bits settings can be selected and modified.

Com port settings are retained even after the program is terminated.

6.2 Monitoring Line Errors

The Errors group of indicators, counters, and controls can be used to observe and monitor the transmission line errors.

Frame Error Indicator and Counter

Whenever an improperly formed character frame is received (Missing start bit, missing stop bit, timing errors, etc.), the indicator flashes and the frame error counter is incremented.

Parity Error Indicator and Counter

Whenever the calculated parity bit does not match the received parity bit, the indicator flashes on and the parity error counter is incremented.

Clear Button

Pressing the *Clear* button clears the error counters back to zero.

6.3 Automatic Repeat Transmission

The Control Panel program has the capability to automatically send different character and text messages and repeat this operation in various different ways. This capability is quite handy when tuning the ICL modules or experimenting with different setups.

The *Auto Repeat* mode is selected with the command button assigned to this job within the *Operation Mode* group of control buttons.

The *Start/Stop* control button starts and stops the automatic transmission.

The *Repeat Mode* group of options control the way in which the Auto Repeat transmission works as follows:

Single

Selected data (character or a text message) is sent only once.

Continuous

Selected data (character or a text message) is sent continuously when the Start button is pressed.

XX Times

Selected data (character or a text message) is sent the number of times indicated by the number typed inside the text box. The default is 10 times.

XX Seconds

Selected data (character or a text message) is sent for the duration indicated by the number typed inside the text box. The default is 10 seconds.

Character or text data to be repeated is selected by the *Repeat Data* group of controls as follows:

Single Character

When this option is selected, a single character that is shown in the small text box becomes the character to be repeated. The character can be changed by typing a new character into the text box.

"Brown Fox" Message

This is a message that has a historic significance from the earlier days of data communication when the teletype (telex) machines were considered state-of-the-art equipment. Since some of the characters could be missed or get "stuck" by these electro-mechanical devices, a short message was devised that would contain all the letters on the teletype character set. By first sending this message, operators could observe and tune the equipment for proper reception of all characters.

QUICKLY THE BROWN FOX JUMPS OVER THE LAZY DOG

Note that each letter of the English Alphabet is used at least once.

8-Bit ASCII Code Set

When this option is selected, all 256 characters of the 8-Bit ASCII code set from $(00)_{HEX}$ to $(FF)_{HEX}$ is transmitted and repeated as determined by the *Repeat Mode* options.

Text Message

This option works as the "Brown Fox" option, with the difference that the user can change the text message that is repeated. When this option is selected, the default message in the text box can be typed over. When the *Auto Repeat* transmission starts, this new message will be transmitted.

6.4 Character Terminal

The character terminal mode is selected with the control button inside the *Operation Mode* group of controls. When this mode is selected, the *Terminal* mode indicator turns on and characters can be typed inside the *Transmit Window*. Characters are transmitted as soon as they are typed.

Any characters received by the serial port are displayed inside the *Receive Window*.

6.5 Data Loopback

In addition to the hardware loopback function provided by the ICL module, the Control Panel program also has the capability to immediately retransmit characters received by the serial port.

The *Loopback* mode of operation is selected by the control button inside the *Operation Mode* group of controls. When this mode is selected, the Loopback indicator turns on and the characters that are received and retransmitted are visible inside the *Receive Window* and the *Transmit Window*.

6.6 Statistical Measurements

Counters and the control buttons included in this group are used to display some statistical and performance data that would be a point of interest for every data communication system: Amount of data transmitted and the rate of data transfer.

Character Counts

The two counters in the Tx and Rx columns show the total number of characters transmitted and received, respectively.

Throughput

These two text boxes in the Rx and Tx columns show the rate of data transfer in the receive and transmit channels, respectively. The rate indicators are updated once every second to show the effective rate of transfer.

Error Rate

The error rate is calculated and displayed once every second by calculating the sum of framing and parity errors observed within that period.

Clear Buttons

The two *Clear* buttons are used to clear statistics displays to zero before starting new observations. The clear operation does not affect the internal counters used for the statistical calculations.

7. SUPPORT

We are here to help if you need assistance in using or troubleshooting the ICL Module. Please do not hesitate to contact Unistep Tech Support using any of the means listed below:

Internet Our web site www.unistep.ca has some support information and we are adding new material all the time.

E-Mail This is our preferred method of communication. Please use our support address support@unistep.ca for any questions, comments, or recommendations you may wish to send our way. We strive to answer all messages within two days.

Phone You can call us at 416-619-9308 and talk to our support staff concerning any technical assistance you may need. If we are unable to receive your call in person, please do leave a message. We strive to return our calls within one day.