XLP 8-Bit Development Board User's Guide

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XLP 8-BIT DEVELOPMENT BOARD USER'S GUIDE

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NOTES:

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Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our web site (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXA", where "XXXXX" is the document number and "A" is the revision level of the document.

For the most up-to-date information on development tools, see the MPLAB® IDE on-line help. Select the Help menu, and then Topics to open a list of available on-line help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the XLP 8-Bit Development Board. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Warranty Registration
- Recommended Reading
- The Microchip Web Site
- Development Systems Customer Change Notification Service
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This document describes how to use the XLP 8-Bit Development Board as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- **Chapter 1. Introduction to the XLP 8-Bit Board** provides a brief overview of the XLP 8-Bit Development Board, its features and its uses
- **Chapter 2. The XLP Demonstration Application** describes the preprogrammed demonstration program
- **Chapter 3. XLP 8-Bit Development Board Hardware** provides a more detailed description of the XLP 8-bit board's hardware features
- **Appendix 1. Development Board Schematics** provides detailed schematics of the XLP 8-Bit Development Board

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*MPLAB® IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	*File>Save*
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic Courier New	A variable argument	*`file`*`.o`, where *`file`* can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [options]` *`file`* `[options]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
Ellipses...	Replaces repeated text	`var_name [, var_name...]`
	Represents code supplied by user	`void main (void) { ... }`

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WARRANTY REGISTRATION

Please complete the enclosed Warranty Registration Card and mail it promptly. Sending in the Warranty Registration Card entitles users to receive new product updates. Interim software releases are available at the Microchip web site.

RECOMMENDED READING

This user's guide describes how to use XLP 8-Bit Development Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

Readme for XLP 8-Bit Development Board

For the latest information on using the XLP 8-Bit Development Board, refer to the file, `readme.pdf`, in the "Documentation" subdirectory (inside the "XLP 8-Bit Development Board Demo" directory). This file contains update information and known issues that may not be included in this user's guide.

PIC16(L)F1947 Family Data Sheet

Consult this document for detailed information on the PIC16LF device that is included with the development board. Reference information found in this data sheet includes:

- Device memory map
- Device pinout and packaging details
- Device electrical specifications
- List of peripherals included on the device

PIC18F87K22 Family Data Sheet

Consult this document for detailed information on the PIC18F device that is pre-installed in the development board. Reference information found in this data sheet includes:

- Device memory map
- Device pinout and packaging details
- Device electrical specifications
- List of peripherals included on the device

PIC16F and PIC18F Family Reference Manuals

This reference manual explains the operation of the PIC18F microcontroller family architecture and peripheral modules. The specifics of each device family are discussed in the individual family's device data sheet.

This useful manual is online in sections at the Technical Documentation section of the Microchip web site. Refer to these sections for detailed information on PIC18F device operation.

The following documents are also available from Microchip to support the use of the XLP 8-Bit Development Board:

- *"25AA256/25LC256 256K SPI Bus Serial EEPROM" Data Sheet* (DS21822)
- *"MCP9700/9700A/9701/9701A Low-Power Linear Active Thermistor™ ICs" Data Sheet* (DS21942)
- *"PICkit™ 2 Programmer/Debugger User's Guide"* (DS51553)
- *"PICkit™ 3 Programmer/Debugger User's Guide"* (DS51795)
- *"Compiled Tips 'n Tricks Guide"* (DS01146)

THE MICROCHIP WEB SITE

Microchip provides online support via our web site at www.microchip.com. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

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The Development Systems product group categories are:

- **Compilers** – The latest information on Microchip C compilers and other language tools. These include the MPLAB® C18 and MPLAB C30 C compilers; MPASM™ and MPLAB ASM30 assemblers; MPLINK™ and MPLAB LINK30 object linkers; and MPLIB™ and MPLAB LIB30 object librarians.
- **Emulators** – The latest information on Microchip in-circuit emulators.This includes the MPLAB ICE 2000 and MPLAB ICE 4000.
- **In-Circuit Debuggers** – The latest information on the Microchip in-circuit debugger, MPLAB ICD 3 and PICkit™ 3.
- **MPLAB® IDE** – The latest information on Microchip MPLAB IDE, the Windows® Integrated Development Environment for development systems tools. This list is focused on the MPLAB IDE, MPLAB SIM simulator, MPLAB IDE Project Manager and general editing and debugging features.
- **Programmers** – The latest information on Microchip programmers, such as the MPLAB PM3 device programmer.

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CUSTOMER SUPPORT

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- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or Field Application Engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the web site at: http://support.microchip.com

DOCUMENT REVISION HISTORY

Revision A (May 2011)

- Initial release of this document.

NOTES:

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Chapter 1. Introduction to the XLP 8-Bit Board

1.1 INTRODUCTION

Thank you for purchasing Microchip Technology's XLP 8-Bit Development Board.

The board provides a low-cost, highly configurable development system for Microchip's new line of 64 and 80-pin Extreme Low-Power (XLP) microcontrollers, including the PIC16(L)F1947 and PIC18F87K22 families.

The XLP 8-bit board permits users to explore and evaluate extreme low-power features, and learn low-power software and hardware techniques. Various headers are available to measure the power consumption of both the microcontroller and development board. It is flexible, supporting five different power sources over a wide voltage range. It is highly configurable, equipped with a variety of common peripheral components that can be selectively enabled. Finally, it is expandable through its modular interface, providing for the addition of advanced interfaces and connectivity methods.

As provided, the XLP 8-Bit Development Board functions as a demonstration platform on initial power-up. The included demonstration software takes a temperature measurement, datalogs information to the serial data EEPROM, and displays information to the on-board LCD. Additional software is provided to demonstrate low-power techniques and IC interface routines.

1.2 HIGHLIGHTS

The XLP 8-Bit Development Board includes these features:

- Support for both 64-pin and 80-pin versions of both PIC16 (L)F-series and PIC18 K-series Flash microcontrollers via Plug-In Modules (PIMs)
- Built-in capability for separately measuring microcontroller and board current consumption
- Multiple oscillator options
- Accommodations for five different power source options
- Configurability for a wide range of operating voltages (1.8V to 3.3V)
- Configuration selection jumpers to disable board components
- A hardware switchable option to control power to board components with port pin
- Three push buttons
- Seven LEDs
- Potentiometer for analog input
- 16x2 character LCD with controller
- Serial EEPROM storage
- PICtail™ interface for connection to various application daughter boards
- Serial Accessory Port (SAP)
- Temperature sensor
- Prototyping Area
- Support for all Microchip compatible programmers and emulators

1.3 WHAT'S IN THE BOX

The XLP 8-Bit Development Board includes the following:

- XLP 8-Bit Development Board
- PIC16(L)F1947 Plug-In Module
- PIC18F87K22 Plug-In Module
- USB mini-B cable
- Power Analyzer cable

1.4 DEVELOPMENT BOARD FEATURES

A layout of the XLP 8-Bit Development Board is shown in Figure 1-1.

The board includes these specific features, as indicated in the diagram:

1. Connector for Plug-In Modules (PIM)
2. Oscillator circuits (10 MHz and 32.768 kHz) for microcontroller on PIM
3. Power supply area (battery holders, external power supply input, LDO regulator and power supply select jumper) interface headers for the energy harvester demonstration board
4. Power LED
5. LDO regulator
6. IC power-select jumpers
7. Microcontroller Master Clear switch
8. Push buttons
9. Potentiometer
10. LEDs
11. 2x16 character LCD
12. Serial EEPROM
13. Temperature sensor
14. PICkit™ programmer/debugger 6-pin interface
15. Modular 28-pin riser interface for daughter boards
16. Serial Accessory Port
17. Prototype area with supply voltage and I^2C™ signal access
18. Current measurement jumpers and access point

A more detailed discussion of each feature and its configuration is provided in **Chapter 3. "XLP 8-Bit Development Board Hardware"**.

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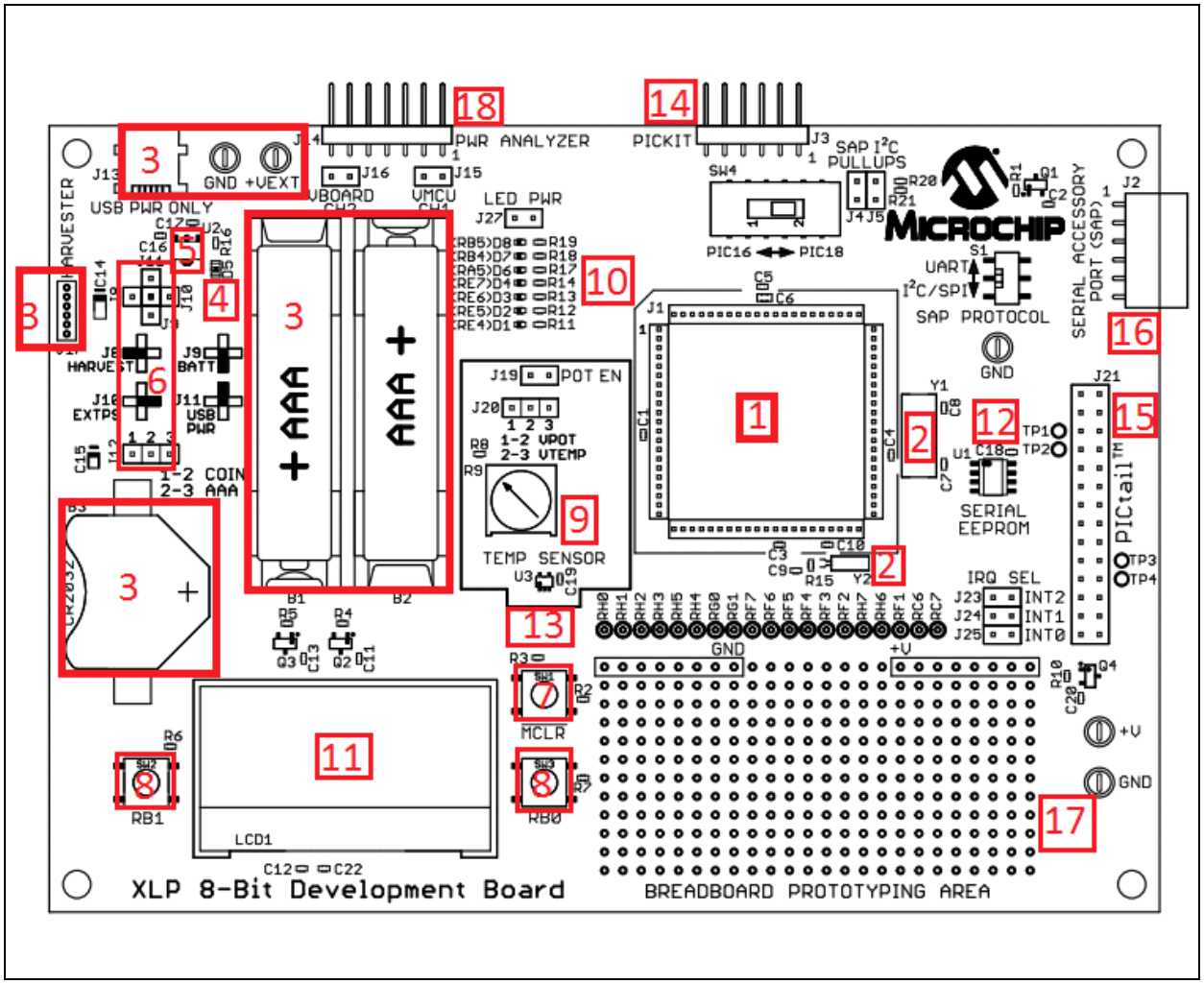
FIGURE 1-1: 8-BIT XLP COMPONENT LAYOUT



1.5 USING THE DEVELOPMENT BOARD OUT OF THE BOX

Although intended as a development platform, the XLP 8-bit board may also be used directly from the box as a demonstration platform for the preprogrammed PIC18F87K22 microcontroller using the provided PIM.

Refer to **Chapter 2. "The XLP Demonstration Application"** for details on the demonstration code operation.

1.6 DEMONSTRATION PROGRAM

The preprogrammed example code on the PIC18F87K22 device as well as the demonstration program for the PIC16(L)F1947 device is available for download from the Microchip web site (www.microchip.com/XLP8BitBoard). All required project files are provided so that the code may be used as an example or a platform for further development. These may be used with the included PIC18F87K22 device by programming the device using any programming tool, such as PICkit™ 3.

NOTES:

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Chapter 2. The XLP Demonstration Application

This chapter describes the demonstration application that is preprogrammed on the PIC18F87K22 microcontroller. It can also be applied to the demonstration program for the PIC16(L)F1947 supplied on the XLP web site. The demonstration program will show the use of low-power techniques in a working application. In the process, the application highlights various features of these two microcontroller families.

2.1 INITIAL SETUP

Although intended as a development platform, the XLP 8-bit board is also designed to be used directly from the box as a demonstration platform. The demonstration firmware preprogrammed in the PIC18F87K22 microcontroller PIM is ready for immediate use. The supplied PIC16(L)F1947 microcontroller PIM needs to be programmed with the code supplied on the XLP web site.

The demonstration firmware uses the on-board LCD to report temperature and timing information while the push buttons select between modes of operation.

2.1.1 Configuring and Connecting the Hardware

To get started with the board, verify that it is properly configured:

1. Verify the PIM is correctly installed into socket J1. The notch on the edge of the PIM should be aligned with the matching print on the board.
2. Verify that SW4 is set to the correct setting as indicated on the board, for the corresponding PIM used.
3. Populate the power source select jumper for USBPWR, J11.
4. Populate the jumpers for VBOARD, J16 and VMCU, J15.
5. Populate the jumper for POT EN, J19. Choose the selection jumper for J20, either VPOT [1-2] or VTEMP [2-3]. J20 can be moved between selections mid-program to explore both options.
6. Populate SAP I^2C pull-ups, J4 and J5. Although not used in the demonstration program, these allow future expansion through the Serial Accessory Port (SAP), J2.
7. Populate INT2, J23. Leave INT0, J25 and INT1, J24 unpopulated.
8. Connect the development board to the PC with the provided USB cable (A to mini-B). The board will not enumerate, but will source power from the USB port.

The default jumper configuration table is shown in Figure 2-1.

FIGURE 2-1: JUMPER TABLE

Jumper	PIC16LF1947	PIC18F87K22	Function
J4	ON	ON	PIC16 SAP I²C Pullup
J5	ON	ON	PIC18 SAP I²C Pullup
J15	ON	ON	MCU Current
J16	ON	ON	Board Current
J19	ON	ON	POT Enable
J20	ON	ON	Select: POT[1-2]; Temp Sensor[2-3]
J27	OFF	OFF	LEDs
J23	ON	ON	IRQ: INT2 (RB2)
J24	OFF	OFF	IRQ: INT1 (RB1)
J25	OFF	OFF	IRQ: INT0 (RB0)
Power Source Jumpers			
J8	ON	ON	USB Power
J9	OFF	OFF	Battery [J12 Used]
J10	OFF	OFF	External Power
J11	OFF	OFF	Harvester
J12	OFF	OFF	Select: - [J9 Used] Coin [1-2]; AAA [2-3]

2.2 DEMONSTRATION PROGRAM OPERATION

The demonstration program uses the on-board LCD to display system status data, temperature and time. The time can be set for the Real-Time Clock operation and be displayed in global time or AM/PM time. The program permits the user to select between operation modes, each with its own current consumption values. This permits users to experiment with the different Low-Power modes and XLP techniques, as well as make direct measurements. The program flowchart is shown in Figure 2-2.

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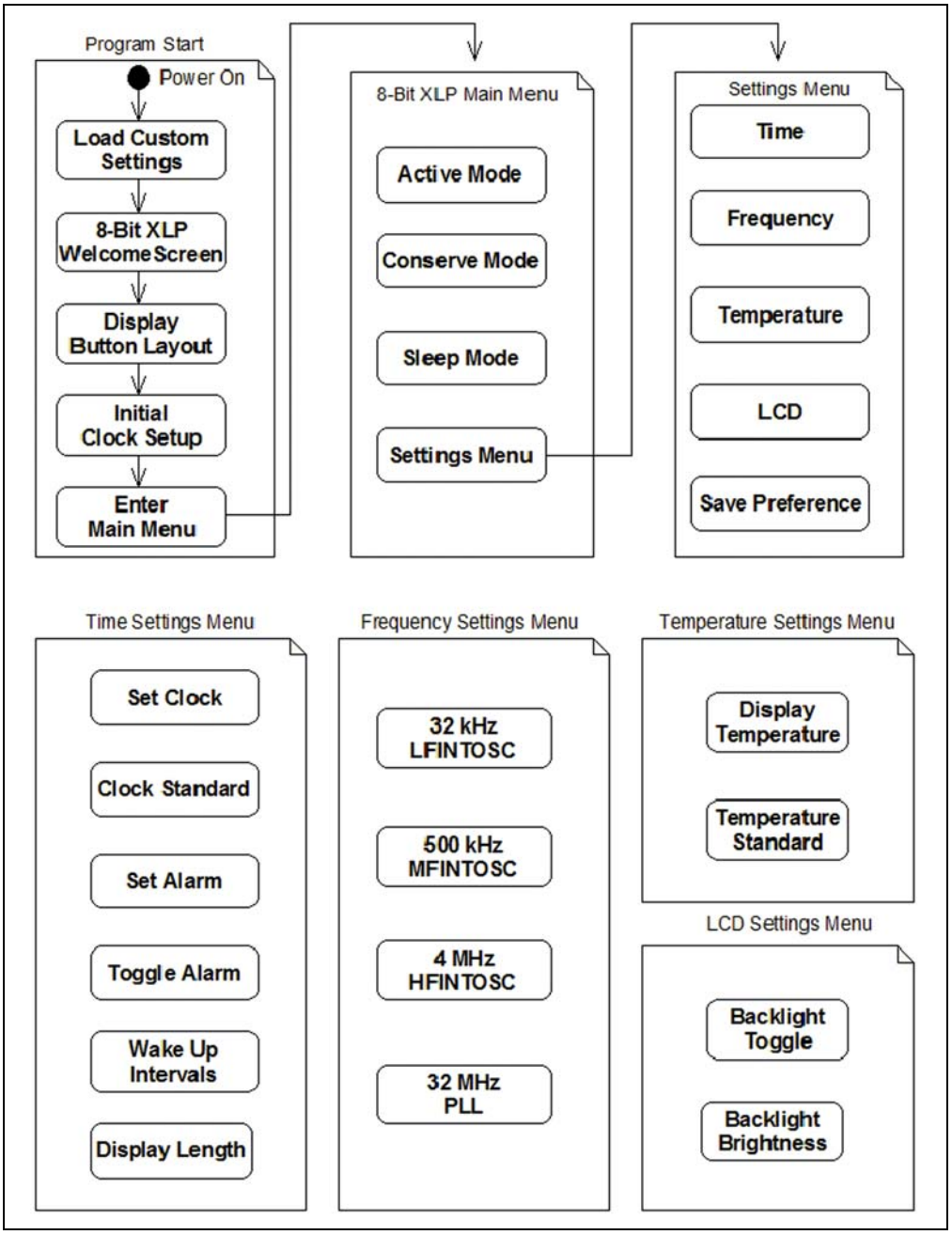
FIGURE 2-2: DEMO APPLICATION SOFTWARE FLOW



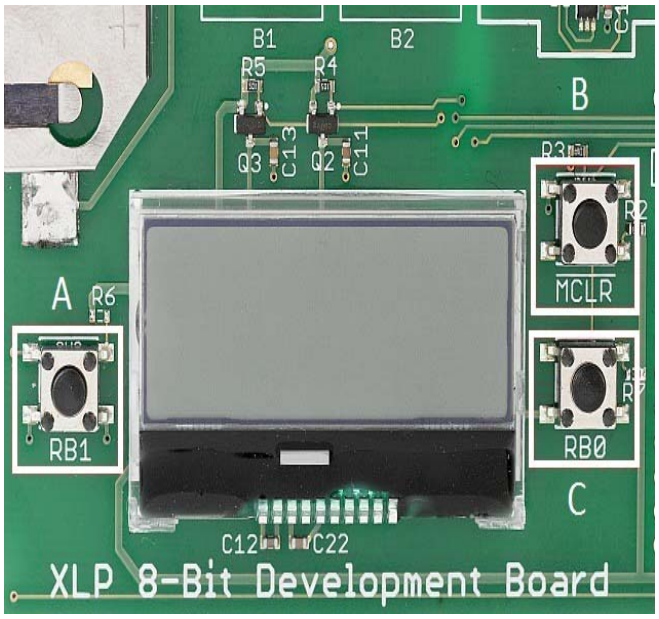
On power-up, the PIC® device will first run through its initialize process. First, it will set the device's system clock to be configured for the custom set frequency. If no custom preferences are set, the device will be set to the program default of 4 MHz.

Next, the program will run through the `Low_Power()` routine, where the devices I/O ports are configured for their ideal low-current use settings. All unused interrupts are disabled. All peripherals not currently used are disabled and the device is set up to enter the lowest possible Sleep state upon execution of the `SLEEP()` command. The LCD is then initialized. The backlight will turn on and the display will begin to show characters. The LCD screen should welcome the user with the display "8-Bit XLP Demo Board" for two seconds. The display will then change to show a clock set to 00:00:00. This is the clock initial setup.

The button layout to set the clock is also displayed on the screen. The clock will display either a 12-hour or 24-hour time scale, depending upon the custom preferences. If no preferences are set, the software default is a 24-hour time scale. After setting the clock, the Real Time Clock Counter (RTCC) will be initialized, enabling and using Timer1, which keeps count of time using the on-board 32 kHz oscillator crystal. The screen will display the main menu for two seconds. The program is now at the "8-Bit XLP Main Menu".

To navigate the menus, the $\overline{\text{MCLR}}$ button function is [Up], the RB0 button function is [Down] and the RB1 button function is [Select]. The RB1 button is also the only button accepted as an interrupt while in SLEEP( ). RB1 is used to enter and exit all three modes [Active, Conserve, Sleep]. The button layout is shown in Figure 2-3.

FIGURE 2-3: BUTTONS LAYOUT



A – Select

B – Up

C – Down

Note 1: B is sometimes used to increment hours.

2: C is sometimes used to increment minutes

3: Holding either B or C down will increment values gradually.

2.2.1 8-Bit XLP Main Menu

From the main menu location the user has four selections: Active mode, Conserve mode, Sleep mode and Settings menu.

2.2.1.1 ACTIVE MODE

In Active mode the CPU and peripherals features are on. The peripherals are still dependent upon software-based enables. In this case, the only peripherals active are the ADC used in connection with the temperature sensor or on-board POT; Timer1 used for the RTCC; Timer2 and CCP2, both used to control backlight brightness through the use of the Pulse-Width Modulator (PWM). All other peripheral features have been disabled through the INTCON, PIR and PIE registers.

Note: On the PIC18 device, the PMD registers are also referenced.

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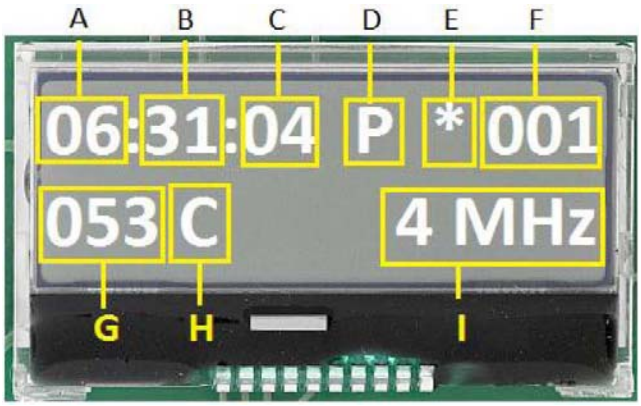
The active display shows the following as displayed in Figure 2-4:

- clock time
- time standard
- alarm indicator
- brightness percentage (PWM)
- temperature value
- temperature standard
- system clock frequency

To escape Active mode the user has the option to press RB1 (Select) at any time. The user also has the option to escape Active mode if the alarm is enabled and the specified time is met. Upon exiting, the user will return to the “8-Bit XLP Main Menu”.

FIGURE 2-4: ACTIVE DISPLAY



A – Hours
B – Minutes
C – Seconds
D – AM/PM
E – Alarm Indicator
F – Brightness Scale
G – Temperature
H – Temp Scale
I – Frequency

2.2.1.2 CONSERVE MODE

In Conserve mode the CPU is off and peripherals are on. In this power-saving state, the peripherals are still active. Through this method we are able to continue monitoring the Timer1 (32 kHz) signal, which allows the clock to stay accurate. To showcase this feature upon entering the mode, the device will remain asleep until a set value of time has elapsed. The wait period before waking from Sleep determined by the user is found under [Settings→Time→Wake Up].

The user can choose to wake-up every 15, 30 or 60 seconds or to not awake at all. By software default this value is 15 seconds. When the device “wakes up” from Sleep, it will run in Active mode until a set value of time has elapsed. The display period is determined by the user, found under [Settings→Time→Display Length]. The user can choose to have a display length of 5 or 10 seconds. If “wake up” is None, the display length will be set to 0. By software default the display length is 5 seconds.

To escape Conserve mode, the user has the option to press RB1 (Select) at any time. This feature shows a wake-up based upon an interrupt (INT1). The user also has the option to escape Conserve mode if the alarm is enabled and the specified time is met. Upon exiting, the user will return to the “8-Bit XLP Main Menu”.

2.2.1.3 SLEEP MODE

In Sleep mode, the CPU and peripherals are off. In this Power-Saving mode the device is fully asleep. The only events which can wake it from Sleep are the Watchdog Timer (WDT), Brown-out Reset (BOR), Secondary Oscillator SOSC, RTCC, ULPWU and I/O-based interrupts. In our demonstration program the WDT and BOR have been disabled in the configuration (fuses). The RTCC and ULPWU are not used in the program and should be considered disabled, and SOSC has been disabled for Sleep mode (enabled in Conserve mode).

In this mode, the device is consuming the least amount of current possible. To escape Sleep mode the user has only to press RB1 (Select) at any time; this acts as INT1, interrupts wakes the device from Sleep. It is important to remember that the SOSC has been disabled, and thus the clock is no longer keeping accurate time. Upon exiting, the user will return to the "8-Bit XLP Main Menu" and the clock will begin to count again. To return the clock to an accurate time, the user will have to set it to the correct time. (Settings → Time → Set Time).

2.2.1.4 TIME-OUT MODE

The demonstration program includes a time-out function. The time-out function is passive and thus runs in the program background while navigating the menu system. If the user fails to do an action within a minute, the system will go to Sleep until woken up by a RB1 button press. In this mode of Sleep the system will continue to keep track of time but the LCD will remain off as well as all other module functions.

The final selection under the "8-Bit XLP Main Menu" is the Settings Menu, which will take the user into the custom preference options within the demonstration program. A program symbol legend can be seen in Figure 2-5.

FIGURE 2-5:

Symbol	Function
*	Alarm is active
A	AM
P	PM
> Text <	Select Cursor
[Text]	Feature Enable

2.2.2 Settings Menu

From the settings menu location, the user has the option to create a custom user preference for the features involved with time, frequency, temperature and the LCD. After modifying the demonstration program the user can select "Save Custom" under the settings menu to store the custom preferences to the on-board serial EEPROM. This allows the demonstration program to start with the user's personal settings already in place at start-up.

2.2.2.1 TIME SETTINGS

Under the time settings the user has the option to set clock, toggle clock standard, set alarm, toggle alarm enable, choose wake-up intervals and choose display length when woken up.

By choosing Set Time, the user will be able to increment hours and minutes as per initial setup. Please note that if Sleep mode is entered, then Set Time has to be entered to re-adjust the clock to make it accurate.

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Under clock standard, the user has the option to toggle between [24-hour] and [12-hour] time. If [12-hour] is selected, it should reflect an accurate representation of [24-hour] time using an ‘A’ or ‘P’ display to indicated morning or evening time.

By choosing Set Alarm, the user will have the option to choose a 30 or 60 minute nap timer or to set a custom alarm time. If the user chooses Custom, a display similar to Set Time will be displayed, giving the user the option to increment hours and minutes to a desired alarm time.

The user has the option to choose to enable/disable the alarm by selecting Alarm.

Note: It is important to note that when the user chooses any of these options, the current time on the clock is used as a starting point. This means if the clock displays 03:30:05 P, if under Set Alarm, the 30 minute nap will chime an alarm at 04:00:05 P, the 60 minute nap at 04:30:05 P, and the Custom will bring up 03:30:05 P on its display, allowing users to increment hours or minutes from that point. This will allow users to quickly set alarm times near the clock base, as well as to ensure the alarm starts from the correct time base. Sleep mode will not affect alarm set times, however, alarm times are dependent upon the clock time, so this should be taken under consideration.

If the user selects Wake-Up, it will toggle between multiple options. The wake-up feature is only used in Conserve mode. Its function is to wake the device from Sleep at the specified time periods (Wake-Up) to go into Active mode for a short period of time (Display Length), and then return back to Sleep until the set amount of time elapses again. The user has the option to select to wake-up every 15, 30 or 60 seconds; or the user can choose to not wake-up and display the active window. If the user chooses the option None for the wake-up timer, the Display Length value will be equal to 0 and will not display for any amount of time. The Display Length feature is only used in Conserve mode. Its function is to display the active display for a set amount of time of 1, 5 or 10 seconds after waking the device from Sleep.

2.2.2.2 FREQUENCY SETTINGS

Under the frequency settings the user will have the option to choose between four system frequency’s which range over multiple power usage ranges. The user can choose to run the system at: 32 kHz LFINTOSC, 500 kHz MFINTOSC, 4 MHz HFINTOSC or 32 MHz PLL. The demonstration program has been modified to allow on-the-fly change of frequency with unique delay routine and LCD write/erase values to allow best operation.

2.2.2.3 TEMPERATURE SETTINGS

Under the temperature settings the user will have the option to choose to display the temperature or to toggle the temperature standard for the Active mode display. If the user chooses the Display option, then the LCD will display the current temperature reading from the temperature sensor (U3); or by using the POT [R9], the user can see the full range of temperature readings in both Celsius and Fahrenheit temperature standards. If the user selects Type, it will toggle between the Celsius and Fahrenheit options. Whichever standard is selected under the Type option will be displayed on the active display.

2.2.2.4 LCD SETTINGS

Under the LCD settings the user will have the option to choose to toggle the backlight for the LCD or to adjust its brightness. If the user selects Backlight, it will toggle on or off. If the user chooses Save Custom, it will store the current Backlight status into the EEPROM for the custom user preferences. By default the demonstration program is set to ON. Note that by toggling the backlight off will reset the brightness value. If the user selects Brightness, it will allow the user to adjust the backlight brightness using the MCLR (UP) and RB0 (DOWN) buttons. The brightness percentage (0-100) will be displayed on the screen in Active mode.

2.2.2.5 SAVE CUSTOMS SETTINGS

If the user chooses Save Custom, all current custom settings will be written and stored to the on-board EEPROM. These custom settings will be loaded at boot-up for all future uses. These will remain the boot-up settings until Save Custom is selected again. All the default settings are listed in Figure 2-6:

FIGURE 2-6: ALL DEFAULT SETTINGS

Standard	[24-HR]
Wake Up	15 seconds
Display Length	5 seconds
Frequency	4 MHz
Type	Celsius
Duty Cycle	100

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Chapter 3. XLP 8-Bit Development Board Hardware

3.1 INTRODUCTION

This chapter provides a more detailed description of the hardware features of the XLP 8-Bit Development Board.

3.2 HARDWARE FEATURES

The key features of the XLP 8-bit board are listed below. They are represented in the order given in **Section 1.4 "Development Board Features"** and Figure 1-1.

3.2.1 64 and 80 PIC MCU Support

The XLP 8-bit board has been designed to accommodate PIC16 and PIC18 microcontrollers through a Plug-In Module (PIM) containing the microcontroller. A wide variety of 64 and 80-pin microcontroller devices are available on Plug-In Modules through Microchip. It is recommended to check all PIM breakout schematics to the XLP schematics to compare for functionality and feature set.

3.2.1.1 FEATURES AVAILABILITY BY PIC16 AND PIC18 DEVICE FAMILY

The high degree of pin compatibility between PIC16 and PIC18 MCU devices allows both device families to be used with the XLP 8-bit board. However, there are minor differences in pin functionality when migrating from a 64-pin device to a 80-pin device requiring reconfiguration of the board and some features of the board are not available for 64-pin devices.

3.2.2 PIC16 and PIC18 Oscillator Options

The installed microcontroller has two separate oscillator circuits connected. An external oscillator of 10 MHz crystal (Y1) is supplied on board but is not used in the demonstration program. The MCU uses the internal system oscillator in the demonstration program. A second oscillator, using a 32.768 kHz crystal (Y2), functions as the Timer1 oscillator and serves as the source for the RTCC and secondary oscillator.

3.2.3 Power Options

There are (4) methods by which the 8-bit XLP board can be powered.

- USB Cable – Bus power via the USB connector (J11). This provides a nominal 5V power source, regulated to approximately 3.3V for the microcontroller and board components, through a Schottky diode and Low Dropout (LDO) regulator circuit (U2). The green power LED (D5) is illuminated when this power source is used and bus power is present.

Note:	There is no USB data connectivity.

- External Power – An external, regulated DC power supply connected to the V_{DD} SRC and one of the GND test points. Voltage is supplied to the board and microcontroller without voltage drops or voltage regulation; therefore, supply voltage must meet the voltage requirements for the installed PIC16 or PIC18 device. The power LED does not illuminate in this configuration.

- Battery Powered – The user has two options available for using external batteries.
  - Populating jumper J9 allows the user the option of selecting either two AAA batteries or a 3V coin battery.
  - Populating jumper J12 allows the user to choose one of the following options:
    a) one 3V coin battery by populating jumper pins [1-2]
    b) two AAA batteries by populating pins [2-3].

  The power LED does not illuminate in this configuration.
- Harvester – The user also has an option to use any of Microchip's Energy Harvester devices. The supplied demonstration DOES NOT support the use of a Harvester. The power LED does not illuminate in this configuration.

Note: An example program which utilizes the Energy Harvester with the 8-bit XLP Development Board is supplied with the 8-bit XLP Software package.

The included PIC16(L)F1947 operates between 1.8V and 3.6V. The included PIC18F87K22 operates between 1.8V and 5.5V, however for our demonstration program the regulator is disabled, and so the device operates between 1.8V and 3.6V. Refer to the appropriate device data sheet for other devices.

A four-way jumper block, POWER SOURCE SELECT (J8, J9, J10, J11), selects the power supply options. See Table 3-1 for layout.

TABLE 3-1: POWER JUMPERS

Power Source Jumpers	
J8	USB Power
J9	Battery [J12 Used]
J10	External Power
J11	Harvester
J12	Select: - [J9 Used] Coin [1-2]; AAA [2-3]

3.2.4 Component Select Jumpers

It is possible to enable and disable multiple component features on the 8-bit XLP Demonstration board by populating/unpopulating specific jumpers on the board. See Table 3-2 for jumper component configuration.

TABLE 3-2: COMPONENT JUMPERS

Jumper	Function
J4	PIC16 SAP I^2C Pullup
J5	PIC18 SAP I^2C Pullup
J15	MCU Current
J16	Board Current
J19	POT Enable
J20	Select: POT[1-2]; Temp Sensor[2-3]
J27	LEDs
J23	IRQ: INT2 (RB2)
J24	IRQ: INT1 (RB1)
J25	IRQ: INT0 (RB0)

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- J4 – Population of this jumper enables the pull-up resistor for the PIC16(L)F1947 SDA line, RD5, supplied to the Serial Accessory Port (SAP). Dependent upon hardware switch (SW4).
- J5 – Population of this jumper enables the pull-up resistor for the PIC18F87K22 SDA line, RD1, supplied to the Serial Accessory Port (SAP). Dependent upon hardware switch (SW4).
- J15 – Population of this jumper disables the ability to take current measurements from the MCU. It is recommended to connect measurement equipment to the PWR ANALYZER header pins [1 – SRC, 2 – GND], by doing this it is easy to enable/disable current measurement of the MCU.
- J16 – Population of this jumper disables the ability to take current measurements from the board. It is recommended to connect measurement equipment to the PWR ANALYZER header pins [7 – SRC, 6 – GND], by doing this it is easy to enable/disable current measurement of the board.
- J19 – Population of this jumper enables the use of the POT, R9. If left unpopulated, POT will be disabled.
- J20 – Populating this jumper on pins [1-2] will enable ADC readings from the POT. Populating this jumper on pins [2-3] will enable ADC reading from the on board MCP9700 temperature sensor. Leaving this jumper unpopulated will disable the temperature reading feature.
- J23 – Populating this jumper will enable readings for the PICtail™ IRQ from INT2 (RB2). RB2 is not used in the demonstration program, it is recommended to leave this jumper populated.
- J24 – Populating this jumper will enable readings for the PICtail IRQ from INT1 (RB1). RB1 is used in the demonstration program for the SELECT (RB1) button. Populating this jumper will prevent the on-board button switch from working correctly. SELECT (RB1) is used to wake from Sleep and basic functionality of the demonstration program. DO NOT populate this jumper if using the demonstration program.
- J25 – Populating this jumper will enable readings for the PICtail IRQ from INT0 (RB0). RB0 is used in the demonstration program for the DOWN (RB0) button. Populating this jumper will prevent the on-board button switch from working correctly. DOWN (RB0) is used for basic functionality of the demonstration program. DO NOT populate this jumper if using the demonstration program.
- J27 – Populating this jumper will enable the LEDs. The LEDs are not used in the demonstration program.

3.2.5 SAP SDA Select Switch

There is an on-board hardware switch (SW4) included to allow multiple PIC MCU architecture functionality on the board. The switch allows the user to choose if a PIC16 or PIC18 device is being used. By toggling the switch, the user is selecting which pin sends SDA signal to the on-board SAP. It is important to note that even with the switch toggled, jumpers J4 or J5 are still required to be populated, depending upon which device is being used.

3.2.6 User-Defined Switches

Three push buttons switches (SW1/$\overline{\text{MCLR}}$, SW2, SW3) are provided for user-defined digital inputs. They are connected to the I/O pins, $\overline{\text{MCLR}}$/RG5, RB1 and RB0. When pressed, they pull the respective port pin to ground. Using these switches requires that the corresponding pins internal weak pull-ups be enabled. When the switches are not required, the pull-ups can be disabled; this adds the ability to reduce power consumption in software.

3.2.7 User-Defined LEDs

The board features seven green LEDs [D8 – D1] (RA5, RB5, RB4, RE7, RE6, RE5 and RE4) that can serve as user-defined outputs. The LEDs are not used in the demonstration software and, by default, jumper J27 is unpopulated, preventing the LEDs use.

3.2.8 Potentiometer

A 100 kΩ potentiometer (R9) is connected to AN3 for both MCU devices. It can be adjusted from V_{DD} to V_{SS} to provide an analog input voltage to the A/D Converter.

The potentiometer functions to show the full capable range of the temperature display. Its functionality is dependent upon J19 and J20 configuration.

3.2.9 16x2 Character LCD with Controller and Backlight

The board includes the NHD-C0216CZ-FSW-FBW-3V3 from Newhaven Display International. The screen features the ability to write 2 lines x 16 characters, runs at 3 V_{DD} with a 3V backlight display supported by two side White LEDs used for backlight.

3.2.10 Serial EEPROM

A 24AA256 256 KB (32 Kbytes x 8) serial EEPROM (U1) is connected to SPI for both the PIC16(L)F1947 64-pin and PIC18F87K22 80-pin devices. It is used to demonstrate SPI bus operation. It is included for nonvolatile firmware storage, in addition to the internal data EEPROM of the PIC16 and PIC18 devices.

3.2.11 Modular Expansion Connector

The XLP 8-bit board implements a 28-pin modular expansion interface (J21).

This modular expansion is in place to allow use with some PICtail™ interface available on many Microchip demo and development boards. It may not implement the full range of signals supported by some PICtail interfaces; the connector pin assignments for J21 are shown in **Appendix 1. "Development Board Schematics"**. It is recommended users reference the schematic before using a PICtail™ expansion on the board. This additional modular expansion allows the user to incorporate other Microchip demo boards or all expansion of peripheral features through use of the expansion interface.

3.2.12 Serial Accessory Port

The XLP 8-bit board supports the expansion and use of a serial connection. The SAP supports the outputs of (TX, V_{DD}, GND, SDA, SCL, RX) from the SAP header (J2). Through the use of SW4 and J4/J5 the user has the ability to output a signal which can be recognized through UART, SAP, or I^2C™. The type of communication is dependent upon the SAP PROTOCOL switch (S1).

3.2.13 Temperature Sensor

The MCP9700 Low-Power Linear Active Thermistor IC supports a range of -40°C to +125°C and operates between the range of 2.3V and 5.5V, consuming typically 6 uA current when active. The temperature sensor's output is read by the MCU through pin RA3 if jumper J20 is set to pins [2-3].

3.2.14 Generous Prototyping Area

To assist in the development and testing of application hardware, the XLP board includes a 24 x 11 prototype area for the installation of the user's custom circuitry. Sources for the board power V_{DD} and ground are located above the area. Supplied from 19 different I/O signals, the prototyping area supplies a wide range of possible features which can be tested and experimented with from the prototyping area.

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3.2.15 Programming Interfaces

The PICkit header (J3) can be used by either the PICkit™ 2 or PICkit™ 3 programming devices. Through use of the PICkit 3 the user is capable of debugging the included demonstration software or creating and debugging custom software in use with the 8-bit XLP.

3.3 CURRENT MEASUREMENT

An advantage to the XLP 8-bit board is its provisions for in-circuit current measurement. Using simple techniques and equipment, users can experiment directly with low-power hardware and software techniques, then directly measure their current consumption without introducing measurement induced artifacts. This provides a fast method of directly validating power-saving strategies. To make measurements more useful, the development board allows for the measurement of microcontroller current draw and non-microcontroller component current separately.

3.3.1 PIC16LF1947 and PIC18F87K22 Current Measurement

To measure current consumed by the PIC microcontrollers, the VMCU jumper (J15) can be removed and a current measurement cable connected to its pins. This allows the user to empirically evaluate the microcontroller's various low-power features. Since J15 interrupts the microcontroller's V_{DD} path, always be certain to re-install the jumper when measurements are not being taken. To avoid starving the microcontroller's current supply and causing low-power conditions, it may be necessary to switch the ammeter to a higher current range during programming and full-power operation. When the microcontroller is operating in a low-power state, switching to a low range will produce a more accurate measurement.

3.3.2 Development Board Power Measurement

The VBOARD jumper (J16) allows the user to measure the current consumed by the various board components. It also permits the user to experiment with low-power techniques on a variety of commonly used components. Current measurements taken at J16 exclude current consumption from the microcontroller, ICSP™ header and the USB interface. Therefore, communications with a host PC and emulator/programmer connections do not need to be accounted for in determining an accurate current measurement, as they are not included in the first place. Since J16 interrupts the V_{DD} path to the board's other components, always be certain to re-install the jumper when measurements are not being taken.

3.3.3 Ammeter Tool Header

The XLP 8-bit board includes a special 7-pin header (J14) for current measurement. The PIC MCU VMCU and VBOARD jumpers (J15 and J16) ensure continuity of power when connecting or disconnecting a current measurement device. Microchip provides an optional XLP Current Measurement Cable (part number AC002023) as a convenient way of connecting the header to an ammeter.

Note: Since the resistor is placed in series with the PIC MCU V_{DD} pin, the resulting voltage drop may affect power calculations. Ensure calculations are based on *actual* V_{DD}, instead of the supplied board voltage.

NOTES:

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Appendix 1. Development Board Schematics

The following schematic diagrams are included in this appendix:

- Figure 1-1: PIC16LF1947 PIM Breakout
- Figure 1-2: PIC18F87K22 PIM Breakout
- Figure 1-3: Schematic for XLP Development Board (1 of 2)
- Figure 1-4: Schematic for XLP Development Board (2 of 2)

FIGURE 1-1: PIC16LF1947 PIM BREAKOUT

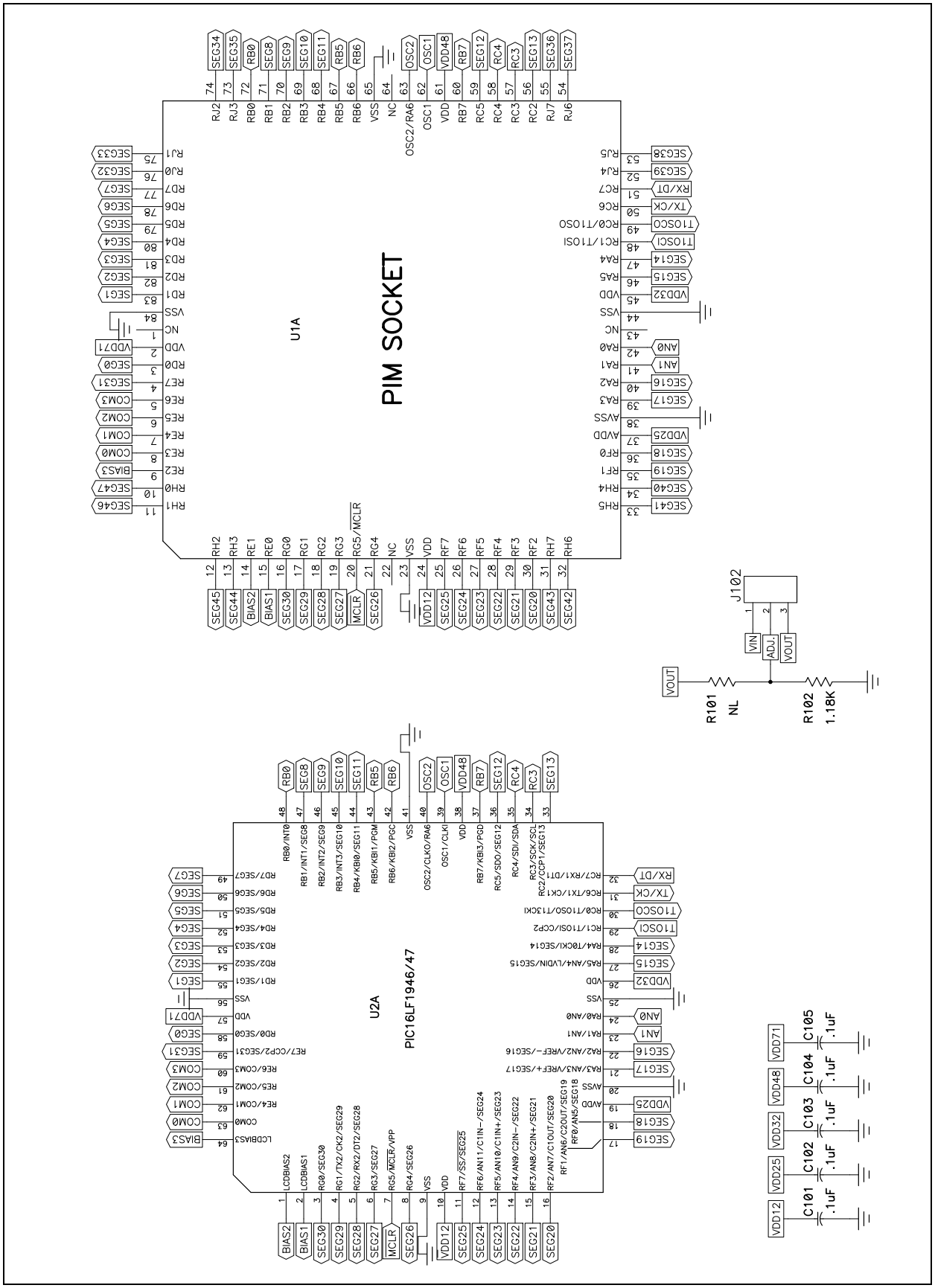

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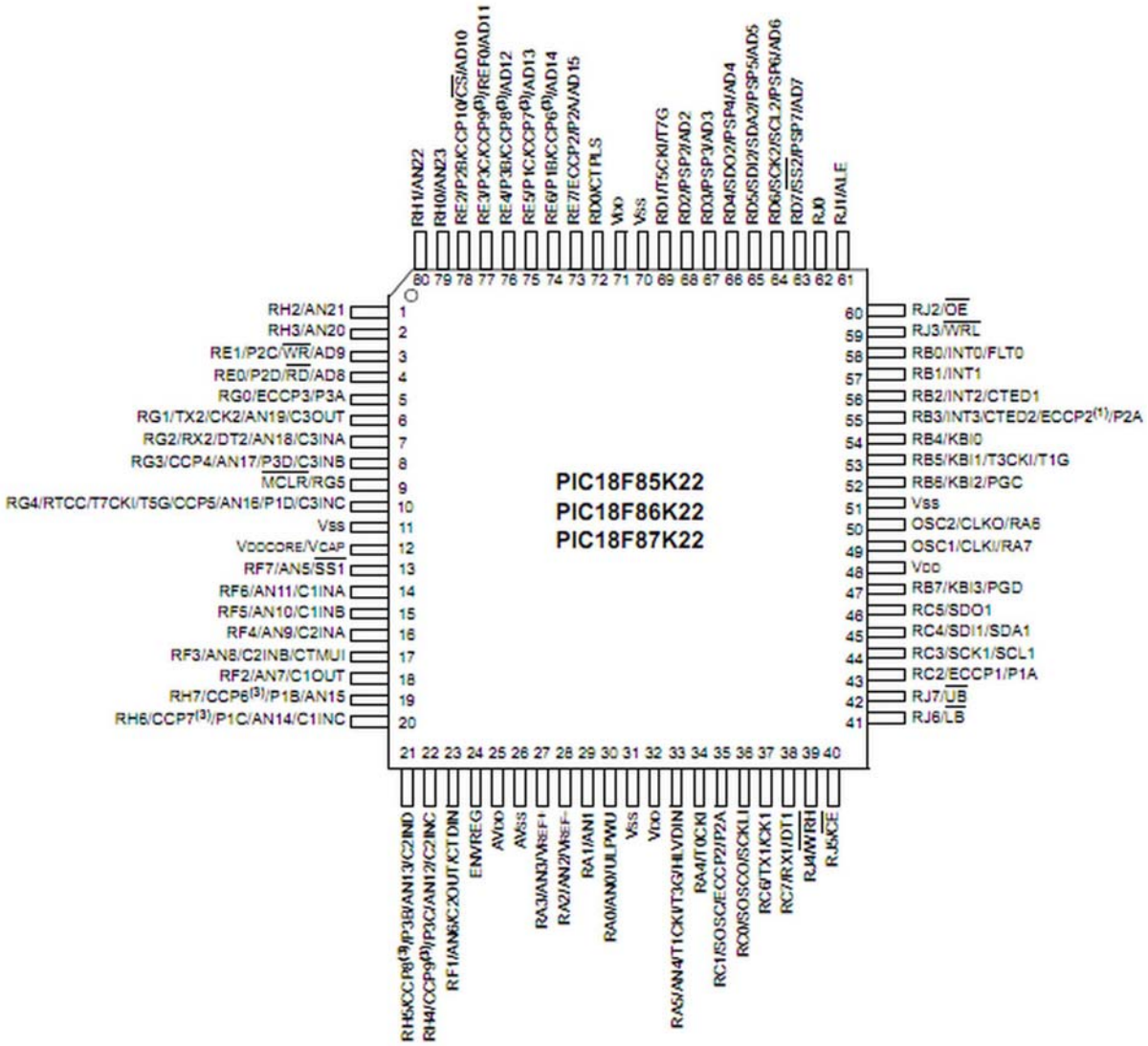
FIGURE 1-2: PIC18F87K22 PIM BREAKOUT



Note 1: The ECCP2 pin placement depends on the CCP2MX Configuration bit setting and whether the device is in Microcontroller or Extended Microcontroller mode.

2: Not available on the PIC18F65K22 and PIC18F85K22 devices.

3: The CC6, CCP7, CCP8 and CCP9 pin placement depends on the setting of the ECCPMX Configuration bit (CONFIG3H<1>).

FIGURE 1-3: SCHEMATIC FOR XLP DEVELOPMENT BOARD (1 OF 2)

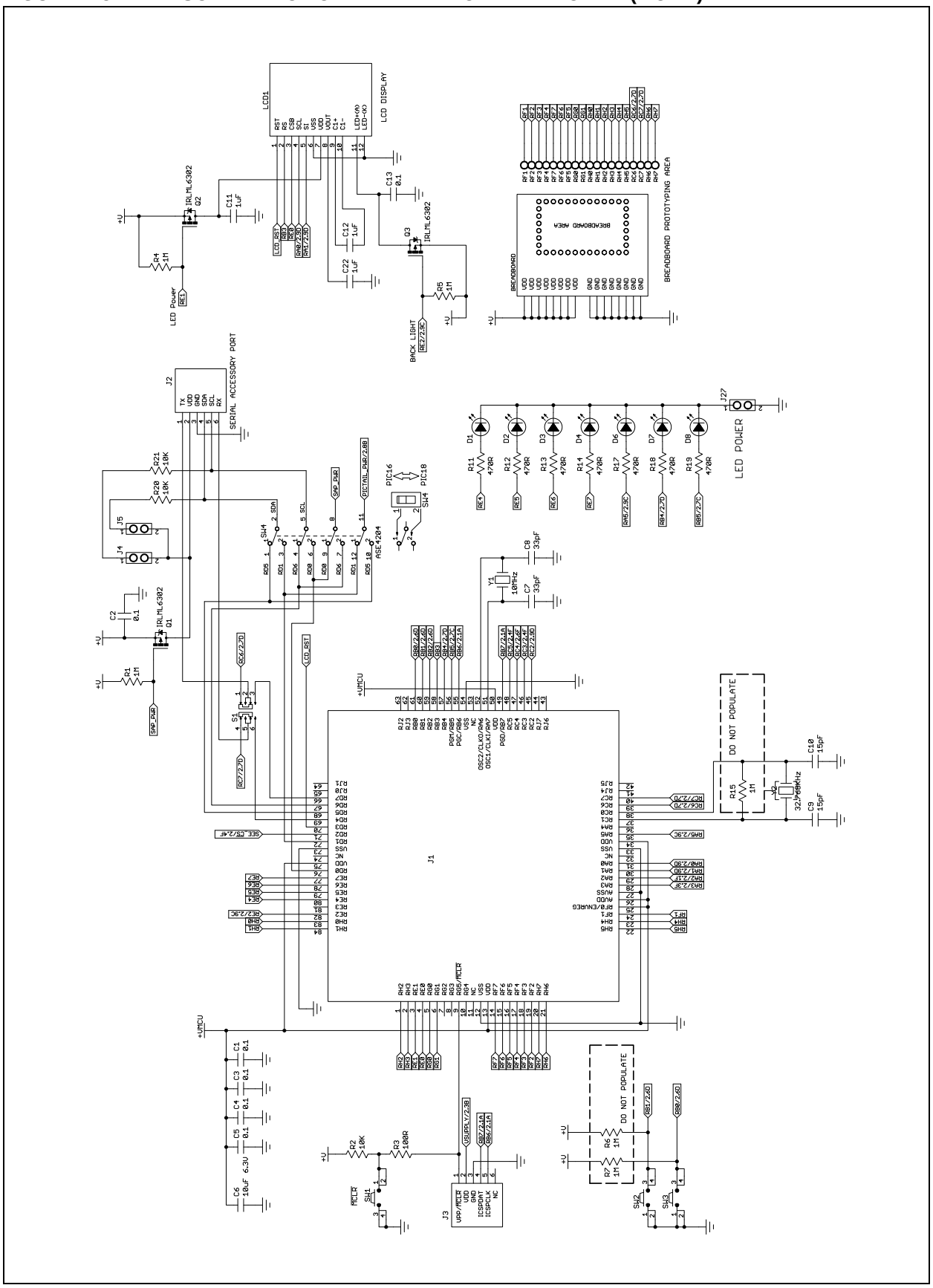


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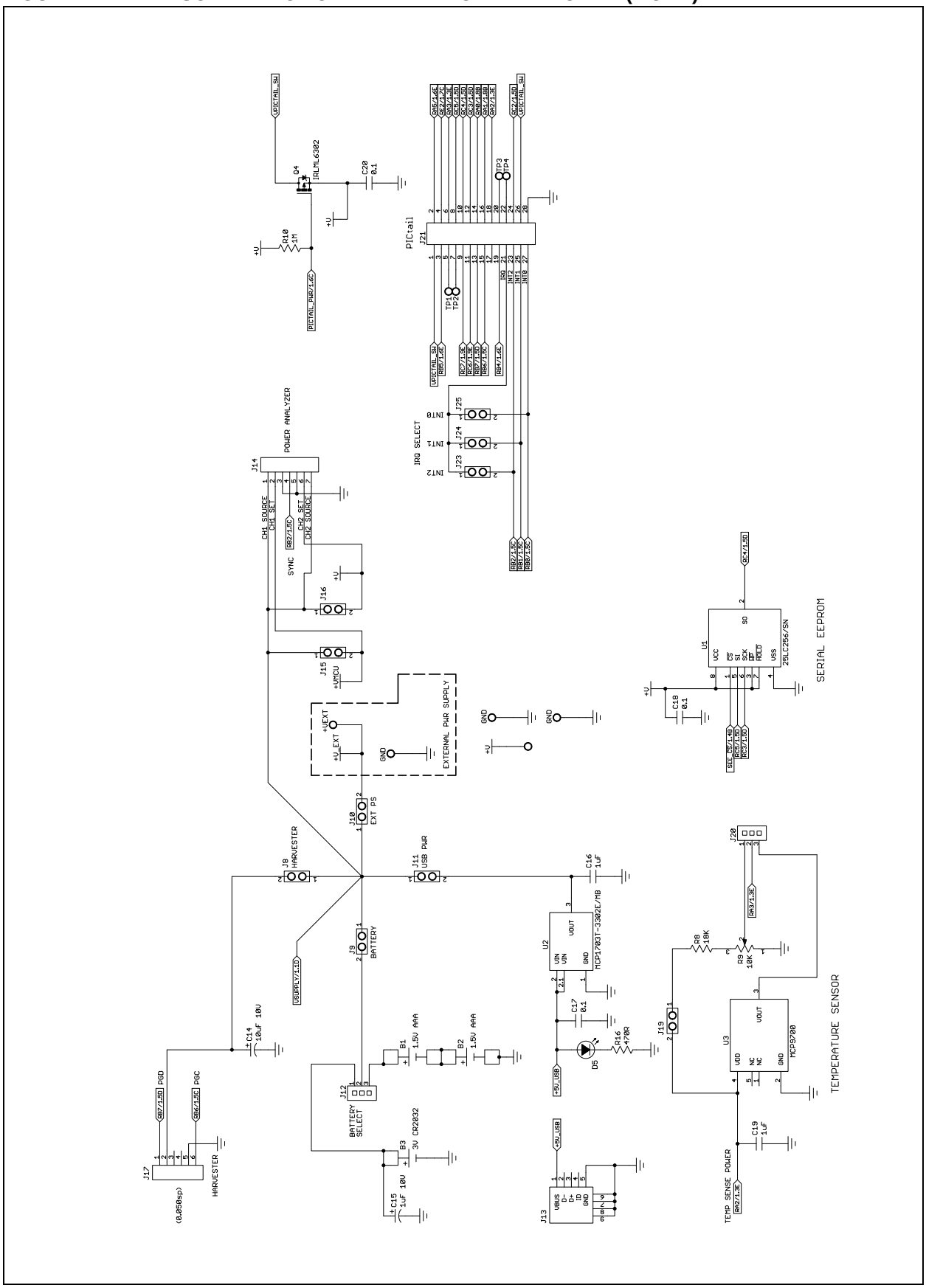
FIGURE 1-4: SCHEMATIC FOR XLP DEVELOPMENT BOARD (2 OF 2)



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