

## chipKIT™ DP32™ Board Reference Manual

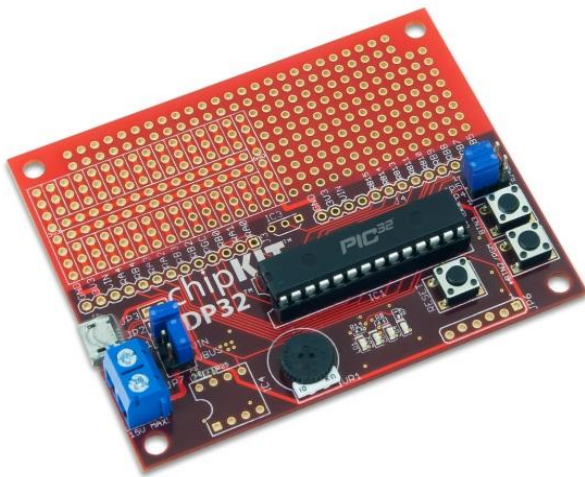
Revised February 13, 2014

This manual applies to the chipKIT DP32 rev. C

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### Overview

The chipKIT DP32 is an MPIDE compatible prototyping and project development board from Digilent. It combines the power of the Microchip® PIC32MX250F128B with a wire wrap prototyping area and provision for an EEPROM non-volatile memory. The chipKIT DP32 has many on board features, including an analog temperature sensor, a potentiometer, buttons, and LEDs. The mounting hole footprint on the board is designed to fit in the Hammond 1591XXSSBK project box.



*The chipKIT DP32 Board.*

- Microchip PIC32MX250F128B microcontroller (40/50 MHz 32-bit MIPS, 128K Flash, 32K SRAM)
- 5 – 12 Volt recommended operating voltage
- 19 available I/O pins
- Up to 9 analog inputs
- 1 Potentiometer connected to an analog input
- Four user LEDs
- Two user push button
- Wire wrap prototype area
- Provision for an SPI EEPROM and an analog temperature sensor
- Mounting Hole compatible with Hammond 1591XXSSBK project box

The DP32 takes advantage of the powerful PIC32MX250F128B microcontroller. This microcontroller features a 32-bit MIPS processor core running at 40 MHz, 128K of flash program memory, and 32K of SRAM data memory. The PIC32MX250F128B is suitable for building projects directly on the board, utilizing the provided prototyping area, but it can also be used as a PIC32MX250F128B programmer to program the microcontrollers for inclusion in custom built projects.

The DP32 can be programmed using the Multi-Platform Integrated Development Environment (MPIDE), an environment based on the open source Arduino™ IDE, modified to support the PIC32 microcontroller. The board provides everything needed to start developing embedded applications using the MPIDE.

The DP32 is also fully compatible with the advanced Microchip MPLAB® IDE and MPLAB® X IDE. To develop embedded applications using MPLAB, a separate In Circuit Serial Programmer (ICSP) such as the Digilent chipKIT PGM or the Microchip PICkit3™, is required.

# 1 Functional Description

The PIC32MX250F12B microcontroller features a 32-bit MIPS processor core capable of running at up to 50 MHz. The DP32 operates the microcontroller at 40 MHz by default. The microcontroller features 128 KB of flash program memory and 32 KB of SRAM data memory. Programming the DP32 can be done using the MPIDE or with the advanced Microchip MPLAB® IDE with the addition of a PICKit3 or chipKIT PGM in-system programmer/debugger.

The DP32 provides 19 I/O pins located on two through-hole header footprints. Some pins share functions with the onboard circuits, such as the on-board 8 MHz oscillator or USB data lines (see the schematic for details). If these peripherals are needed in the design, then the microcontroller can be reconfigured to allow these pins to be utilized for other purposes. Nine of the digital I/O pins are shared with the analog inputs and can be used as analog input pins.

The PIC32MX250F128B microcontroller supports peripheral functions such as UART, SPI, and I<sup>2</sup>C, as well as pulse-width modulated outputs. To use the peripheral functions, the PIC32MX2xx family of microcontrollers features a mappable I/O system called peripheral pin select (PPS), which allows select peripheral functionality to be mapped to multiple pins on the device. The default DP32 MPIDE environment provides a specific mapping of peripheral functions to microcontroller pins. This default pinout can be over-ridden by the user's sketch if a different mapping is desired.

Additional features of the board include an 8-pin DIP header labeled IC4 that is mapped for use with a customer supplied Microchip 25LC256 EEPROM. The SPI bus and power signals are mapped to the correct pins so that the user can solder in an 8-pin dip socket or directly solder the IC into the holes. Similarly, the IC3 header on the board is mapped for a customer supplied Microchip MCP9701A analog temperature sensor.

## 2 chipKIT DP32 Hardware Overview

The DP32 has the following hardware features:

1. **J2 – USB Connector for USB Serial Converter:**  
This connects to a USB port on the PC to provide the communications port for the MPIDE to talk to the DP32 board. This can also be used to power the DP32 when connected to the PC.
2. **JP6 – Microchip Debug Tool Connector:**  
This connector is used to connect ICSP tools, such as the PICKit™3 or Digilent chipKIT PGM. This allows the DP32 board to be used as a traditional microcontroller development board using the Microchip MPLAB® IDE.
3. **J6 – External Power Screw Terminal Connectors:**  
This screw terminal connector may be used to provide up to 15VDC to the DP32. The polarity of the terminals is marked on the silkscreen and must be followed to avoid damaging the board.
4. **JP7 – Power Select Jumper:**  
This jumper may be set to either power the DP32 via USB (J2), or Screw Terminal (J6). To power via USB, set the jumper to short the pins with VIN and VUSB. To power via external supply, short the two pins at JP7.

5. JP1 – USBID Jumper for use with USB OTG:  
This jumper allows Digital I/O pin 0 (RB5) to be disconnected from the USBID line on the USB Port. If JP1 is shorted, pin 0 may not operate as expected. Some users may wish to keep JP1 shorted for USB operations.
6. JP2 and JP3 – D+ and D- USB Signals:  
These jumpers are shipped unloaded. The trace between the two terminals may be cut if USB functionality is required to be permanently disabled. Once the traces have been cut, it is possible to solder jumper pins in these locations to re-enable the D+ and D- signals as desired.
7. IC4 – SPI EEPROM Device (Microchip 25LC256) Loading Point:  
This 8-pin DIP footprint is designed so that a SPI controlled EEPROM device could be added at a later time, if desired. It is intended that an 8-pin DIP socket or a Microchip 25LC256 device would be soldered into this location.
8. VR1 – Analog Potentiometer:  
An analog potentiometer connected to chipKIT analog pin A2. Analog pin A2 is mapped to digital chipKIT pin 8. When rotated fully counter clockwise, 0V is read on the pin. When rotated fully clockwise, 3.3V is read on the pin.
9. User LEDs:  
Four LEDs connected to digital signal pins 11, 12, 13, and 14. An additional power-on LED has been added to the power supply circuit. When using a debugger signal pins 11 and 12 are dedicated to the debugger circuit and therefore cannot be used as LEDs.
10. Reset Button:  
When pressed, the microcontroller resets the currently loaded sketch. If Button 2 (BTN2/PGM) is held down while pressing the reset button, the microcontroller will start from the boot loader, allowing a new sketch to be loaded.
11. BTN2/PGM and BTN3 User Buttons:  
These user buttons are connected to digital signal pins 1 and 17. They produce a logic high signal when depressed, and a logic low signal when released.
12. JP4/JP5 – Pull-up/Pull-down jumpers:  
These jumpers are used to add 2.2KΩ pull-up or pull down resistors to the digital signal pins 2 and 3. Pull-ups are necessary when utilizing I<sup>2</sup>C on these two pins. These two jumpers can be used as settable logic states either pulled high or pulled low, depending on the jumper settings. In addition, if no pull-ups or pull-downs are desired, the jumper may be safely removed completely, allowing the pins to be used for other input/output purposes.
13. IC1 PIC32 Microcontroller:  
The PIC32MX250F128B microcontroller is the main processor for the board.
14. J4 – Digital and Analog I/O Connector #1:  
The set of Digital I/Os with chipKIT numbers 0 through 8 and Analog pins A0-A2. See table 1 in appendix A for more details.
15. IC3 – Analog Temperature Sensor (Microchip MCP9701A) Loading Point:  
This 3-pin footprint is intended for an analog temperature sensor to be loaded by the user. It was designed with the Microchip MCP9701A Linear Active Thermistor in mind. The pin one (square pin) is for VCC3V3 of the device, pin two (center pin) is for the A0/pin 6 pin of the device, and pin three is for the ground pin (chipKIT pin 6).

16. J3 – Digital and Analog I/O Connector #2:  
The set of Digital I/Os with chipKIT numbers 9 through 18 and Analog pins A3-A8. See table 1 in appendix A for more details.
17. Prototyping Area:  
This area may be used to prototype any desired hardware designs using standard wire wrapping methods.

## 3 Programming the chipKIT DP32

### 3.1 MPIDE Development Tool

The DP32 uses the PIC32MX250F128B onboard USB peripheral to program the microcontroller with the MPIDE environment. This requires a driver to be installed to accommodate this programming solution. The driver file is called Stk500v2.inf and is available in the driver's folder in the MPIDE distribution.

Once the driver is installed and the computer has recognized the board, it is ready to be programmed. The board has two modes of operation. The first is the bootloader mode, to enter this mode you must press and hold down BTN2/PGM button while the PGM button is depressed press and release the RESET button, finally release the PGM button to place the board into program mode. In program mode, LD1 will flash to show you that the bootloader is running and the board is ready to be programmed.

Once the board is programmed, it will execute the programmed sketch. If there is a sketch loaded on the board and you cycle power to the board, it will automatically reenter sketch mode. To exit sketch mode, you must put the board into program mode as described in the above paragraph.

Since the board resets between program mode and sketch mode the serial port will disconnect and then reconnect. The MPIDE serial monitor will not work unless there is a delay of at least 5 seconds in the user sketch before it begins to send data to the computer. To ensure the serial monitor is ready, it is recommended that users watch the device manager or similar program for your OS after the reset to watch for the reconnection of the serial port before attempting to open the Serial Monitor in MPIDE. The delay is required for proper operation of the serial port so that the board can disconnect and reconnect to the computer before the DP32 begins sending data out while the OS is not listing. This is a byproduct of the embedded USB controller solution on the DP32.

### 3.2 Microchip MPLAB IDE and MPLAB X IDE Development Tool Compatibility

In addition to being compatible with the MPIDE, the DP32 board can be used as a more traditional microcontroller development board using Microchip Development Tools.

The unloaded connector JP6 on the right side of the board is used to connect to a Microchip development tool, such as the PICkit3 or the Digiilent chipKIT PGM. The holes for JP6 are staggered so that a standard 100-mil spaced 6-pin header can be press fit to the board without the need to solder it in place. Any hardware programmer can be used provided it uses the same 6-pin interface as the PICkit3.

Typically, a right-angle male connector is used in JP6 so that a PICkit3 can be attached coplanar with the DP32 board. The connector can be loaded from the top, or it can be loaded from the bottom.

The Microchip MPLAB® IDE or the MPLAB® X IDE can be used to program and debug code running on the DP32 board. These tools can be downloaded from the Microchip website.

Using the Microchip development tools to program the DP32 board will cause the boot loader to be erased. To use the board with the MPIDE again, it is necessary to program the bootloader back onto the board. The boot loader image can be downloaded from the DP32 product page on the Digiilent website.

## 4 chipKIT DP32 Jumper Settings

### JP1 USBID Connect (USB OTG)

Loaded: USBID is connected to Digital I/O pin 0 (RB5) and is usable by the microcontroller.

Unloaded: Pin 0 is unconnected to USBID and freely usable.

### JP2 USB Data+

### JP3 USB Data-

For most users, these traces should be left uncut. Cutting the trace will remove the ability to program the microcontroller from the USB Port. Users may optionally add jumper pins and a shorting block to restore the original functionality of the DP32 if the traces have been cut.

### JP4/JP5

Default configuration is with the shorting blocks loaded on pins 1 and 2, which results in pull-up configuration. Shorting pins 2 and 3 results in pull-down operation. Users may choose to remove shorting blocks entirely if no pull-up/pull-down settings are desired.

### JP7 Power Select Jumper

Default power is selected with the shorting block connecting the two pins labeled VBUS, providing power from the USB connector. If external power is desired, connect the two pins labeled VIN.

## 4.1 Power Supply

The DP32 is designed to be powered either via USB or from an external power supply. Only one supply should be selected at a time. A power-on LED has been added to the power supply circuit.

The DP32 has a single voltage regulator which regulates either 5V from USB to 3.3V, or a maximum of 15V external voltage to 3.3V. The 3.3V regulator is a Microchip MCP1703. This regulator is rated for a maximum output current of 250mA. The absolute maximum input voltage for the MCP1703 is 16V. This regulator has internal short circuit protection as well as thermal protection. It will get noticeably warm when the current consumed by the VCC3V3 bus is close to the 250mA maximum.

## 4.2 5V Compatibility

The PIC32 microcontroller operates at 3.3V. There are two issues to consider when dealing with 5V compatibility for 3.3V logic. The first is protection of 3.3V inputs from damage caused by 5V signals. The second is whether the 3.3V output is high enough to be recognized as a logic high value by a 5V input.

Only MIPDE pin numbers 0 - 3 on the PIC32 microcontroller are 5V tolerant, all other pins are 3.3V tolerant only. To provide 5V tolerance on those pins, you will have to add clamping diodes and current limiting resistors to those pins. Please check the table 1 in appendix A to confirm 5V tolerant pins.

The minimum high-voltage output of the PIC32 microcontroller is rated at 2.4V when sourcing 12mA of current. When driving a high impedance input (typical of CMOS logic), the output high voltage will typically be close to 3.3V. Some 5V devices will recognize this voltage as a logic high input, and some will not. You will have to read the datasheet for the 5V parts you are using to ensure that 3.3V will satisfy the logic high conditions for the part. Many 5V logic devices will work reliably with 3.3V inputs.

## 4.3 Input/Output Connections

The DP32 board provides all 19 I/O pins of the PIC32MX250F128B microcontroller to through-hole points on the PCB.

The PIC32 microcontroller can source 10mA with a minimum V<sub>OH</sub> of 3V and sink 15mA with a maximum V<sub>OL</sub> of .4V on all digital I/O pins. The maximum current that can be sourced or sunk across all I/O pins simultaneously is +/- 200mA. For more detailed specifications, refer to the PIC32MX1XX/2XX Data Sheet available from the Microchip web site.

The DP32 uses logical pin numbers to identify digital I/O pins. Pins 0 through 8 are located on J4, counting up from the square pad of J4. Pins 9 through 18 are located on J3, counting up from the square pad. In addition, several of these I/O pins share functionality with other devices on the board. See table 1 in appendix A for more information.

Pins 15 and 16 are shared with the crystal for the internal oscillator, and are not typically usable. Pin 6 is shared with the Analog Temperature Sensor. Pin 8 is shared with the onboard Potentiometer. Pins 4 and 5 are shared with the USB Data+ and Data- signals. Pin 0 is shared with the USBID function, but removing jumper 1 clears this conflict. Pins 9, 18, 7, and 10 are used for the SPI EEPROM device if it is loaded, on its Chip Select, Master Out/Slave In, Serial Clock, and Master In/Slave Out lines respectively.

In addition to the digital I/O, there are Analog inputs available on the board, called A0 through A8. These pins are shared on digital pins 6 through 14.

## 4.4 Peripheral I/O Functions

I<sup>2</sup>C: Synchronous serial interface. The I2C1 interface is available on pins 2 and 3. When using the I<sup>2</sup>C interface, it is necessary to set JP4 and JP5 such that pull-ups are present on the bus. This is accomplished by moving the jumpers to pins 2 and 3 on each jumper, the default setting.

User LEDs: Pins 11 (LD4), 12 (LD3), 13 (LD2), and 14 (LD1) are shared between the through-hole connection and the LED. Driving the pin high turns the LED on, driving it low turns it off.

User Buttons: Pins 1 (BTN2/PGM) and 17 (BTN3) are shared between a through-hole connection and a push button. Pushing the button drives the input high. Releasing it brings the input low.

External Interrupts: Only INT0 is hard-mapped on the microcontroller. It is connected to pin 1. The other external interrupts are accessible via PPS described below.

Reset: The Reset button is utilized to bring the MCLR pin low on the microcontroller, thus restarting the currently loaded sketch. If the user wishes to reprogram the device, refer to section 3.1 for program mode instructions.

## 4.5 Peripheral Pin Select

An advanced feature of the PIC32MX1xx/2xx family of microcontrollers is the ability to re-map the locations of peripheral devices. MPIDE does the default mapping.

## PPS Assigned Peripherals:

- Output Compare: Pin 8 (OC1), Pin 2 (OC2), Pin 3 (OC3), Pin 13 (OC4), Pin 6 (OC5). Output compare allows for the implementation of PWM signals.
- Input Capture: Pin 6 (IC1), Pin 11 (IC2), Pin 2 (IC3), Pin 14 (IC4), Pin 13 (IC5). Input capture allows for the synchronization of timers with captured signals, along with the execution of interrupts.
- External Timer Input: Pin 18 (TCK1), Pin 14 (TCK2), Pin 12 (TCK3), Pin 6 (TCK4), Pin 3 (TCK5) allows for timers to be clocked from external sources.
- External Interrupt: Pin 3 (INT1), Pin 13 (INT2), Pin 2 (INT3), Pin 17 (INT4). Allows for external interrupts to be triggered in their own ISRs. Interrupts may be edge triggered or level triggered, though only one of rising, falling, high, or low, may be chosen for trigger sensitivity.
- Change Notice Pins: All change notice pins are matched with their chipKIT pin numbers (e.g. CN0 is associated with Pin 0). There is a change notice pin for each I/O pin.
- UART: Pin 14 (U1TX), Pin 6 (U1RX), Pin 7 (U2TX), and Pin 10 (U2RX) are used to implement UART peripheral controls. Unlike other chipKIT boards, the USB Serial communication is not implemented using a UART controller.
- SPI: Synchronous serial port. Pin 9 (SS), Pin 18 (MOSI), Pin 7 (SCK), Pin 10 (MISO). This uses SPI1 on the PIC32 Microcontroller. The second SPI is implemented as Pin 14 (SS), Pin 2 (MOSI), Pin 13 (MISO), and Pin 8 (SCK).

## Appendix A: Pinout Tables

### Table 1: Pinout Table by chipKIT Pin Number

chipKIT Pin #	Connect or Pin #	Pic32 Pin #	PIC32 Signal	Notes
0 *	RB5	14	TMS/RPB5/USBID/RB5	USBID w/ JP1 short
1 *	RB7	16	TDI/RB7/CTED3/PMD5/INT0/RB7	BTN3
2 *	RB8	17	TCK/RPB8/SCL1/CTED10/PMD4/RB8	PU/PD w/ JP5
3 *	RB9	18	TDO/RPB9/SDA1/SCTED4/PMD3/RB9	PU/PD w/ JP6
4	RB10	21	PGED2/RPB10/D+/CTED11/RB10	USB Data+
5	RB11	22	PGEC2/RPB11/D-/RB11	USB Data-
6/A0	RB13	24	AN11/RPB13/CTPLS/PMRD/RB13	Analog Temp Pin A0
7/A1	RB14	25	CVREF/AN10/C3INB/RPB14/VBUSON/SCK1/CTED5/RB14	IC4 – Serial Clock
8/A2	RB15	26	AN9/C3INA/RPB15/SCK2/CTED6/PMCS1/RB15	Dial Pot – Pin A2
9/A3	RA0	2	PGED3/VREF+/CVREF+/AN0/C3INC/RPA0/CTED1/PMD7/RA0	IC4 – Chip Select
10/A4	RA1	3	PGEC3/VREF-/CVREF-/AN1/RPA1/CTED2/PMD6/RA1	IC4 – Serial Out
11/A5	RB0	4	PGED1/AN2/C1IND/C2INB/C3IND/RPB0/PMD0/RB0	LD4
12/A6	RB1	5	PGEC1/AND3/C1INC/C2INA/RPB1/CTED12/PMD1/RB1	LD3
13/A7	RB2	6	AN4/C1INB/C2IND/RPB2/SDA2/CTED13/PMD2/RB2	LD2
14/A8	RB3	7	AN5/C1INA/C2INC/RTCC/RPB3/SCL2/PMWR/RB3	LD1
15	RA2	9	OSC1/CLKI/RPA2/RA2	8 MHz Clock In
16	RA3	10	OSC2/CLKO/RPA3/PMA0/RA3	8 MHz Clock Out
17	RB4	11	SOSCI/RPB4/RB4	BTN4
18	RA4	12	SOSCO/RPA4/T1CK/CTED9/PMA1/RA4	IC4 – Serial In

\*Pins are 5v Tolerant



Table 2: Pinout Table by Socket Pin

Socket Pin #	chipKIT Pin #	Connector Pin #	PIC32 Signal	Notes
1 *	-	-	nMCLR	Reset Button Circuit
2	9/A3	RA0	PGED3/VREF+/CVREF+/AN0/C3INC/RPA0/CTED1/PMD7/RA0	IC4 – Chip Select
3	10/A4	RA1	PGEC3/VREF-/CVREF-/AN1/RPA1/CTED2/PMD6/RA1	IC4 – Serial Out
4	11/A5	RB0	PGED1/AN2/C1IND/C2INB/C3IND/RPB0/PMD0/RB0	LD4
5	12/A6	RB1	PGEC1/AND3/C1INC/C2INA/RPB1/CTED12/PMD1/RB1	LD3
6	13/A7	RB2	AN4/C1INB/C2IND/RPB2/SDA2/CTED13/PMD2/RB2	LD2
7	14/A8	RB3	AN5/C1INA/C2INC/RTCC/RPB3/SCL2/PMWR/RB3	LD1
8	-	GND	VSS	
9	15	RA2	OSC1/CLKI/RPA2/RA2	8 MHz Clock In
10	16	RA3	OSC2/CLKO/RPA3/PMA0/RA3	8 MHz Clock Out
11	17	RB4	SOSCI/RPB4/RB4	BTN4
12	18	RA4	SOSCO/RPA4/T1CK/CTED9/PMA1/RA4	IC4 – Serial In
13	-	VDD	VDD	
14 *	0	RB5	TMS/RPB5/USBID/RB5	USBID w/ JP1 short
15 *	-	VBUS	VBUS	
16 *	1	RB7	TDI/RB7/CTED3/PMD5/INT0/RB7	BTN3
17 *	2	RB8	TCK/RPB8/SCL1/CTED10/PMD4/RB8	PU/PD w/ JP5
18 *	3	RB9	TDO/RPB9/SDA1/SCTED4/PMD3/RB9	PU/PD w/ JP6
19	-	GND	VSS	
20	-	-	VCAP	
21	4	RB10	PGED2/RPB10/D+/CTED11/RB10	USB Data+
22	5	RB11	PGEC2/RPB11/D-/RB11	USB Data-
23	-	-	VUSB3V3	
24	6/A0	RB13	AN11/RPB13/CTPLS/PMRD/RB13	Analog Temp Pin A0
25	7/A1	RB14	CVREF/AN10/C3INB/RPB14/VBUSON/SCK1/CTED5/RB14	IC4 – Serial Clock
26	8/A2	RB15	AN9/C3INA/RPB15/SCK2/CTED6/PMCS1/RB15	Dial Pot – Pin A2
27	-	-	AVSS	N/C
28	-	-	AVDD	

\*Pins are 5V Tolerant