AN3329

VBAT Emulation Using PIC24F eXtreme Low-Power Microcontrollers

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INTRODUCTION

This document describes how to switch between the main power supply and battery backup (VBAT) in devices that do not support on-chip VBAT capability. The methods to achieve VBAT emulation using some of the Core-Independent Peripherals (CIPs) available on the PIC24F eXtreme Low-Power (XLP) microcontrollers and a few external passive components are described in this document. The proposed VBAT Emulation modes offer a comparable low-power performance, while adding minimal cost, and can be implemented with any of the PIC24F XLP microcontrollers.

This document considers applications having two sources of power:

- Main power
- Backup power

In most situations, an application makes use of the main power. The main power is the power supply that sources the current required to run the entire application. In the absence of main power, backup power acts as a secondary source. Backup power can be a battery, coin cell, super capacitor or another power source.

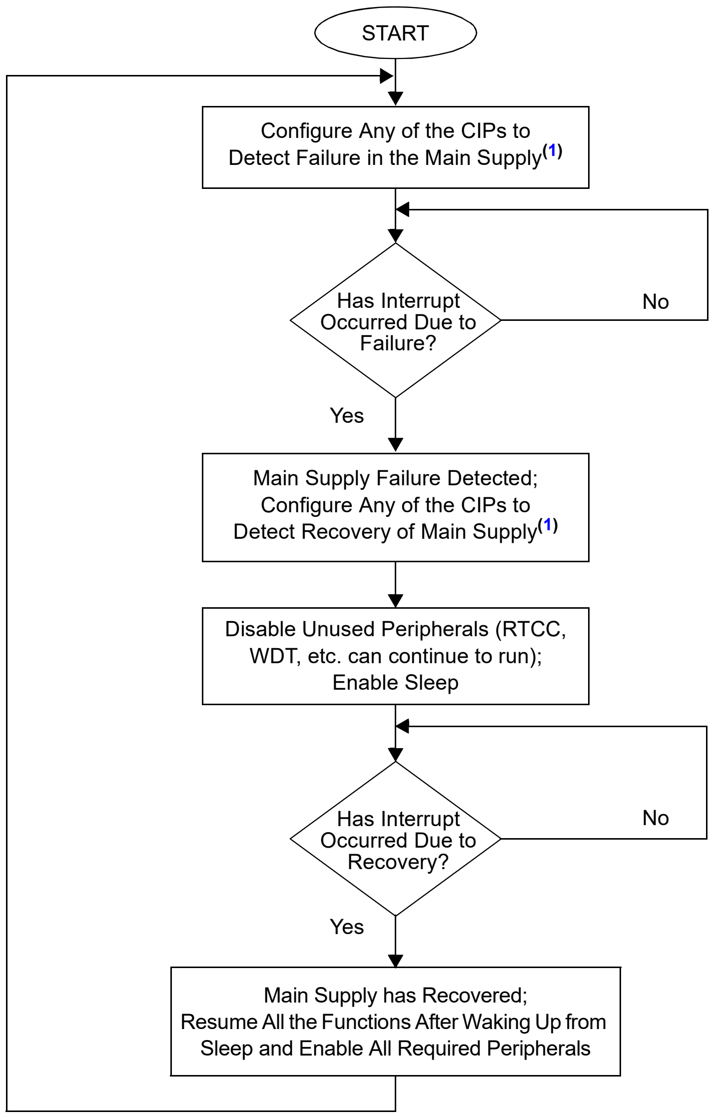
Emulated VBAT offers several benefits:

- Flexibility to keep more than just RTCC and backup registers operational.
- Uses CIPs for the emulation that are functional in power-saving modes without any core intervention.
- Increases flexibility when selecting an ideal microcontroller from a large portfolio of PIC24F microcontrollers based on application needs.

The user application should monitor the state of the main supply voltage. The main supply health can be monitored using various peripherals available on the device in a core-independent manner, such as High/Low-Voltage Detect (HLVD), interrupt-on-change, ADC with Threshold Detect, Comparator, etc. The hardware should have a provision to switch to the backup source, on detection of main supply failure. In Emulated VBAT mode, it is advisable to put the CPU in Sleep mode for increased power savings. The user application can configure peripherals, such as RTCC and WDT, to function in VBAT mode when needed, while the rest of the peripherals are shut off. This ensures maximum power conservation in VBAT mode to extend the battery life.

A high-level flow of the process is shown in Figure 1.

FIGURE 1: VBAT EMULATION PROCESS



Note 1: Refer to the different methods mentioned in the following sections to configure the required Core-Independent Peripheral that aids in power supply monitoring.

Different possibilities of implementing emulated VBAT are proposed in this document. Depending on the application, one or more methods can be combined to implement VBAT emulation.

The criteria to consider when selecting a method to implement VBAT emulation are:

1. When the exact voltage levels of the main supply and/or backup supply are known, HLVD and ADC can be used to detect main supply failure/recovery.
2. When there is immediate power loss, rather than a gradual discharge of main power, interrupt-on-change can be used.
3. Power consumption of peripheral in the power-saving mode.

MONITOR MAIN SUPPLY

Method 1: Using HLVD

Configurable High/Low-Voltage Detection (HLVD) can be used to detect the drop/rise in the VDD. The threshold can be set based on the main supply and backup supply voltage levels. For example, to detect failure in the main power supply, set the HLVD threshold (VHLVD) value to a value less than the main supply voltage and configure an HLVD interrupt to assert when VDD < VHLVD. Similarly, recovery of the main supply can be detected when VDD > VHLVD and will assert an interrupt to wake up the device from the power-saving mode. Voltage direction can be configured to detect if the VDD is above or below threshold.

This method does not require any additional I/O requirement with respect to the device (Figure 2). Also, there are different threshold options available. HLVD, being a CIP, requires minimal CPU intervention for loss detection and recovery of main supply (Figure 3).

For more information on HLVD, refer to **"High-Level Integration with Programmable High/Low-Voltage Detect (HLVD)"** (www.microchip.com/DS39725) in the *"dsPIC33/PIC24 Family Reference Manual"*.

FIGURE 2: CIRCUIT FOR MAIN SUPPLY MONITOR USING HLVD

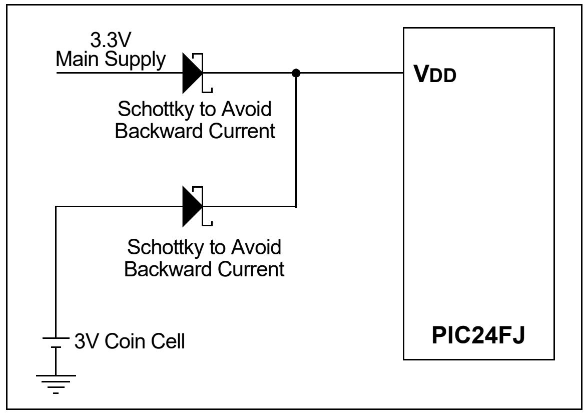
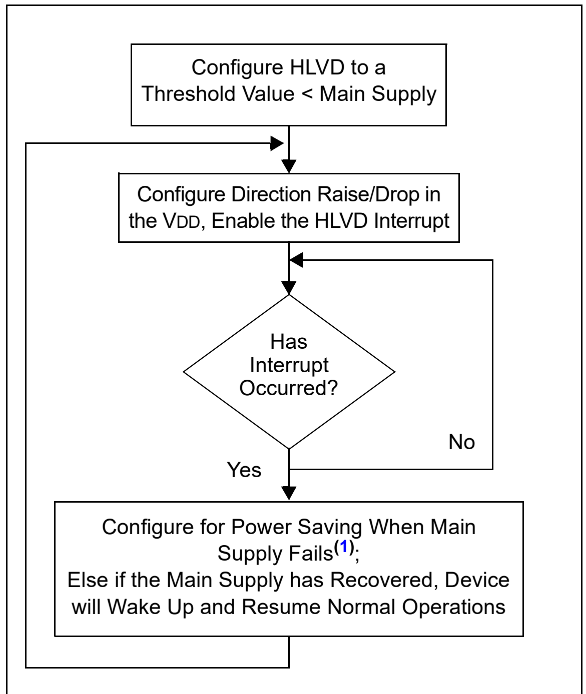


FIGURE 3: MONITORING MAIN SUPPLY USING HLVD



Note 1: Refer to the **"Power Saving"** section.

Method 2: Using Interrupt-on-Change

Interrupt-on-change can be used to detect loss in the main supply. Any I/O can be configured to detect a drop in the main supply. The positive/negative edge trigger on an I/O can be configured to detect failure/recovery of the main supply. An interrupt-on-change interrupt will be enabled, thus the CPU intervention is not required.

This method does not require any additional peripherals, so additional power consumption is avoided. However, an additional I/O is required for loss detection and recovery of the main supply (Figure 4). This method can be used when there is immediate (total) power loss rather than a gradual discharge of power (battery) (Figure 5).

For more information on interrupt-on-change, refer to **"I/O Ports with Interrupt-on-Change (IOC)"** (www.microchip.com/DS70005186) in the *"dsPIC33/PIC24 Family Reference Manual"*.

FIGURE 4: CIRCUIT FOR MAIN SUPPLY MONITOR USING IOC

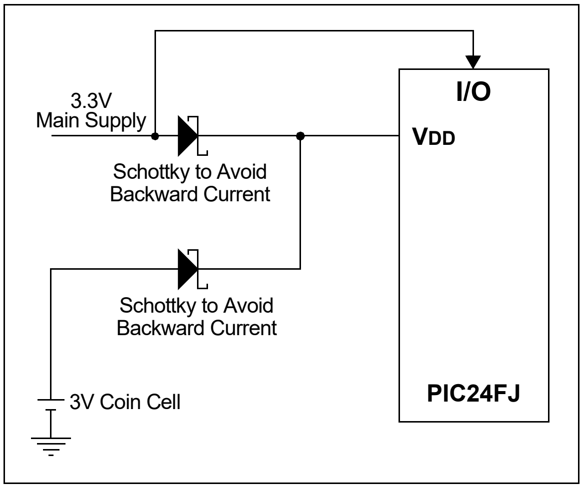
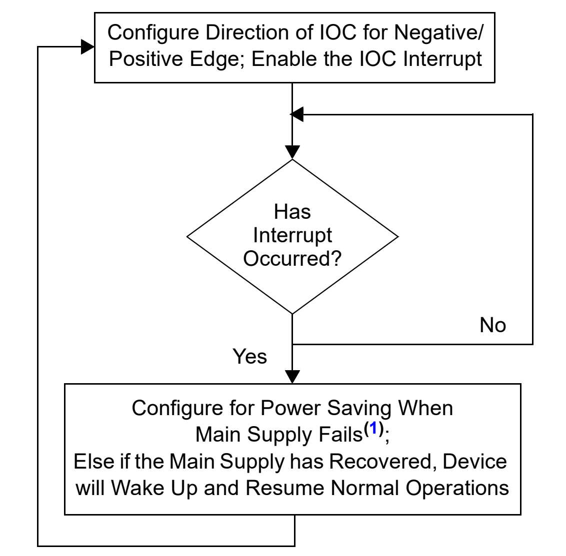


FIGURE 5: MONITORING MAIN SUPPLY USING IOC



Note 1: Refer to the **"Power Saving"** section.

Method 3a: Using ADC

The ADC can be used to measure the Band gap voltage to detect loss in the main supply on devices that have external VREF+ pins. The main supply is connected to VREF+, as shown in Figure 6. The main supply voltage can be calculated by measuring the band gap voltage and used to determine if the main supply has fallen below some predetermined threshold.

To check if the main supply has recovered, the device should wake up from the power-saving mode at the regular interval. A timer configured to run in power-saving mode can be used to wake up the device and measure the main supply (Figure 7).

By using this method, the main supply voltage can be measured more accurately.

FIGURE 6: CIRCUIT FOR MAIN SUPPLY MONITOR USING ADC

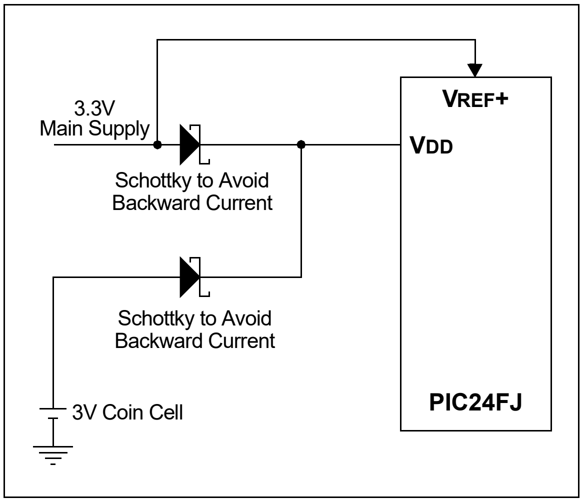
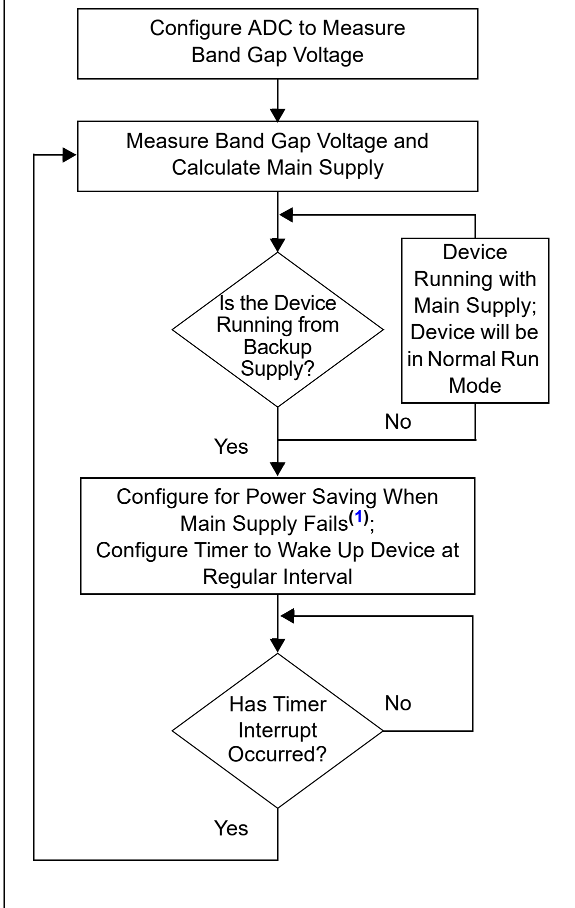


FIGURE 7: MONITORING MAIN SUPPLY USING ADC



Note 1: Refer to the **"Power Saving"** section.

Method 3b: Using ADC Threshold Detect

The Threshold Detect feature in the ADC can be used to detect loss in the main supply. A timer can be configured to trigger the ADC in Sleep to sample and convert. The ADC module will keep monitoring the ADC channel (Figure 8) in a core-independent manner. The threshold value must be set much lower than the main supply voltage. When the measured ADC value goes below the threshold, an interrupt will be asserted, indicating there is loss of power in the main supply.

In order to determine if the main supply has recovered, a threshold value which will indicate the recovery of the main supply can be set. When the measured ADC value goes above the threshold, an interrupt will be generated which will wake up the device from power saving mode.

ADC can continue to run in Low-Power mode when the internal ADC RC oscillator is selected as its clock source. Also, the timer that triggers the ADC should be configured to run in power-saving mode.

This method can be used when there is immediate (total) power loss, rather than a gradual discharge of power (battery). (See Figure 9.)

For more information on ADC Threshold Detect, refer to **"12-Bit A/D Converter with Threshold Detect"** (www.microchip.com/DS39739) in the *"dsPIC33/PIC24 Family Reference Manual"*.

FIGURE 8: CIRCUIT FOR MAIN SUPPLY MONITOR USING ADC THRESHOLD

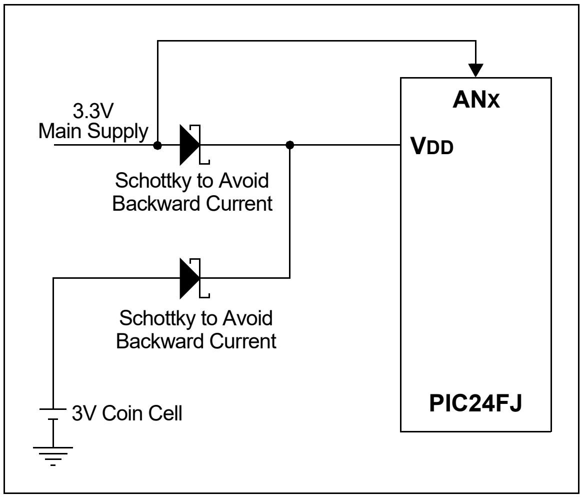
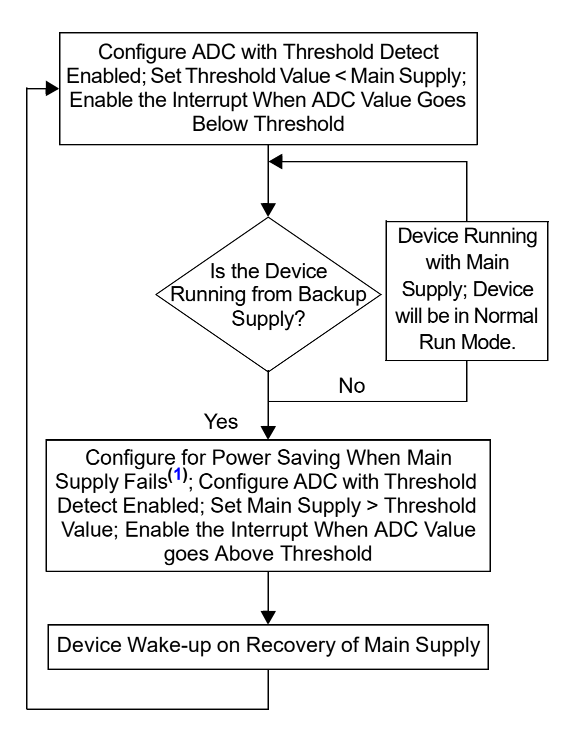


FIGURE 9: MONITORING MAIN SUPPLY USING ADC THRESHOLD



Note 1: Refer to the **"Power Saving"** section.

Method 4: Using the Comparator

The comparator can be used to detect loss of the main power supply, with the comparator inverting and noninverting input terminals connected as shown in Figure 10. The comparator interrupt is configured to generate an interrupt on any change in the comparator output.

The comparator is also a CIP; minimum CPU intervention is required for loss and recovery detection of the main supply (Figure 11).

For more information on the comparator, refer to **"Scalable Comparator Module"** (www.microchip.com/DS39734) in the *"dsPIC33/PIC24 Family Reference Manual"*.

FIGURE 10: CIRCUIT FOR MAIN SUPPLY MONITOR USING COMPARATOR

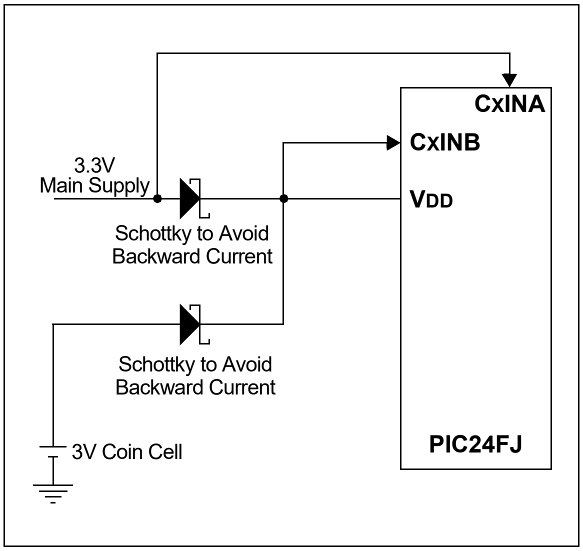
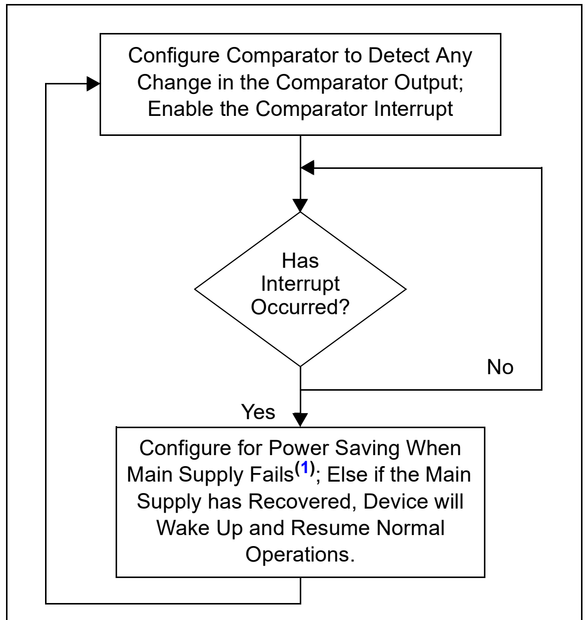


FIGURE 11: MONITORING MAIN SUPPLY USING COMPARATOR



Note 1: Refer to the **"Power Saving"** section.

POWER SAVING

In VBAT mode, the user application should use minimum hardware resources/peripherals required for the application. The user application can configure peripherals, such as RTCC and WDT "Active/Run", in VBAT when needed. All other peripherals that are not necessary should be turned off to ensure less power is consumed in VBAT mode and to extend the battery life. Power consumption of the PIC24F device can be reduced by entering Low-Power modes (Sleep or Retention Sleep).

For more information on power saving, refer to **"Power-Saving Features with Deep Sleep"** (www.microchip.com/DS39727) in the *"dsPIC33/PIC24 Family Reference Manual"* and the *"eXtreme Low-Power (XLP) PIC® Microcontrollers: An introduction to Microchip's Low-Power Devices"* Application Note (www.microchip.com/DS00001267).

CONCLUSION

VBAT functionality can be easily emulated with minimal external components by using various Core-Independent Peripherals available to detect failure/recovery of the main supply and power-saving features in the device. These features offer greater flexibility for an application to keep more than just RTCC and backup registers operational. Using CIPs for the emulation, which are functional in power-saving modes, helps offload the CPU and extend the battery life.

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