

# LPM Registers Definition

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## Requirements

#	Requirement	Design Input	Design Output	Validation
	The firmware should be update-able through I2C supporting a dual bank mechanism			
	During an update, the firmware should ensure the bank B is valid before to jump the code and should fallback if anything abnormal occurs			
	The power mode should be implemented following the state diagram in the SkyHawk Hardware Platform v2.0 (page 15)			
	The LPM should allow to configure VIN threshold			
	The LPM should manage the battery charging	If Vin is present, the charge should be enable		
	The LPM should do the GPS external antenna auto-detection			
	All the configuration registers should be saved in flash so when the device reboots the CPU do not need to reconfigure the settings			

## Registers

## **[0x00-0x0E] - Firmware Version**

Register to read firmware version (String). When you issue a read command, simply read 30 bytes directly to get the whole firmware version. Calls to any other register between 0x01 and 0x0E will result in fault.

Firmware Version																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description	FWVER															
permission	RO															
default value	0															

**FWVER:** Firmware Version

String : 15 characters max

**Keyword :** This register has no Keyword, use grpc call GetFWVersion()

## **0x0F - Hardware Version**

Register to read hardware version

Hardware Version																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description	HWVER															
permission	RO															
default value	0															

**HWVER:** Hardware Version

0-63

**Keyword :** This register has no Keyword, use grpc call GetHWVersion()

## **0x10 - CPU Wake Event Mask**

Register to configure what will enable CPU and move the state machine from Low Power to Normal mode.

If at least one event is writing on bit 01 to 06 and VIN is present, the LPM will wake-up the CPU.

Otherwise, the LPM will wake-up CPU only on cold start when VIN is present (default).

CPU Wake Event Mask																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description							VBATLOW	VINLOST	VINT	CAN	ACC	DI2	DI1	RTC	IGN	VIN
permission							RW	RW	RW	RW	RW	RW	RW	RW	RW	RW
default value							0	0	0	0	0	0	0	0	1	1

**VIN:** New VIN Connection Event

**Keyword :** CPU\_WAKE\_VIN

**IGN:** Ignition Event

**Keyword :** CPU\_WAKE\_IGN

**RTC:** RTC Timeout

Handled by the "rtcwake" command in combination with the rtc-skyhawk linux driver

**DI1:** Digital Input Event

**Keyword :** CPU\_WAKE\_DI1

**DI2:** Digital Input Event

**Keyword :** CPU\_WAKE\_DI2

**ACC:** Accelerometer Event

**Keyword :** CPU\_WAKE\_ACC

**CAN:** CAN Activity Event

**Keyword :** CPU\_WAKE\_CAN

**AVINT:** VIN Threshold Event (VIN rised above defined VIN Wake Threshold)

**Keyword :** CPU\_WAKE\_VINT

**VINLOST:** Wake on VIN loss

**Keyword :** CPU\_WAKE\_VINLOST

**VBATLOW:** Wake on VBAT Low

**Keyword :** CPU\_WAKE\_VBATLOW

## 0x11 - CPU Wake Event Delay

Register to configure the delay before enabling the CPU following the Wake Event. This configuration can help to prevent the CPU to restart to fast if a shutdown was issued and the wake up condition are meet before the board was correctly shutdown.

CPU Wake Event Delay																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description	Delay (msec)															
permission	RW															
default value	0															

**Keyword :** CPU\_WAKE\_DELAY.

## 0x20 - Digital Inputs Polarity

Register to configure the digital inputs polarity.

Digital Inputs Polarity																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description													D12		D11	
permission													RW		RW	
default value													00		00	

### **D11**

00: Disable

01: Rising edge

10: Falling edge

11: Both edge

**Keyword :** DIG1\_POLARITY

### **D12**

00: Disable

01: Rising edge

10: Falling edge

11: Both edge

**Keyword :** DIG2\_POLARITY

## 0x21 - Power Control

Register to control the Power Mode and power to the external interfaces.

Power Control																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description						CANLPEN	CANEN	BPLPEN	BPEN	GPSLPEN	GPSEN	VREFLPEN	VREFSEL	VREFEN	RSM	RLP
permission						RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW
default value						0	0	0	0	0	0	0	0	0	0	0

**RLP:** Request Low Power

**Keyword :** POWER\_CTRL\_RLP

**RSM:** Request Shelf Mode

**Keyword :** POWER\_CTRL\_RSM

**VREFEN:** VREF Enable

**Keyword :** POWER\_CTRL\_VREFEN

**VRESEL:**VREF Selector

0: 5V

1: Vin

**Keyword :** POWER\_CTRL\_VRESEL

**VREFLPEN:** VREF Low Power Enable

**Keyword :** POWER\_CTRL\_VREFLPEN

**GPSEN:** GPS Enable

**Keyword :** POWER\_CTRL\_GPSEN

**Keyword :** POWER\_CTRL\_GPSPEN

**BPEN:** BitPipe Enable

**Keyword :** POWER\_CTRL\_BPEN

**BPLPEN:** BitPipe Low Power Mode Enable

**Keyword :** POWER\_CTRL\_BPLPEN

**CANEN:** CAN Bus Enable

**Keyword :** POWER\_CTRL\_CANEN

**CANLPEN:** CAN Bus Low Power Mode Enable

**Keyword :** POWER\_CTRL\_CANLPEN

## 0x22 - GPS External Antenna Control

Register to control the external antennas of the GPS.

[illegible]

**GPSEXTANTE:** GPS External Antenna Enable

**Keyword :** GPS\_EXT\_ANT\_CTRL

### 0x30 - VBAT Low Threshold

Register to configure the battery voltage (VBAT) threshold to trigger VBATLOW IRQ.

VBAT Low Threshold																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description	Voltage (mV)															
permission	RW															
default value	3000															

**Keyword :** VBAT\_LOW\_THRESHOLD

### **0x31 - VBAT Shelf Mode**

Register to configure the battery voltage (VBAT) threshold for VBAT Shelf Mode.

If VBAT falls below THRESHOLD - HYSTERESIS, LPM transitions to Shelf Mode.

If VBAT rises above  $\text{THRESHOLD} + \text{HYSTERESIS}$ , LPM transitions to RTC Only.

Even if this value is set to 0, the minimum value is 2700mV

VBAT Shelf Mode																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description	Voltage (mV)															
permission	RW															
default value	2700															

**Keyword :** VBAT\_SHELF\_MODE.

### 0x32 - VIN RTC Mode (VIN Lost)

Register to configure the input voltage (VIN) threshold for VIN RTC Mode.

If VIN falls below THRESHOLD - HYSTERESIS, LPM transitions to RTC Mode.

If VIN rises above THRESHOLD + HYSTERESIS, LPM transitions to Low Power Mode.

VIN RTC Mode (VIN Lost)																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description	Voltage (mV)															

permission	RW
default value	6000

**Keyword :** VIN\_RTC\_MODE

### **0x33 - VIN Normal (Low Voltage) Mode**

Register to configure the input voltage (VIN) threshold for VIN Normal (Low Voltage) Mode.  
If VIN falls below THRESHOLD - HYSTERESIS, LPM transitions to Normal (Low Voltage) Mode.  
If VIN rises above THRESHOLD + HYSTERESIS, LPM transitions to Normal Mode.

VIN Normal (Low voltage) Mode																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description	Voltage (mV)															
permission	RW															
default value	12000															

**Keyword :** VIN\_NORM\_LV\_MODE

### **0x34 - VIN Wake Threshold**

Register to configure the vin value to which the CPU will be awoken, if enabled in the CPU Wake Mask.

VIN Wake Threshold																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description	Voltage (mV)															
permission	RW															
default value	13000															

**Keyword :** VIN\_WAKE\_THRESH

### **0x40 - VIN Hysteresis**

Register to configure the VIN hysteresis before to change the power mode.

VIN Hysteresis																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description	Voltage (mV)															
permission	RW															
default value	200															

**Keyword :** VIN\_HYSTERESIS

### **0x41 - VBAT Hysteresis**

Register to configure the VBAT hysteresis before to change the power mode.

VBAT Hysteresis																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description	Voltage (mV)															
permission	RW															
default value	100															

**Keyword :** VBAT\_HYSTERESIS

### **0x50 - IRQ Enable**

VIN Alarm																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description													KAWARN	VINLOST	VBATLOWE	MODECHGE
permission													RO	RW	RW	RW
default value													1	1	1	1

**Keyword :** IRQ\_KAWARN

Low Power Mode Request Timeout																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description	Timeout (sec)															
permission	RW															
default value	0															

CPU Cold Boot Keep Alive Timeout																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description	Timeout (sec)															
permission	RW															
default value	60															

CPU Keep Alive Timeout																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description	Timeout (sec)															
permission	RW															
default value	30															

Power Loss Warning Delay
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bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description	Delay (sec)															
permission	RW															
default value	5															

0-65535: Delay in sec

**Keyword** : POWER\_LOSS\_WARNING\_DELAY

## 0x55 - Power Loss Shutdown Timeout

Register to configure the timeout after which the CPU will be powered off even if it's not correctly shutdown.

Time timeout will start after the **VINLOST** IRQ.

Power Loss Shutdown Timeout																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description	Timeout (sec)															
permission	RW															
default value	0															

0: Disable

1-65535: Timeout in sec

**Keyword** : POWER\_LOSS\_SHUTDOWN\_TIMEOUT

## 0x60 - Last Wake Event Status

Register to read the last wake event that powered the CPU

Last Wake Event Status																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description							VBATLOW	VINLOST	VINT	CAN	ACC	DI2	DI1	RTC	IGN	VIN
permission							RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
default value							0	0	0	0	0	0	0	0	0	0

**VIN**: VIN condition

**Keyword** : LAST\_WAKE\_VIN

**IGN**: Ignition Event

**Keyword** : LAST\_WAKE\_IGN

**RTC**: RTC Timeout

**Keyword** : LAST\_WAKE\_RTC

**DI1**: Digital Input Event

**Keyword** : LAST\_WAKE\_DI1

**DI2**: Digital Input Event

**Keyword** : LAST\_WAKE\_DI2

**ACC**: Accelerometer Event

**Keyword** : LAST\_WAKE\_ACC

**CAN**: CAN Activity Event

**Keyword** : LAST\_WAKE\_CAN

**VINT**: VIN Threshold Event

**Keyword** : LAST\_WAKE\_VINT

**VINLOST**: Wake on VIN loss Event

**Keyword** : LAST\_WAKE\_VINLOST

**VBATLOW**: Wake on VBAT Low Event

**Keyword** : LAST\_WAKE\_VBATLOW

## 0x61 - VIN Voltage Status

Register to read the current VIN voltage.

VIN Voltage Status																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description	VIN (mV)															
permission	RO															
default value	0															

**Keyword :** VIN\_STATUS

## 0x62 - VBAT Voltage Status

Register to read the current VBAT voltage.

VBAT Voltage Status																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description	VBAT (mV)															
permission	RO															
default value	0															

**Keyword :** VBAT\_STATUS

## 0x63 - Power Status

Register to read the current power mode, the battery voltage and the charge status.

Power Status																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description			IGN	VBATT				CHGSTS				PM				
permission			RO	RO				RO				RO		RO		
default value			0	0				00				00		000		

**PM:** Power Mode

000: Shutdown / Shelf Mode (not used)

001: RTC Only (Not used)

010: Low power mode

011: Normal (Low voltage)

100: Normal

**Keyword :** POWER\_STATUS\_PM

**CHGSTS:** Charge Status

00: Charge complete

01: Charging

10: Safety timer fault or cell temperature invalid

11: Reserved

**Keyword :** POWER\_STATUS\_CHGSTS

**VBATT:** Battery voltage in percentage

**Keyword :** POWER\_STATUS\_VBATT

**IGN:** Ignition Status

**Keyword :** POWER\_STATUS\_IGN

## 0x64 - GPS External Antenna Status

Register to read GPS External Antenna Status.

GPS External Antenna Status																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description															GPSANTSHRT	GPSANTDET
permission															RO	RO
default value															0	0

**GPSANTDET:** GPS External Antenna Detected



**Keyword :** GPS\_ANT\_DET

**GPSANTSHRT:** GPS External Antenna Short

**Keyword :** GPS\_ANT\_SHRT

## **0x65 - IRQ Status**

Register to read IRQ status. This register is cleared on read.

IRQ Status																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description													KAWARN	VINLOST	VBATLOW	MODECHG
permission													RO	RO	RO	RO
default value													0	0	0	0

**MODECHG:** Power Mode Change

**Keyword :** IRQ\_STATUS\_MODECHG

**VBATLOW:** VBAT is under VBATLOW threshold

**Keyword :** IRQ\_STATUS\_VBATLOW

**VINLOST:** VIN is under VIN RTC Mode threshold

**Keyword :** IRQ\_STATUS\_VINLOST

**KAWARN:** Keep Alive Warning occurs when CPU forgot to kick the LPM for a keep alive timeout cycle. The LPM will trigger the CPU reset after the second keep alive timeout cycle.

**Keyword :** IRQ\_STATUS\_KAWARN

## **0x70 - Firmware Update Commands**

Register to control the firmware update process. The firmware update status will be automatically clear when a new command is received.

Following the command, a buffer of 128 bytes is available to add a payload.

Firmware Update Request																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description											REBOOT	VALIDATE	WRITEADR	WRITECRC	WRITE	ERASE
permission											WO	WO	WO	WO	WO	WO
default value											0	0	0	0	0	0

**ERASE:** Erase the inactive bank

**Keyword :** FW\_UPDT\_CMD\_ERASE

**WRITE:** Write data to flash. This command will fill a buffer (Write Buffer) waiting for CRC confirmation before to write the data to the flash. A minimum of 2 bytes is required in the payload.

**Keyword :** FW\_UPDT\_CMD\_WRITE

**WRITECRC:** Validate CRC of the last command. On CRC match, the data from the last WRITE operation will be write to the flash. A 4 bytes CRC value is required in the payload.

**Keyword :** FW\_UPDT\_CMD\_WRITECRC

**WRITEADR:** Modify the current write address. This command can be used to skip blank space in application. A 4 bytes address value is required in the payload and the address should be a multiple of 4.

**Keyword :** FW\_UPDT\_CMD\_WRITEADR

**VALIDATE:** Validate request command. This command will check the CRC of the whole application. The CRC value is already include in the transferred file.

**Keyword :** FW\_UPDT\_CMD\_VALIDATE

**REBOOT:** Reboot the Low Power Manager. This command will do the exact same thing as CPU shutdown request, but in addition it will reboot the LPM.

**Keyword :** FW\_UPDT\_CMD\_REBOOT

## **[0x71-0x72] - Firmware Update Start Address**

Register to get the starting address of the currently inactive bank. Sends 32 bits of data containing the starting address.

When you issue a read command, simply read 4 bytes directly to get the whole firmware update start address.

Calls to register 0x72 will result in fault.

Firmware Update Start Address																
bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

description	FWSTARTADR
permission	RO
default value	0

Value between 0 and 2,147,483,647.

## **[0x73-0x74] - Firmware Update End Address**

Register to get the ending address of the currently inactive bank. Sends 32 bits of data containing the ending address. When you issue a read command, simply read 4 bytes directly to get the whole firmware update end address. Calls to register 0x74 will result in fault.

Firmware Update Start Address																
bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
description	FWENDADR															
permission	RO															
default value	0															

Value between 0 and 2,147,483,647.

## **0x75 - Firmware Update Status**

Register to read firmware update status. This register is cleared on read.

Firmware Update Status																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description					REBOOTSTS	VALIDATESTS	WRITEADRSTS	WRITECRCSTS	WRITESTS	ERASESTS						
permission					RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
default value					00	00	00	00	00	00	00	00	00	00	00	00

00: Idle  
01: Command in progress  
10: Command failed  
11: Command succeed

**ERASESTS:** Erase command status. Fail reason: Cannot erase flash.

**Keyword :** FW\_UPDT\_STS\_ERASE

**WRITESTS:** Write command status. Fail reason: Cannot write data from "Write Buffer" to flash.

**Keyword :** FW\_UPDT\_STS\_WRITE

**WRITECRCSTS:** Write CRC command status. Fail reason: "Write buffer" CRC doesn't match with the WRITECRC command payload.

**Keyword :** FW\_UPDT\_STS\_WRITECRC

**WRITEADRSTS:** Write ADR command status. Fail reason: The address from WRITEADR payload is out of range.

**Keyword :** FW\_UPDT\_STS\_WRITEADR

**VALIDATESTS:** Validate command status. Fail reason: Application CRC doesn't match with the VALIDATE command payload.

**Keyword :** FW\_UPDT\_STS\_VALIDATE

**REBOOTSTS:** Reboot command status. Fail reason: ?

**Keyword :** FW\_UPDT\_STS\_REBOOT

## **[0x80-0x84] - RTC Time**

Register to read and write the RTC time. (EPOCH format)

RTC Time																
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
description	RTCTIME															
permission	RW															
default value	0															

RTCTIME: Handled by the "rtcwake" command in combination with the rtc-skyhawk linux driver

## **[0x85-0x88] - RTC Alarm**

Register to read and write the RTC alarm. (EPOCH format)

When the RTC time is greater than RTC Alarm, an IRQ will be generated

RTC Alarm															
bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01 00
description	RTCALARM														
permission	RW														
default value	0														

RTCALARM:Handled by the "rtcwake" command in combination with the rtc-skyhawk linux driver