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| | TECHNICAL NOTE On LCU SW Redundant Modification | |

Document Change Record

| Issue | Date | Changed Sect. | Description of Change |
|-------|----------|---------------|---|
| 1.0 | Nov 2009 | | New document |
| 1.1 | Nov 2009 | §4 | Change STATUS for standby 1 mode and activation HL_STANDBY command to be executed in dissipative mode |
| 1.2 | Nov 2009 | §3, §4.4 | General description in chapt.3, power-down interrupt service modification added in chapt.4.4 |



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1 Scope

The purpose of this TN is to clarify the changes in LCU software proposed to be implemented to LCU-redundant unit when switched on in flight for further LO subsystem operation. The changes are to minimize the possible unwanted effects caused by SEU and hardware procedure including a switch of the standby relay.

This document is based on LCU-main failure's analysis, on results of tests performed with LCU-IM3 and discussions within HIFI team in August – October 2009.

2 Applicable and Referenced Documents

2.1 Applicable documents

MPIfR/HIFI/TN/2009-544 HIFI LO software modifications

2.2 Referenced documents


SRC/LCU/PR/2002-018 LCU Software & Operational Modes, Commands and Housekeeping

SRC/LCU/PR/2009-0756 FHLCU FM failure investigations done on DIGIT_FS in Warsaw, October 2009

3 Introduction

In general the two new features (modes) will be added to the LCU software:

- Standby 1 mode - this mode shall be entered for LCU table upload or any other memory modification, if no primary power cycle was preceded.
- Dissipative mode - this mode shall be entered, when HIFI is commanded to STANDBY

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Since the new Standby 1 mode has been introduced which replaces the old Standby mode in LCU operation after the boot, some modification of power-down interrupt service has been also necessary to ensure the proper switching off the bias voltages in case of not switching the hardware standby relay.

4 Changes in LCU software

It is possible to modify the LCU software with loading the new patch to it after primary power-on and after the original software is loaded from PROM to RAM. The new patch will contain the patch17 used for normal operation in flight and some new lines.

The features of implemented modifications have been verified during the tests performed on LO subsystem with LCU-IM3 unit in Groningen.

4.1 Standby 1 mode

During normal operation the LCU transition to standby mode can be initiated in two cases:

1. When LCU receives the command HL_STANDBY from ICU
2. When LCU receives the interrupt from undervoltage protection system

HL_STANDBY command itself will remain as it is and it automatically will force LCU to enter Standby 1 Mode of operation with status mode 0x01. Only Standby 1 Mode will be enabled after the software modification done by loading the patch.

Standby 1 Mode can be used as the old Standby Mode but without any touching *standby* relay.

Modification proposal: since there is only one place in the code where hardware of *standby* relay is set, modification is very simple. The patch eliminates the code of loading the logical “0” and “1” to the address of standby relay (replaces them by NOP instructions) keeping the subroutine timing as it was.

| Updated procedures | Memory address | Number of bytes |
|--------------------|-----------------|-----------------|
| Set_standby_relay | 0x0BB5 – 0x0BBA | 6 |
| | 0x0BBF – 0x0BC4 | 6 |



| Memory address | Byte value in LCU-FM after hardware RESET (hex) | Instruction | Byte value after loading the patch (hex) | Instruction |
|----------------|---|-------------------|--|-------------|
| 0x0BB5 | 90 | Mov dptr, #0FF8CH | 00 | Nop |
| 0x0BB6 | FF | | 00 | Nop |
| 0x0BB7 | 8C | | 00 | Nop |
| 0x0BB8 | 74 | Mov a, #1 | 00 | Nop |
| 0x0BB9 | 01 | | 00 | Nop |
| 0x0BBA | F0 | Movx @dptr,a | 00 | Nop |
| | | | | |
| 0x0BBF | 90 | Mov dptr, #0FF8CH | 00 | Nop |
| 0x0BC0 | FF | | 00 | Nop |
| 0x0BC1 | 8C | | 00 | Nop |
| 0x0BC2 | 74 | Mov a, #0 | 00 | Nop |
| 0x0BC3 | 00 | | 00 | Nop |
| 0x0BC4 | F0 | Movx @dptr,a | 00 | Nop |


The second option of entering the standby mode after receiving the interrupt from undervoltage protection system is kept as it is. The exit from this kind of interrupt is automatically to Standby 1 mode. However after preliminary tests with LCU-IM3 it turned out that the power-down interrupt service procedure itself has to be modified a little bit as well. The details of the modification is described in chapter 4.4.

MODE in STATUS word (HL_RD_STATUS) for Standby 1 mode will be 1 (decimal).

Modification proposal: to implement the new mode value in STATUS word it is necessary to change exchange the old MODE_STANDBY value (0) to new one (1).

| Updated procedures | Memory address | Number of bytes |
|------------------------|----------------|-----------------|
| check_mode | 0x0F39 | 1 |
| komF002 (goto standby) | 0x10B0 | 1 |

| Memory address | Byte value in LCU-FM after hardware RESET (hex) | Instruction | Byte value after loading the patch (hex) | Instruction |
|----------------|---|--------------------------------------|--|--|
| 0x0F39 | 00 | cjne a,#MODE_STBY, ?cm_no_standby | 01 | cjne a,#MODE_STBY_1, ?cm_no_standby |
| 0x10B0 | 00 | orl STATUS, #MODE_STBY | 01 | orl STATUS, #MODE_STBY_1 |

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When LCU is powered on it starts to operate in standby 0 mode with the STATUS read as 0x00. To move LCU in standby 1 mode, the commanding sequence should be the following:

- 1) Supply 28 V: LCU is booted and goes to standby 0 mode
- 2) Verify STATUS (standby 0 mode)
- 3) Verify checksum value
- 4) Upload the Patch
- 5) Verify checksum value
- 6) Send the command HL_STANDBY: this command is **necessary** because LCU goes to standby 1 mode only when it is executed, otherwise if LCU is still in standby 0 mode no other command will be executed
- 7) Verify STATUS (standby 1 mode)
- 8) Upload the Tables
- 9) Verify STATUS (standby 1 mode)
- 10) Verify checksum value
- 11) Send the command HL_NORMAL
- 12) ...

4.2 Dissipative mode

The new command HL_DISSIPATIVE (0xF00D0D0D) from ICU is necessary to force LCU to start DISSIPATIVE mode of operation. In this mode the band remains tuned as it was before entering the mode. None of new tuning can be done in this mode.


MODE in STATUS word (HL_RD_STATUS) for Dissipative mode is now 8 (decimal).

MODE

- = 0 - standby 0
- = 1 - standby 1
- = 8 - disipative
- = 10 - normal
- = 11 - diagnostic
- = 15 - failure

Execution of only 4 commands is allowed in Dissipative mode:

1. HL_NORMAL – return from Dissipative mode to Normal
2. HL_STANDBY – go to Standby (standby 1 mode)
3. HL_SET_RAMPAGE

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4. HL_CHECKSUM – calculate checksum of XRAM

Modification proposal: to put the new subroutine address to command address's table and add the subroutine for setting the dissipative mode. It is also necessary to modify the *goto standby* procedure to enable its execution in dissipative mode.

| Updated procedures | Memory address | Number of bytes |
|------------------------|-----------------|-----------------|
| commF00x_jump_table | 0x0FB2 – 0x0FB4 | 3 |
| komF002 (goto standby) | 0x108A – 0x108F | 6 |
| Dissipative_mode | 0x6B2A – 0x6B41 | 24 |

| Memory address | Byte value in LCU-FM after hardware RESET (hex) | Instruction | Byte value after loading the patch (hex) | Instruction |
|----------------|---|-----------------------------|--|---|
| 0x0FB2 | 02 | Ljmp 011C0H | 02 | Ljmp 6B2AH |
| 0x0FB3 | 11 | | 6B | |
| 0x0FB4 | C0 | | 2A | |
| 0x108A | 75 | mov b,#DIAG+ NORMAL+STBY | 00 | Nop |
| 0x108B | F0 | | 00 | Nop |
| 0x108C | 07 | | 00 | Nop |
| 0x108D | 12 | Call check_mode | 00 | Nop |
| 0x108E | 0F | | 00 | Nop |
| 0x108F | 24 | | 00 | Nop |
| 0x6B2A | FF FF | Patch area | E5 30 | Mox a,EXE_COMM+1 |
| 0x6B2C | FF FF FF | Patch area | B5 31 10 | Cjne a, EXE_COM+2, error_com_code_s7 |
| 0x6B2F | FF FF FF | Patch area | B5 32 0D | Cjne a, EXE_COM+3, error_com_code_s7 |
| 0x6B32 | FF FF FF | Patch area | 75 F0 02 | mov b, #NORMAL |
| 0x6B35 | FF FF FF | Patch area | 12 0F 24 | Call check_mode |
| 0x6B38 | FF FF FF | Patch area | 53 20 0F | Anl STATUS, #0FH |
| 0x6B3B | FF FF FF | Patch area | 43 20 80 | orl STATUS, #MODE DISSIPATIVE |
| 0x6B3E | FF FF FF | Patch area | 22 | ret |
| 0x6B3F | FF FF FF | Patch area | 02 10 2E | Ljmp error_com_code |

4.3 Modification in case of unexpected booting procedure

During the normal boot procedure (when LCU is powered-on) the program starts to execute the following sequence from PROM:



1. Set the stack
2. Clear RAM
3. Clear XRAM
4. Copy PROM to XRAM
5. Decompress LSU table
6. Decompress green table
7. Calculate the checksum value of XRAM
8. Switch off the PROM
9. Predefine some variables
- 10....

In case of unexpected boot (without hardware switching LCU on) the program runs from memory (XRAM) and then the procedures 2) – 6) should be cancelled to avoid the program crash. Also it is foreseen to add the additional procedure for returning from interrupt (if there was any) and restoring the interrupt logic to keep the LCU in communication with ICU.

Modification proposal: to erase from memory (boot procedure) the call to subroutines from pp. 2) – 6).

| Updated procedures | Memory address | Number of bytes |
|--------------------|-----------------|-----------------|
| BOOT procedure | 0x208E – 0x209F | 18 |

| Memory address | Byte value in LCU-FM after hardware RESET (hex) | Instruction | Byte value after loading the patch (hex) | Instruction |
|----------------|---|-----------------------------|--|-------------|
| 0x208E | 12 | call clear_RAM | 12 | call reti0 |
| 0x208F | 00 | | 21 | |
| 0x2090 | A3 | | 71 | |
| 0x2091 | 12 | call clear_XRAM | 00 | Nop |
| 0x2092 | 00 | | 00 | |
| 0x2093 | AD | | 00 | |
| 0x2094 | 12 | Call Copy_ROM0_to_XRAM | 00 | Nop |
| 0x2095 | 00 | | 00 | |
| 0x2096 | BD | | 00 | |
| 0x2097 | 12 | Call Copy_ROM1_to_XRAM | 00 | Nop |
| 0x2098 | 00 | | 00 | |
| 0x2099 | C2 | | 00 | |
| 0x209A | 12 | Call decompress_LSU_table | 00 | Nop |
| 0x209B | 01 | | 00 | |
| 0x209C | 52 | | 00 | |
| 0x209D | 12 | Call decompress_green_table | 00 | Nop |
| 0x209E | 01 | | 00 | |
| 0x209F | BF | | 00 | |

4.4 Modification of power-down interrupt service procedure

When the interrupt from under-voltage protection system has been detected then the program starts to execute the following sequence:

1. disable interrupts from LCU lock
2. set STANDBY relay
3. set band relay off
4. do restart

Because of some modification in set STANDBY relay procedure (having the impact on real hardware) it is necessary to add to this sequence the procedure to set the drains D2 and D1 voltages to zero as quickly as possible.

Modification proposal: to put the new subroutine address inside the power-down interrupt service procedure add the subroutine for this new service.

| Updated procedures | Memory address | Number of bytes |
|--------------------|-----------------|-----------------|
| ?power_interrupt | 0x2163 - 0x2164 | 2 |
| New_power_int | 0x6B42 - 0x6B60 | 31 |

| Memory address | Byte value in LCU-FM after hardware RESET (hex) | Instruction | Byte value after loading the patch (hex) | Instruction |
|----------------|---|-------------------|--|-----------------------------------|
| 0x2163 | 0B | call | 6B | call new_power_int |
| 0x2164 | B2 | set_standby_relay | 42 | |
| 0x6B42 | FF FF FF | Patch area | 12 06 CF | call set_lsu_off |
| 0x6B45 | FF FF | Patch area | C0 3F | Push SUPPLY_INDEX |
| 0x6B47 | FF FF FF | Patch area | 75 3F 03 | mov SUPPLY_INDEX, #D2_SUPP_OFFSET |
| 0x6B4A | FF FF FF | Patch area | 12 08 83 | call load_zero_supply |
| 0x6B4D | FF FF FF | Patch area | 12 09 23 | call set_voltage_quick |
| 0x6B50 | FF FF FF | Patch area | 75 3F 02 | mov SUPPLY_INDEX, #D1_SUPP_OFFSET |
| 0x6B53 | FF FF FF | Patch area | 12 08 83 | call load_zero_supply |
| 0x6B56 | FF FF FF | Patch area | 12 09 23 | call set_voltage_quick |
| 0x6B59 | FF FF | Patch area | D0 3F | Pop SUPPLY_INDEX |
| 0x6B5B | FF FF FF | Patch area | 12 0B B2 | Call set_standby_relay |
| 0x6B5E | FF FF FF | Patch area | 02 21 65 | jmp restart_from_int-3 |