

FHIT - Quick reference guide

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1 Front-end Hybrid Industrial Tester (FHIT)

1.1 Purposes

The FHIT aims at testing the Front-End Hybrids (FEH) for CMS tracker in the industry (hybrid manufacturers) and after micro bonding of pitch adapter (CERN). It is a performant application specific device able to carry out three different and complementary tests, a connectivity test (CT), an electrical test (ET) and a functional test (FT), with a low cost relative to old or generic industrial tester which are not able to perform easily every test. FHIT is a compact machine performing automatically and quickly these three tests. The FHIT setup can be used at different stages in the production chain

- as **soon** as possible, to detect connectivity or electrical problems (open or short circuits, wrong bondings, ...),
- as **late** as possible before module assembly, to check that no failure appeared during handling (broken lines, ...).

FHIT is an industrial tester but it will also be useful for a quick hybrid test before starting deeper and longer tests in a laboratory. So, FHIT will serve both as an **industrial tester** and as a **fast laboratory tester**.

1.2 FHIT systems

Three types of FHIT are available according to specific requirements. They are

- the **mono-FHIT** (Figure 1) : this setup is recommended for **laboratory** purposes, when a full industrial test (CT, ET and FT) is required, but when matters of timing are not critical (few FEH to be tested). The mono-FHIT setup, automatically driven via a specific software, can host only one FEH.
- the **dual-FHIT** (Figure 2) : this setup is recommended for **industries** which produce or handle a lot of FEH. The dual-FHIT facility is a merging of two mono-FHIT which gives the possibility to perform consecutive tests without any downtime. The dual-FHIT setup is also automatically driven via a specific software and can host two FEHs.
- the **easy-FHIT** : this setup is recommended for **laboratories** which are working on developing and debugging the hybrid and which do not need any functional test of FEH. The easy-FHIT setup is an expert user FHIT, with a lot of debugging possibilities and is driven by messages sent by user through an hyperterminal. It can host one FEH and performs only CT and ET, as it is not provided with an ARC board.

Both mono- and dual-FHIT can also be run as an easy-FHIT, through an hyperterminal.

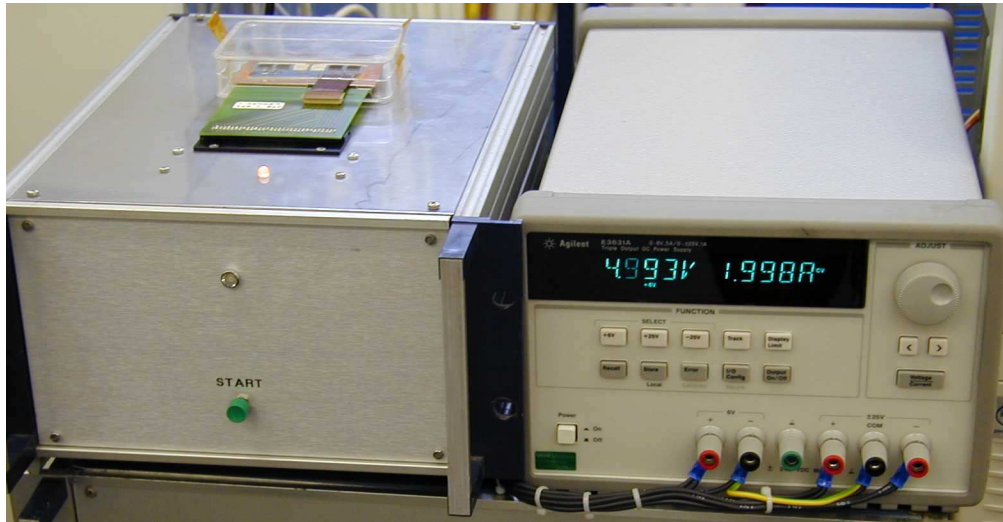


Figure 1: mono-FHIT with power supply



Figure 2: dual-FHIT

Setup type	hosted hybrids	ARC board inside	performed tests	mode
easy-FHIT	1	no	CT, ET	terminal
mono-FHIT	1	yes	CT, ET, FT	FHITS
dual-FHIT	2	yes	CT, ET, FT	FHITS

Table 1: Setup types and features

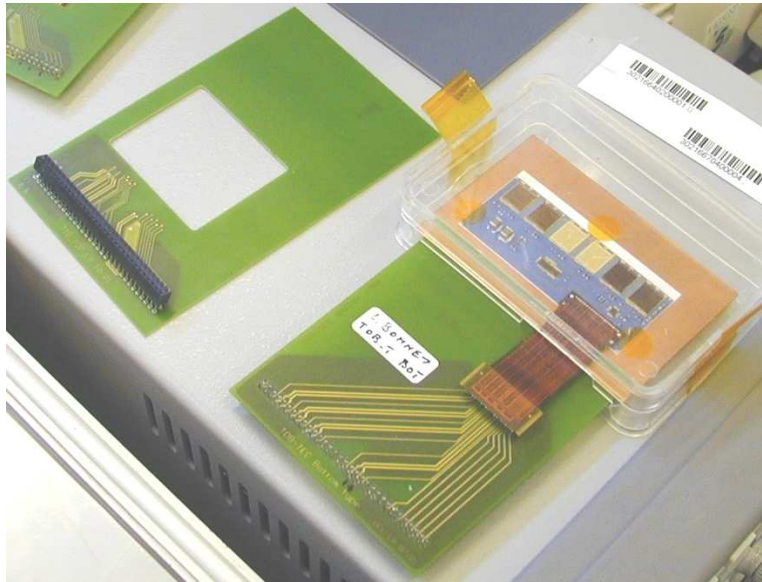


Figure 3: Some transition boards (FEHC)

1.3 Transition boards

The FEH are connected to FHIT via a PCB transition board. Every type of transition boards (TOB/TEC_{bottom} , TOB/TEC_{top} , TIB_{bottom} , TIB_{top} , ...) can be plugged. These transition boards can also serve as hybrid carriers (FEHC), as they are transition boards from the fragile NAIS connector on the hybrid to the robust male SAMTEC connector of FHIT. Some of the available transition boards are displayed in Figure 3. These transition boards also allow cooling of the FEH. Furthermore, for a more safety, the FHIT Tool number 1 (Figure 5) should be used to easily unplug the hybrid from FHIT. For more information about transition boards, please refer to the FHIT detailed guide [2].

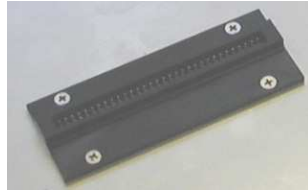


Figure 4: top panel SAMTEC compatible connector

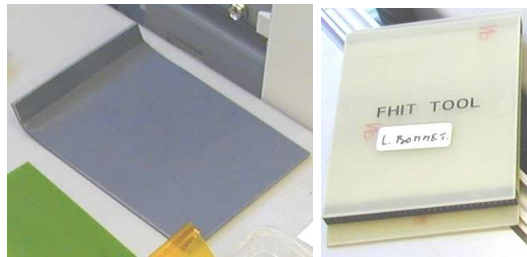


Figure 5: FHIT Tools number 1 and 2

Top panel connector A big advantage a FHIT is its high quality connector on the top panel. This male connector is compatible with the cheap and robust SAMTEC connector. A big attention was focussed on this connector and once it becomes old and worn, changing it takes less than 5 minutes. First of all, the black plastic device (Figure 4) around the connector itself has to be removed (4 screws) and then, the connector can be removed easily using the FHIT Tool number 2 (Figure 5). The new connector can then be plugged in the reverse way and, once the black device is screwed, FHIT is ready for new FEH tests.

1.4 Component layout and LED code

The mono-FHIT (dual-FHIT) consist of one (two) electronic board(s), the FHIT board, which is connected as a front-end to an ARC board, from RWTH - Aachen¹ (Figure 6). The easy-FHIT setup is not provided with an ARC board and consist only of an FHIT board. These electronic boards are inclosed inside a metallic box.

Layout

- On the front panel, lie a ‘START’ button and a first LED (result LED).
- On the top side are two other LEDs and the SAMTEC connector.

¹for information about ARC boards, refer to <http://www.physik.rwth-aachen.de/group/IIIphys/CMS/tracker/en/index.html>

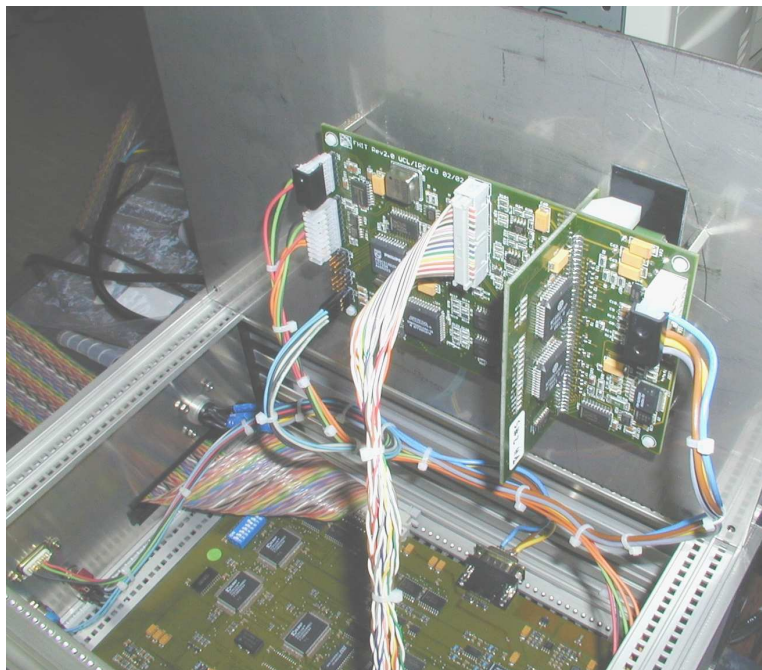


Figure 6: FHIT (top) and ARC (bottom) boards - inside the FHIT box

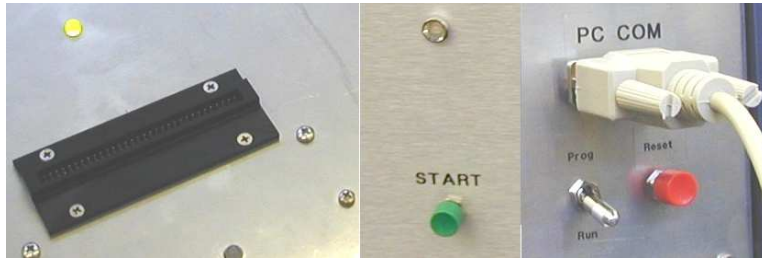


Figure 7: FHIT top, front and rear panels

LED	Function	Color	Meaning
Front	IT Result	Green	Grade A hybrid
		Blinking green	Grade B hybrid
		Orange	Grade C hybrid (if defined)
		Blinking orange	Grade D hybrid (if defined)
		Red	Bad hybrid
		Blinking red	Test failed (fatal error)
Top	Info	Green	Hybrid (un)plugging allowed
		Orange	Waiting for information; FEH (un)plugging allowed
		Red	FEH powered ON : unplugging NOT allowed
All		Blinking red	FHIT powered ON with FEH connected

Table 2: LED color code

- On the back side lie the RS232 connector, the power supply input, the mode switch² and the reset button.

The industrial test global result will be displayed on the front panel LED whereas the other LED indicates whether it is possible to plug or unplug the hybrid. The meaning of LED colors is provided in Table 2.

The result LED (front panel) provides user with information about industrial test result (hybrid grade³ or fatal error). When the top LEDs are Green or Orange, user is authorized to plug or unplug the hybrid. On the other hand, when it is red, hybrid is powered and the FEH should not be removed. When FHIT is powered ON, no hybrid is supposed to be plugged. Otherwise, LED will blink Red and a power OFF followed by hybrid unplugging will be necessary before proper power ON. Indeed, the FHIT self check makes sure that supplies have the correct values. If it is not the case, no hybrid should be powered ON,

²to run or program FHIT

³refer to [1] for information about hybrid grades

as it could be dangerous for it. This explains why no FEH should be plugged during FHIT self check (after FHIT power on or after a press on the RESET button).

2 FHIT Software (FHITS)

2.1 Introduction

The following section is only for mono- and dual-FHIT. The Industrial Test consists in three subtests :

- the *Connectivity Test* (CT): searches for short or open circuits, bad connections, ...
- the *Electrical Test* (ET): checks supplies, access to registers, current consumption, performs a DCU calibration, ...
- the *Functional Test* (FT): tests chip functionalities, measures pedestal, noise, response to a calibration pulse, ...

To perform these tests, the Industrial Tester Software (FHITS) has been written with LabVIEW 6.0 for Windows 98. FHITS will work as an interface gathering information from subtests and as a controller (power supply remote controller, scanner driver, local file generator, ...). The FHITS software is the same for mono- and dual-FHIT. The user simply has to change one parameter⁴ in the configuration file to choose between mono- or dual-FHIT (see section 4.3.1 for more details on the configuration file).

2.2 General description of subtests and other features

2.2.1 Connectivity Test

This is the first part of the IT. It consists in a passive test, without power supply connected. Each pin of the FEH connector is tested in order to find open or short circuit. Connectivity test is performed 10 times if everything is OK. This lasts less than 5 seconds.

2.2.2 Electrical Test

This test is the second part of IT. It includes tests of power supply currents and voltages; test of access to I²C chips, including DCU, PLL, MUX and APV's. During the electrical test, a DCU calibration and linearity check are also performed. Both connectivity and electrical tests allow finding most of errors on FEH. Electrical test is performed with different hybrid supply values (nominal, maximal and minimal voltages).

⁴** FHIT type::1** is for mono-FHIT and ** FHIT type::2** is for dual-FHIT

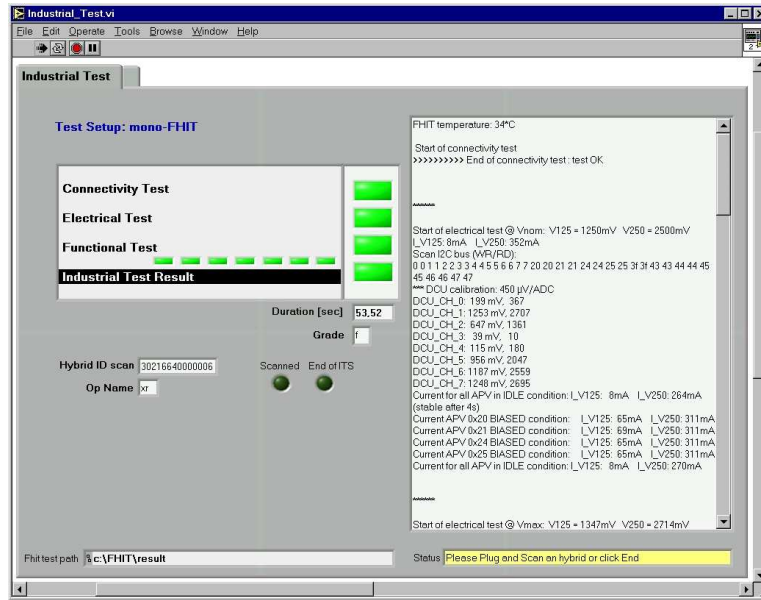


Figure 8: FHITS screenshot

2.2.3 Functional Test

This is the last part of IT. The hybrid is now controlled by the ARC board. The algorithms of the functional test⁵ are performed in C++ and applied thanks to a LabVIEW interface (standard *dll* call). The functional test includes :

- ARC board self test
- APV I²C access test
- APV data output test
- MUX response test
- Pedestal and noise tests
- Calibration pulse test

During the functional test, access and full functionality of chips present on the hybrid are tested, as well as output quality through the pedestal, noise and calibration tests that give information on the bad channels⁶. Full details about these tests are given in the detailed guide [2].

⁵functional test is a part of ARCS software from RWTH Aachen

⁶refer to [1] for further information about bad channel definition

2.2.4 FHITS features

FHITS

- can remotely control the power supply (if available, hardware dependent)
- manages the dialog between computer and FHIT
- drives the barcode scanner
- gathers information from CT, ET and FT
- computes the hybrid grade
- creates a log file which could become a database stored XML file.

2.3 FHITS performances

FHITS was developed with

- TOB/TEC bottom, TIB top and a TOB/TEC top hybrids provided with a DCU2 and 4 APVs
- a ISA board connection to ARC
- mono-FHIT and dual-FHIT setups

The global industrial test duration is always less than 100 seconds. This time is needed in order to perform CT, ET and FT with a 1000 data acquisition per APV and a calibration pulse test.

3 Industrial Test procedure

Performing an industrial test is easy. Once FHITS has started without any hybrid on FHIT, the user has to plug an hybrid and to scan its barcode. After less than two minutes FHIT will give the hybrid grade. As soon as an industrial test has ended, the user can plug and scan a new hybrid or quit FHITS by clicking the END button. Some features are set in the configuration file (`ITS_init.cfg`), which has to be in the `c:\FHIT` folder. More information about FHITS is given in the detailed guide [2].

4 Installation

This section will give only the steps to quickly install a FHIT setup.

4.1 Hardware identification

First of all, the user have to identify the available hardware, so that the setup procedure will be correctly described.

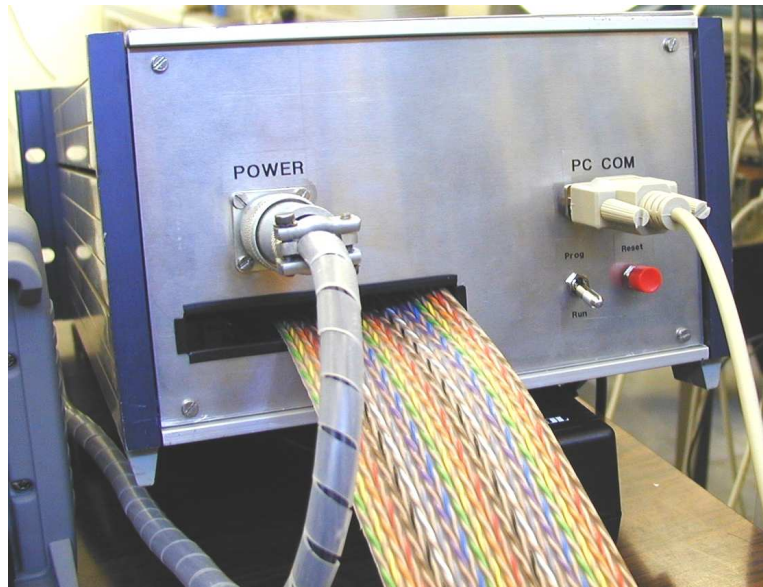


Figure 9: mono-FHIT rear panel (with flat wire)

4.1.1 FHIT type

There are three different type of FHIT : easy-FHIT, mono-FHIT and dual-FHIT.

dual-FHIT has two connectors on the top panel (Figure 2).

mono-FHIT has only one connector (Figure 1).

easy-FHIT has one connector on the top panel and flat wire⁷ going out from rear panel.

4.1.2 Power supply control

There are three way to control the power supply.

- GPIBUS remote control
- serial remote control
- manual control

Remote control is safer for the hardware as it prevents from doing manually something wrong. For a remote control, two things are needed :

- An Agilent HP313x power supply

⁷See Figure 9

FHIT	Scanner	PS control	FHIT A	FHIT B	Needed board
mono	COM1	GPIBUS	COM 2	-	GPIBUS
dual			COM 5	COM 6	GPIBUS + COM ext
mono		COM 2	COM 5	-	COM ext
dual			COM 5	COM 6	COM ext
mono		manual	COM 2	-	-
easy			COM 2	-	-
dual			COM 5	COM 6	COM ext

Table 3: Connection table

- Either a GPIBUS controller board (not provided) or a free COM port (serial extension board can be provided)

4.2 Hardware installation

Power supply The needed voltages are +5V, +12V, -5V. Check that every GND are tied altogether. Power supply output is supposed to be gathered in the rounded connector (Figure 9). For remote control (Agilent HP313x power supply only), the input (serial or GPIBUS, depending on your system) has also to be connected to computer via the proper wire. Be careful that no fuse is present on FHIT, this is therefore the current limitation of the power supply which avoids electronics to get to much current.

Barcode scanner The barcode scanner used for FHIT is a serial one (Datalogic Gryphon D200) and has to be plugged on COM 1, according to Table 3.

FHIT Make sure that the mode switch is in RUN position and that the following wires are plugged :

- power supply (rear panel; rounded connector)
- communication wire(s) (back side; to PC COM) ; refer to Table 3 for more information
- flat wire (back side; to PC ISA board; mono- and dual-FHIT only)

To know how to connect your FHIT and power supply remote control wires, refer to Table 3. If it is needed to change the configuration, using different COM ports than in Table 3, the configuration file can be changed.

Serial port extension board (if needed) This plug-and-play board has to be inserted into a free PCI slot. Please have a look in the board documentation for more information.

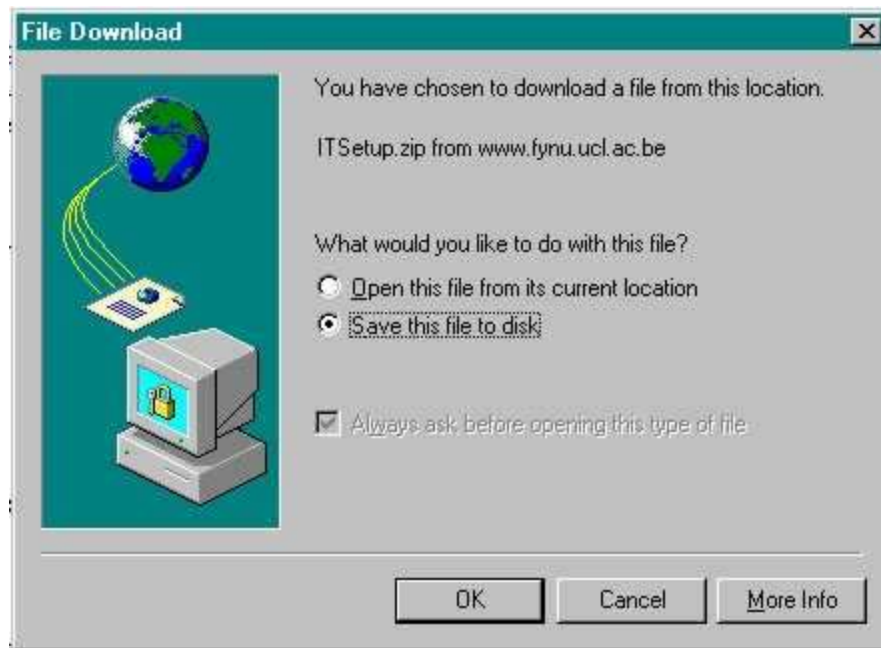


Figure 10: ITSetup.zip download

4.3 Software installation (mono- and dual-FHIT)

Industrial Tester Software Installation The FHITS installation is easy. The first thing is to download the installation files from

<http://www.fynu.ucl.ac.be/themes/he/cms/activities/tracker/hybrids.html>

Just click on the '[zip]' link in the 'FHITS executable' section and the download of 'FHITSsetup.zip' will begin.

The zip file has been created from WinZIP. Once the download is completed, unzip the file into a temporary folder and run the 'Setup.exe' executable file. This will install first FHITS itself and then the LabVIEW Run-Time Engine into the chosen folders. Take care that the LabVIEW Run-Time Engine is needed. Once the setup is completed, the FHITS is ready to run.

mono-FHIT and dual-FHIT After downloading and unzipping the installation files, run 'setup.exe'. This will install both the Industrial Tester Software (FHITS) and the LabVIEW Run-Time Engine (which is needed) into the chosen folders. Once this installation has been completed, the user still has to create the folder `C:\FHIT` and to copy and paste `ITS_init.cfg` into this folder. After these steps, check the parameters from the configuration file (Section 4.3.1)

and then run 'IndustrialTest.exe'. The industrial test will start as explained in section 3.

4.3.1 FHITS configuration file

This file contains some features that could be changed when needed. For instance, the different COM ports can be changed there, as well as the power supply control mode or the log file path. An example of this configuration file is shown in Figure 11.

- `FHIT type::2` defines whether a mono-FHIT or a dual-FHIT has to be controlled by FHITS.


```
mono-FHIT  FHIT type::1
dual-FHIT  FHIT type::2
```
- `Barcode scanner address ::1` defines the COM port for the serial barcode scanner. In this case 1 means COM 1.
- `Power supply remote control mode ::2` defines the power supply control mode.


```
serial remote control  ...control mode ::0
GPIBUS remote control  ...control mode ::1
manual control          ...control mode ::2
```
- `Power supply remote control address ::2` defines the COM port or GPIBUS address for power supply remote control.
- `FHIT A address ::3` defines the COM port for FHIT A. FHIT A corresponds to the FHIT inside a mono-FHIT or to the left-hand FHIT inside a dual-FHIT.
- `FHIT B address ::4` defines the COM port for the right-hand FHIT inside a dual-FHIT.
- `Local file path::c:\FHIT\result` defines the path to store the log file created at the end of an industrial test.

4.4 easy-FHIT

This FHIT setup is an expert user FHIT, able to perform different debug operations. It can not perform a full industrial test as it is not able to perform the functional test. So there is no need to install FHITS for an easy-FHIT as it won't be able to use it. The only thing is to use a basic terminal (as **TeraTerm Pro** for instance) to read what FHIT is writing on the serial line⁸. The easy-FHIT setup allows easy access to signal through an oscilloscope as probe connections

⁸COM settings: Baud rate: 115200; data: 8bit; Parity: none; Stop: 1bit; Flow control: none

```

FHITS Config file
-----

** FHIT type::2**                monoFHIT=1, dualFHIT=2
** Barcode scanner address ::1**  default: COM 1
** Power supply remote control mode ::2**  serial control=0, GPIBUS=1, manual=2
** Power supply remote control address ::2**  COM port (def: COM 2)or GPIBUS add
** FHIT A address ::3**          default : COM 5
** FHIT B address ::4**          default : COM 6
** Local file path::c:\FHIT\result**      default : c:\FHIT\result

```

Figure 11: FHITS configuration file: c:\FHIT\ITS_init.cfg

can be connected and as synchronization with header is also possible. Different options are accessible through the serial line, such as sending reset, trigger or double trigger patterns. User just have to send messages, following a given code. This code is available at the end of this document (section 8.1).

TeraTerm Pro This is a freeware available at <http://hp.vector.co.jp/authors/VA002416/teraterm.html>. This hyperterminal is really suitable to control an easy-FHIT and is recommended.

The settings (Setup\serial port... menu) are

```

Baud rate:    115200
Data:         8bit
Parity:       none
Stop:         1bit
Flow control: none
Transmit delays: 0

```

and (Setup\terminal... menu) New line: Receive : CR+LF.

4.5 Installation summary

4.5.1 mono- and dual-FHIT

- | | |
|----------|---|
| Hardware | <ul style="list-style-type: none"> • Power supply : connections to FHIT (rounded connector) and to the computer (if remote control) : sections 4.1.2 and 4.2. • FHIT : connections of serial lines to the computer and of flat wire to the ISA board : section 4.2. • Barcode scanner : connection to COM 1 : section 4.2. • Serial extension board, if needed, into a free PCI slot : section 4.2. |
| Software | <ul style="list-style-type: none"> • download ITSetup.zip, unzip it and run setup.exe: section 4.3. • create C:\FHIT and paste ITS_init.cfg into this folder. |

- check the configuration file parameters : section 4.3.1.
- run `IndustrialTest.exe`

4.5.2 easy-FHIT

Hardware same procedure as for mono- and dual-FHIT

Software download `TeraTermPro` software, configure and run it : section 4.4.

5 Problems

5.1 Troubleshooting

1. If FHIT serial connection is bad, no industrial test will be performed. Just after power on, FHITS proceeds in an automatic check of this connection by sending a message through the serial line and by listening to FHIT response. If wires are not plugged or if real COM port is not the same as the COM port from configuration file, no access to FHIT will be possible from computer and FHITS will automatically stops, after complaining.
2. If the configuration file `ITS.init.cfg` is not found, FHITS won't properly work. This file has to lie in the `c:\FHIT` folder.

5.2 Known bugs

No bug has been discovered yet.

6 FHIT working group

FHIT project is carried by UCL (Louvain-la-Neuve).

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7 Dictionary

dual-FHIT : Two hybrid FHIT

CR : Carriage Return character

CT : Connectivity Test, first part of IT

ET : Electrical Test, second part of IT

easy-FHIT : mono-FHIT without ARC board (CT & ET only)

FE : Front-End (ARC-FE or FHIT)

FEH : Front-End Hybrid

FEHC : FEH Carrier, ie, the transition board

FHIT : Front-End Hybrid Industrial Tester

FT : Functional Test, third part of IT

IT : Industrial Test (CT, ET, FT)

FHITS : FHIT Software

mono-FHIT : One hybrid FHIT

PS : Power Supply

UCL : Université Catholique de Louvain

8 Appendix

This appendix gathers :

- the bibliography
- the **code** for serial messages sent to FHIT (easy-FHIT setup)
- the standard **labelsuser** by the CMS collaboration for FEH barcode.

References

- [1] L. Demaria, M. Meschini, F. Hartman, G. Dirkes: *Procedures for Module Test - Draft 1*, 18p (26/02/02)
- [2] FHIT group: *FHIT detailed guide*

8.1 Serial language to FHIT

FHIT and the computer communicate via the serial line. FHITS simply reads what FHIT is sending through the line, whatever it sends. In turn, FHITS can send well-defined messages to FHIT in the same way, but these messages must follow a given code. This code is written here. This code won't be useful for user, unless an easy-FHIT is used.

Before the beginning of the industrial test, the hybrid has to be identified (by scanning it). This will provide FHIT with some information about the hybrid (TIB or TOB), the FEHC board (TOP or BOTTOM) and the number of APV's on the hybrid. All the information needed is sent to FHIT with different characters, defined in Table 4. Please note that this language is case sensitive. The string always begins with the ':' character and ends with '\n' character. In between lie the different instructions⁹.

At the end of the industrial test, another message will be sent to FHIT, giving it the final result of the test from four different values¹⁰ : *Grade A*, *Grade B*, *Bad Hybrid* or *Test Failed*. Here is the sent character.

“A” Grade A: if hybrid has less than 0.2% bad channels

“B” Grade B: if hybrid has less than 0.5% bad channels

“E” Bad Hybrid: if more than 0.5% bad channels or any of MUX/PLL/DCU or APV25 fails

“F” Test Failed: if a fatal error occurred during the test

The characters “C” and “D” are free so they can be used if more hybrid grades are necessary in the future.

The summary of the code (and the corresponding Front LED color¹¹ when meaningful) is available in the Table 4.

Important things :

- every message must start with the : character and finish with \n¹².
- sending : remove every other character written after the last CR. So any mistake in the message can be corrected by rewriting the whole message before pressing CR.
- CT and ET can start after having plug an hybrid (top panel LED is Orange) by sending the message :Pxxxx\n, where xxxx has to be replace by the correct part number relative to the FEH.

⁹example : 'P1664s\n' sends the part number 1664 and starts the industrial test

¹⁰the hybrid grade definition is provided by [1], p10

¹¹for further details on the LED color, please have a look at Table 2

¹²With TeraTerm Pro, the \n is generated by a CR (press Enter)

Instruction	Meaning
Result of industrial test	
Ga	grade A hybrid green LED
Gb	grade B hybrid blinking green LED
Gc	grade C hybrid (if defined) orange LED
Gd	grade D hybrid (if defined) blinking orange LED
Ge	bad hybrid red LED
Gf	test failed blinking red LED
Settings	
S or s	starts the test
N4	hybrid with 4 APV's
N6	hybrid with 6 APV's
Innn	change V_{MIN}
Annn	change V_{MAX}
Occc	operator identifier (3 char max)
Pxxxx	part number (from digits 4..7 of the label)
F/f	enable/disable Local File
R/r	enable/disable reset pattern generation
T/t	enable/disable trigger pattern generation
U/u	enable/disable dual trigger pattern generation
Wapv,r,v	write apv register r with value v (Ex : W20,0a,f4\n)
Z or z	reset insertion
!nnnnn	change ARC timeout (default:60s)
:	First character of transmission
\n	Last character of transmission
DEBUG commands	
B/b	enable breakpoints
E/e	enable break on error mode
L/l	enable loop on error mode
M/m	enable break and print after measurements
V/v	verbose mode ON / OFF

Table 4: Serial Code to FHIT

- after the end of ET, FHIT is waiting to the hybrid grade to display on its front LED (result LED). So, user has to send either a grade message (as :Ga\n) or press the Start button

8.2 CMS label for hybrids

Here is the CMS standard labels :

1	2	3	4	5	6	7	8	9	10	11	12	13	14
3	0	2	*	*	*	*	x	x	x	x	x	x	x
part							part serial ID number						

The part number will give the information about the hybrid type (TOB/TIB, top/bottom, 4/6 APV's):

part#	TOB/TIB	top/bottom	4/6APV's
1663	TOB	t	4
1664	TOB	b	4
1665	TOB	t	6
1666	TOB	b	6
1667	TIB	t	4
1668	TIB	b	4
1669	TIB	t	6
1670	TIB	b	6

The digits 8 and 9 in the CMS standard label of an hybrid represent a sub-type (express-line, Dorazil prototype, ...). The digits between 10 and 14 are the hybrid serial number between 1 and 17 500.