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ICS Engineering Manual

FOR MRF MTCA-EVR-300

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1 Overview

At European Spallation Source (ESS), Integrated Control System (ICS) does use the Micro Research Finland (MRF) Timing System¹ as its timing system of the ESS site. The consistent and up-to-date engineering manual is essential for the ESS Timing system.

1.1 Scope

- This document identifies one of the MRF Timing Event Receivers (EVR) that needs to be configured for an ESS subsystem that needs synchronous frequencies, trigger signals and sequences of events [1].
- This document provides the generic description of the MRF MTCA-EVR-300 and its interface board (IFB-300). In addition, it affords the minimal, essential, and generic information for the system configuration.
- The purpose of this document is to describe the engineering procedure and troubleshooting about how the MRF MTCA-EVR-300 board will be integrated in cooperation with the ESS EPICS Environment (EEE).
- This document attempts to maintain consistency with existing ESS Timing system hardware as far as possible.

Note that this is a very early draft document and should be updated as development progresses.

1.2 Target Audience

This document is targeted to ICS engineers and technical stakeholders of the ESS timing system. It is assumed that the target audience has a technical background in the MRF Timing System, the EPICS development, and a Linux environment.

2 System Description

MRF Technical Reference [see 1, p45] explained Event Receivers and wrote :

Event Receivers decode timing events and signals from an optical event stream transmitted by an Event Generator. Events and signals are received at pre-defined rate the event clock that is usually divided down from an accelerators main RF reference. The event receivers lock to the phase event clock of the Event Generator and are thus phase locked to the RF reference. Event Receivers convert event codes transmitted by an Event Generator to hardware

¹<http://www.mrf.fi/>

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outputs. They can also generate software interrupts and store the event codes with globally distributed timestamps into FIFO memory to be read by a CPU.

ICS uses and will use the following different types of EVR :

- MTCA-EVR-300
- PCIe-EVR-300DC

The scope of this document is to cover MTCA-EVR-300 board.

2.1 MTCA-EVR-300

Figure 1 shows the rough physical dimensions $181 \times 148 \text{ mm}^2$ of the MTCA-EVR-300 card.

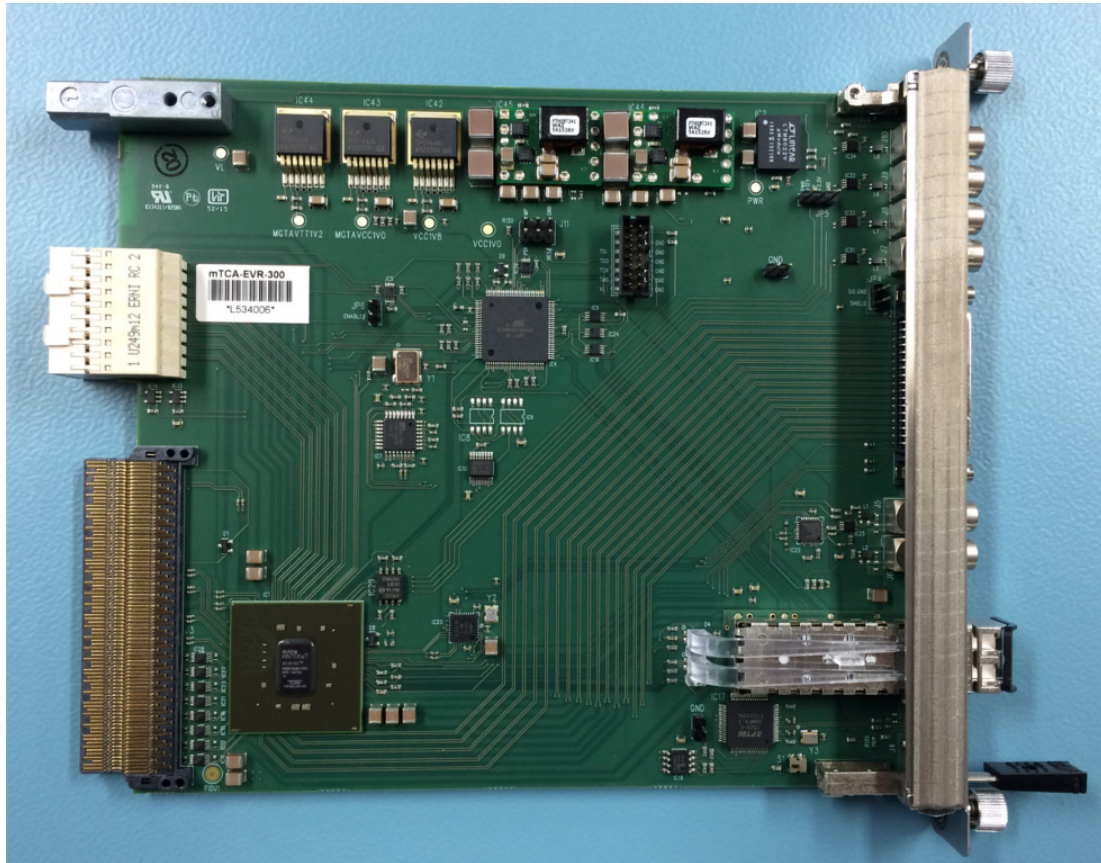


Figure 1 MRF MTCA-EVR-300 board.

The MTCA-EVR-300 has a SFP transceiver as an input from EVG and several outputs: 4 front panel outputs, 16 front universal outputs (through the IFB-300 extension

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board) and 40 rear outputs. The initial 32 rear outputs map to the RTM connector, the last 8 rear outputs map to the MTCA backplane. The 16 front universal outputs are implemented through a micro-SCSI type connector for an interface board IFB-300. The IFB-300 has eight Universal I/O slots, shown in Figure 2. With different type of MRF Universal I/O modules, each slot can be used as an unique trigger or event signal source.

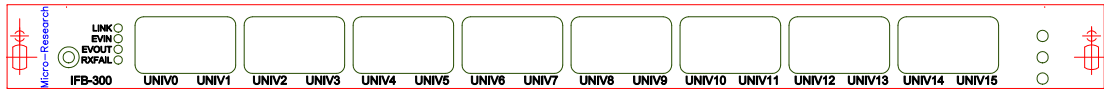


Figure 2 MRF Interface Board IFB 300 Front Panel [1].

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3 System Environment

Before describing the engineering procedure for an EEE integration of the MRF MTCA-EVR-300 board, it is mandatory to have proper system environment that consists of specific hardware and software lists. Here we will show the hardware and software lists, their block diagrams, and their setup in the ICS lab at ESS. The information shown in this chapter is used in the ICS Lab at ESS.

3.1 Hardware

Table 1 shows the hardware list and its environment. Here, TAG is used as the prefix of the ICS internal inventory system in order to track it down.

Hardware	Info	Serial Number
MRF MTCA-EVR-300	ICS TAG-???	???
NAT-MCH-PHYS	ICS TAG-???	???
Concurrent Technologies AMC CPU	ICS TAG-???, hostname: ???	???
ELMA MTCA crate 12 slots, 9U	ICS TAG-???	???
Wiener power supply unit 1000W	ICS TAG-???	???
Ethernet cables		???

Table 1 Hardware List and Its Environment.

Figure 3 shows the MTCA-EVR-300 setup in the lab. From left to right, the power supply, MCH, CPU, MTCA-EVR-300 and Struck SIS8300 (not used in this document).

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Figure 3 Hardware Setup in the ICS lab.

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3.2 Software

Table 2 shows the Software list and its environment. It is mandatory to check the kernel version, and the mrf kernel module version. Since the mrfioc2 is dependent upon devLibs2 EEE internally, an end-user is unnecessary to check its version explicitly.

Item	Version Info.
CentOS Linux	7.1.1503
Kernel	3.10.0-229.7.2.el7.x86_64
mrf kernel module	version : 1 / srcversion 9E849DD3775C8555B8B88BF
EEE	1.8.2
EPICS Base	3.15.4
mrfioc2	EEE module ver. 2.7.13
devLib2	EEE module ver. 2.7.0

Table 2 Software and its version information.

3.3 EVR Firmware

Table 3 shows EVR FPGA Firmware Version Register.

EVR FPGA Firmware Version Register	0x18000207	
Board Type	EVR	0x18000207
Form Factor	mTCA.4	0x18000207
EVR Firmware ID	Delay Compensation Firmware	0x18000207
EVR Revision ID	7	0x18000207

Table 3 EVR FPGA Firmware Version Register in Reference [see 1, p66].

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4 Engineering Procedure

This chapter provides the minimal information to configure the EVR board properly.

4.1 System Installation

Figure 3 shows the glimpse of what system might be like in a Lab. **Note that the cable between the mTCA-EVR-300DC and IFB-300 (not shown in the figure) should be connected, disconnected, or both only when powered down.** Please see the detail information in Reference [1, p54].

It is assumed that the MTCA-EVR-300 is installed in a crate with a CPU running CentOS 7.1 with EEE.

4.2 mTCA-EVR-300 Board Identification

4.2.1 Fixing PCI IDs

The PCI ID list does not include the MRF products. It can be updated as follows:

- Cloning the sort of ESS customized PCI.IDS db:

```
iocuser@localhost: ics_gitsrc$ git clone https://github.com/jeonghanlee/pciids
```

- Replace the pci.ids file:

```
iocuser@localhost: pciids (master)$ bash replace-pciids.bash
centos was determined.
[sudo] password for iocuser:
```

- Check MRF products by the ventor's id (1a3e):

```
iocuser@localhost: pciids (master)$ lspci -nmmn | grep -E "\<(1a3e)"
05:00.0 "Signal processing controller [1180]" "Xilinx Corporation [10ee]" "XILINX PCI
DEVICE [7011]" "Micro-Research Finland Oy [1a3e]" "MTCA Event Receiver 300 [132c]"
```

4.2.2 Setting up MRF environment

The MTCA-EVR-300 needs a kernel module to work. It can be installed by simply running a script. Do the following:

- Get the script:

```
iocuser@localhost: ics_gitsrc$ git clone https://github.com/icshwi/icsem_scripts
```

- Check the information:

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```

iocuser@localhost: icsem_scripts (master)$ bash mrf_setup.bash

usage: mrf_setup.bash <arg>

    <arg> : info

    show  : show the found mrf boards information

    pac   : mrf package from ESS (do not use now)
            We are working on this....

    src   : compile kernel module from git repository
            https://bitbucket.org/europeanspallationsource/m-epics-mrfioc2
            tag name : ess-2-7

    rule  : put only the mrf kernel and udev rules

iocuser@localhost: icsem_scripts (master)$ bash mrf_setup.bash show

We've found the MRF boards as follows:
-----
05:00.0 "Signal processing controller [1180]" "Xilinx Corporation [10ee]" "XILINX PCI
        DEVICE [7011]" "Micro-Research Finland Oy [1a3e]" "MTCA Event Receiver 300 [132c]"

```

- Install the kernel module:

```

iocuser@localhost: icsem_scripts (master)$ bash mrf_setup.bash src
[sudo] password for iocuser:

>>>> You are entering in : git_compile_mrf

>>>> You are entering in : git_clone
No git source repository in the expected location /home/iocuser/ics_gitsrc/icsem_scripts/m-epics-mrfioc2
Cloning into '/home/iocuser/ics_gitsrc/icsem_scripts/m-epics-mrfioc2'...
remote: Counting objects: 460, done.
remote: Compressing objects: 100% (364/364), done.
remote: Total 460 (delta 156), reused 246 (delta 84)
Receiving objects: 100% (460/460), 1.76 MiB | 1.34 MiB/s, done.
Resolving deltas: 100% (156/156), done.

<<<< You are leaving from : git_clone
~/ics_gitsrc/icsem_scripts/m-epics-mrfioc2/mrmShared/linux ~/ics_gitsrc/icsem_scripts
make -C /lib/modules/3.10.0-229.7.2.el7.x86_64/build M=/home/iocuser/ics_gitsrc/
icsem_scripts/m-epics-mrfioc2/mrmShared/linux modules
make[1]: Entering directory '/usr/src/kernels/3.10.0-229.7.2.el7.x86_64'
CC [M] /home/iocuser/ics_gitsrc/icsem_scripts/m-epics-mrfioc2/mrmShared/linux/uio_mrf.o
CC [M] /home/iocuser/ics_gitsrc/icsem_scripts/m-epics-mrfioc2/mrmShared/linux/jtag_mrf.o
LD [M] /home/iocuser/ics_gitsrc/icsem_scripts/m-epics-mrfioc2/mrmShared/linux/mrf.o
Building modules, stage 2.
MODPOST 1 modules
CC /home/iocuser/ics_gitsrc/icsem_scripts/m-epics-mrfioc2/mrmShared/linux/mrf.mod.o
LD [M] /home/iocuser/ics_gitsrc/icsem_scripts/m-epics-mrfioc2/mrmShared/linux/mrf.ko
make[1]: Leaving directory '/usr/src/kernels/3.10.0-229.7.2.el7.x86_64'
make -C /lib/modules/3.10.0-229.7.2.el7.x86_64/build M=/home/iocuser/ics_gitsrc/
icsem_scripts/m-epics-mrfioc2/mrmShared/linux modules_install
make[1]: Entering directory '/usr/src/kernels/3.10.0-229.7.2.el7.x86_64'
INSTALL /home/iocuser/ics_gitsrc/icsem_scripts/m-epics-mrfioc2/mrmShared/linux/mrf.ko
Can't read private key
DEPMOD 3.10.0-229.7.2.el7.x86_64
make[1]: Leaving directory '/usr/src/kernels/3.10.0-229.7.2.el7.x86_64'

```

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```

make -C /lib/modules/3.10.0-229.7.2.el7.x86_64/build M=/home/iocuser/ics_gitsrc/
icsem_scripts/m-epics-mrfioc2/mrmShared/linux clean
make[1]: Entering directory '/usr/src/kernels/3.10.0-229.7.2.el7.x86_64'
CLEAN /home/iocuser/ics_gitsrc/icsem_scripts/m-epics-mrfioc2/mrmShared/linux/.
tmp_versions
CLEAN /home/iocuser/ics_gitsrc/icsem_scripts/m-epics-mrfioc2/mrmShared/linux/Module.
symvers
make[1]: Leaving directory '/usr/src/kernels/3.10.0-229.7.2.el7.x86_64'
~/ics_gitsrc/icsem_scripts

<<<< You are leaving from : git_compile_mrf

>>>> You are entering in : modprobe_mrf

<<<< You are leaving from : modprobe_mrf

>>>> You are entering in : put_mrf_rule
Put the rule : mrf in /etc/modules-load.d/mrf.conf to load the mrf module at boot time.
mrf
<<<< You are leaving from : put_mrf_rule

>>>> You are entering in : put_udev_rule
Put the rule : KERNEL=="uio*", ATTR{name}=="mrf-pci", MODE="0666" in /etc/udev/rules.d/99-
mrfioc2.rules to be accessible via an user.
KERNEL=="uio*", ATTR{name}=="mrf-pci", MODE="0666"
<<<< You are leaving from : put_udev_rule
0: SCRPTIT : /home/iocuser/ics_gitsrc/icsem_scripts/mrf_setup.bash
1: SCRIPT NAME : mrf_setup.bash
2: SCRIPT TOP : /home/iocuser/ics_gitsrc/icsem_scripts
3: LOGDATE : 2017Feb06-1435-02CET
4: filename: /lib/modules/3.10.0-229.7.2.el7.x86_64/extra/mrf.ko
author: Michael Davidsaver <mdavidsaver@bnl.gov>
version: 1
license: GPL v2
rhelversion: 7.1
srcversion: 9E849DD3775C8555B8B88BF
depends: parport,uio
vermagic: 3.10.0-229.7.2.el7.x86_64 SMP mod_unload modversions
parm: cable:Name of JTAG parallel port cable to emulate (charp)
parm: interfaceversion:User space interface version (int)
5: mrf 17592 0
uio 19259 1 mrf
parport 42348 1 mrf

```

- Check kernel module information:

```

iocuser@localhost: icsem_scripts (master)$ lsmod |grep mrf
mrf 17592 0
uio 19259 1 mrf
parport 42348 1 mrf
iocuser@localhost: icsem_scripts (master)$ modinfo mrf
filename: /lib/modules/3.10.0-229.7.2.el7.x86_64/extra/mrf.ko
author: Michael Davidsaver <mdavidsaver@bnl.gov>
version: 1
license: GPL v2
rhelversion: 7.1
srcversion: 9E849DD3775C8555B8B88BF
depends: parport,uio
vermagic: 3.10.0-229.7.2.el7.x86_64 SMP mod_unload modversions
parm: cable:Name of JTAG parallel port cable to emulate (charp)
parm: interfaceversion:User space interface version (int)

```

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Check that the source version is the same as shown; it should be if these steps are followed as shown. Otherwise please inform ICS.

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4.3.3 EPICS IOC

Under EEE, the EPICS IOC can be started via the command `iocsh test_evr-mtca-300.cmd`. The output should look like as follows:

```
iocuser@localhost: mtca-evr-300 (master)$ iocsh test_evr-mtca-300.cmd
/opt/epics/bases/base-3.15.4/bin/centos7-x86_64/softIoc -D /opt/epics/bases/base-3.15.4/dbd/
softIoc.dbd /tmp/iocsh.startup.4388
#date="Mon Feb 6 14:50:24 CET 2017"
#user="iocuser"
#PWD="/home/iocuser/ics_gitsrc/icsem_scripts/mtca-evr-300"
#EPICSVERSION="3.15.4"
#EPICS_HOST_ARCH="centos7-x86_64"
#SHELLBOX=""
#EPICS_CA_ADDR_LIST=""
#EPICS_MODULE_INCLUDE_PATH=".:usr/lib64:/usr/lib:/lib64:/lib"
dload /opt/epics/modules/environment/1.8.2/3.15.4/lib/centos7-x86_64/libenvironment.so
dbLoadDatabase /opt/epics/modules/environment/1.8.2/3.15.4/dbd/environment.dbd
environment_registerRecordDeviceDriver
< "test_evr-mtca-300.cmd"
# -*- mode: epics -*-
# $ iocsh test_evr-mtca-300.cmd
require mrfioc2,2.7.13
require: mrfioc2 depends on devlib2 (2.7+).
require: Loading library /opt/epics/modules/devlib2/2.7.0/3.15.4/lib/centos7-x86_64/libdevlib2.so.
require: Loading /opt/epics/modules/devlib2/2.7.0/3.15.4/dbd/devlib2.dbd.
require: Calling devlib2_registerRecordDeviceDriver function.
require: Loading library /opt/epics/modules/mrfioc2/2.7.13/3.15.4/lib/centos7-x86_64/libmrfioc2.so
.
require: Adding /opt/epics/modules/mrfioc2/2.7.13/db.
require: Adding /opt/epics/modules/mrfioc2/2.7.13/startup.
require: Loading /opt/epics/modules/mrfioc2/2.7.13/3.15.4/dbd/mrfioc2.dbd.
require: Calling mrfioc2_registerRecordDeviceDriver function.
epicsEnvSet( "SYS" "MTCA424")
epicsEnvSet( "EVR" "EVRO")
epicsEnvSet( "EVR_BUS" "0x05")
epicsEnvSet( "EVR_DEV" "0x00")
epicsEnvSet( "EVR_FUNC" "0x0")
epicsEnvSet("EVR_DOMAIN" "0x0000")
mrmEvrSetupPCI(EVR0, 0x0000, 0x05, 0x00, 0x0)
Device EVR0 5:0.0
Using IRQ 17
Setting magic LE number!
FPGA version 0x18000207
Firmware version: 00000207
Found EVR0:SFP0 SFP transceiver
Flash access: this form factor is not supported.
MTCA: Out FP:4 FPUNIV:16 RB:40 IFP:2 GPIO:0
dbLoadRecords("evr-mtca-300.db", "DEVICE=EVRO, SYS=MTCA424, Link-Clk-SP=88.0525")
iocInit
Starting iocInit
#####
## EPICS R3.15.4-2016-05 $$Date$$
## EPICS Base built May 31 2016
#####
MTCA424-EVRO:Time-Src-Sel_: read error: TS Clock rate invalid
Set EVR clock 88052500.000000
iocRun: All initialization complete
epicsEnvSet IOCSH_PS1,"localhost> "
```

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4.3.4 Checking automatic configuration after reboot

Reboot and check that the module is loaded and the IOC correctly starts:

```
iocuser@localhost: ~$ lsmod |grep mrf
mrf                17592  0
uio                 19259  1 mrf
parport            42348  1 mrf
iocuser@localhost: ~$ cd ics_gitsrc/icsem_scripts/mtca-evr-300/
iocuser@localhost: mtca-evr-300 (master)$ iocsh test_evr-mtca-300.cmd
/opt/epics/bases/base-3.15.4/bin/centos7-x86_64/softIoc -D /opt/epics/bases/base-3.15.4/dbd/
softIoc.dbd /tmp/iocsh.startup.2998
#date="Mon Feb  6 15:10:42 CET 2017"
#user="iocuser"
#PWD="/home/iocuser/ics_gitsrc/icsem_scripts/mtca-evr-300"
#EPICSVERSION="3.15.4"
#EPICS_HOST_ARCH="centos7-x86_64"
#SHELLBOX=""
#EPICS_CA_ADDR_LIST=""
#EPICS_MODULE_INCLUDE_PATH=".:usr/lib64:/usr/lib:/lib64:/lib"
dload /opt/epics/modules/environment/1.8.2/3.15.4/lib/centos7-x86_64/libenvironment.so
dbLoadDatabase /opt/epics/modules/environment/1.8.2/3.15.4/dbd/environment.dbd
environment_registerRecordDeviceDriver
< "test_evr-mtca-300.cmd"
#  -*- mode: epics -*-
# $ iocsh test_evr-mtca-300.cmd
require mrfioc2,2.7.13
require: mrfioc2 depends on devlib2 (2.7+).
require: Loading library /opt/epics/modules/devlib2/2.7.0/3.15.4/lib/centos7-x86_64/libdevlib2.so.
require: Loading /opt/epics/modules/devlib2/2.7.0/3.15.4/dbd/devlib2.dbd.
require: Calling devlib2_registerRecordDeviceDriver function.
require: Loading library /opt/epics/modules/mrfioc2/2.7.13/3.15.4/lib/centos7-x86_64/libmrfioc2.so
.
require: Adding /opt/epics/modules/mrfioc2/2.7.13/db.
require: Adding /opt/epics/modules/mrfioc2/2.7.13/startup.
require: Loading /opt/epics/modules/mrfioc2/2.7.13/3.15.4/dbd/mrfioc2.dbd.
require: Calling mrfioc2_registerRecordDeviceDriver function.
epicsEnvSet( "SYS" "MTCA424")
epicsEnvSet( "EVR" "EVR0")
epicsEnvSet( "EVR_BUS" "0x05")
epicsEnvSet( "EVR_DEV" "0x00")
epicsEnvSet( "EVR_FUNC" "0x0")
epicsEnvSet("EVR_DOMAIN" "0x0000")
mrmEvrSetupPCI(EVR0, 0x0000, 0x05, 0x00, 0x0)
Device EVR0 5:0.0
Using IRQ 17
Setting magic LE number!
FPGA version 0x18000207
Firmware version: 00000207
Found EVR0:SFP0 SFP transceiver
Flash access: this form factor is not supported.
MTCA: Out FP:4 FPUNIV:16 RB:40 IFP:2 GPIO:0
dbLoadRecords("evr-mtca-300.db", "DEVICE=EVR0, SYS=MTCA424, Link-Clk-SP=88.0525")
iocInit
Starting iocInit
#####
## EPICS R3.15.4-2016-05 $$Date$$
## EPICS Base built May 31 2016
#####
Set EVR clock 88052500.000000
iocRun: All initialization complete
epicsEnvSet IOCSH_PS1,"localhost> "
```

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localhost>

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Bibliography

- [1] MRF Technical Reference. *Event System with Delay Compensation Technical Reference Firmware 0205*, April 26, 2016.