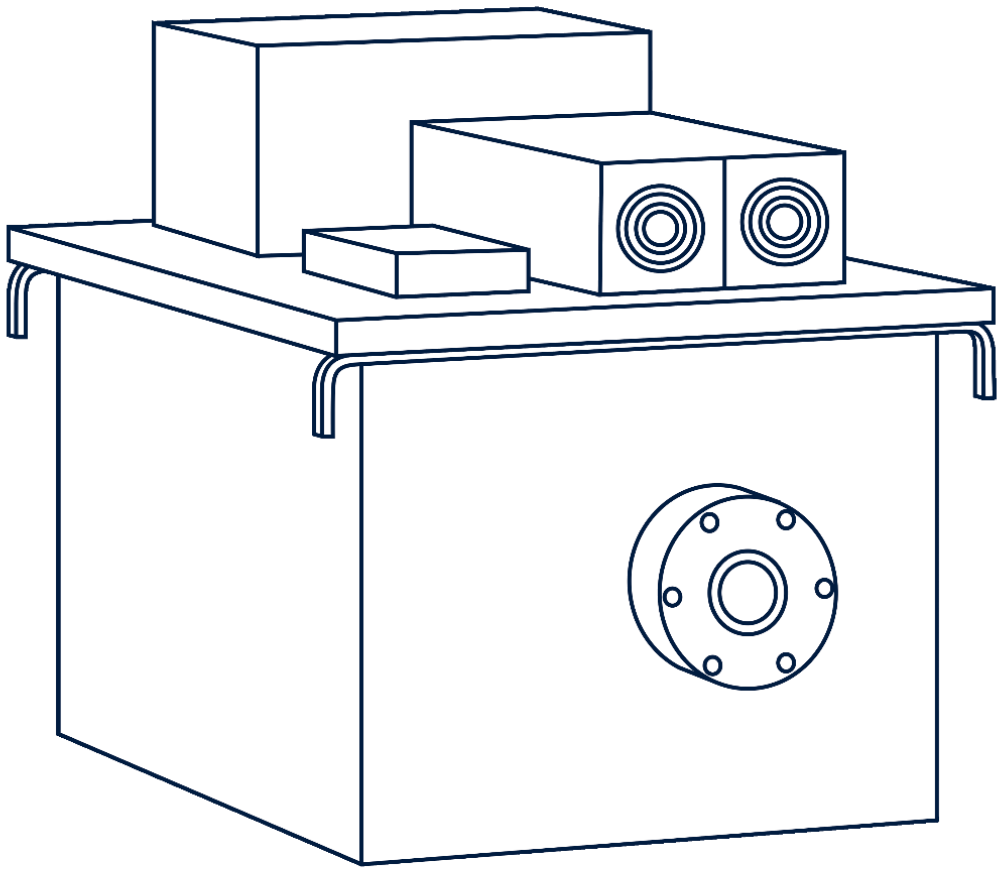
Integrator manual

iVario Status

Details of status, warnings, not ready and shutdown conditions - SW V.4.0.0



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1 Scope

This document describes the system status, the warning-, the not-ready-, the shutdown- and the error codes.

All these codes help for a better diagnosis and a better overview about the state of the iVario generator.

2 System status

The system status contains information about the state of the iVario generator. It consists of 3 values determining the operating mode (2 more are reserved for future use), the iVario generator status and the HV ON status.

System Status	Operation Status	Operation Sub-Status	*Reserved*	*Reserved*

The system status is a top down structure (from left to right).

1. Layer: System Status -> 2. Layer: Operating Status -> 3. Layer: Operation Sub-Status.

Example (T3-Protocol): SYSSTAT=2,7,80,0,0
System is ramping up the high voltage. For more details about the interpretation read the following chapters.

2.1 System status

The system status reflects the state of the top-level state-machine and has the following states:

Status	Name	Description
1,0,0,0,0	Boot	HVPS is booting / starting up
2,x,x,0,0	Normal	Normal operation
3,x,x,0,0	Warmup	Warm-Up operation (warmup required or running)
0xFFFFFFFF	Severe Error	Severe error

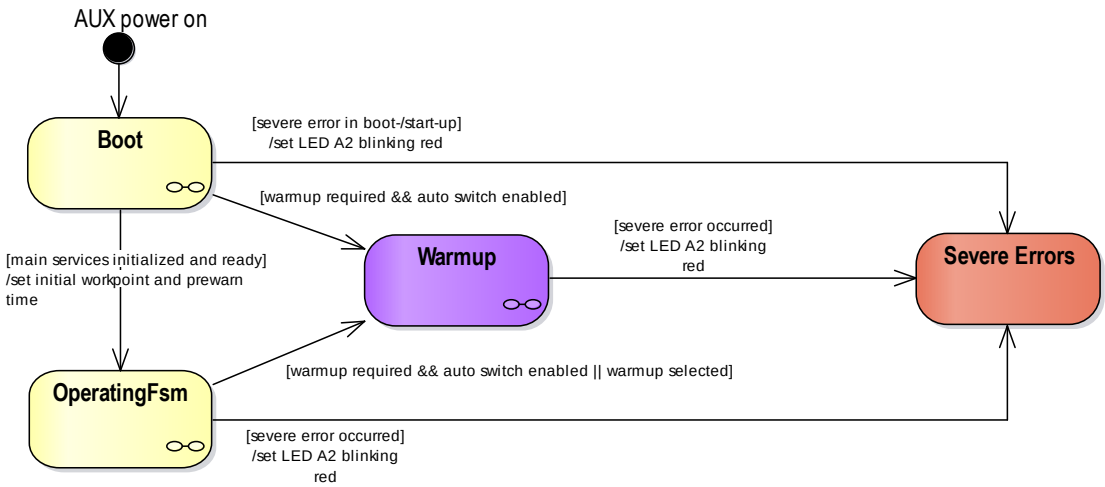

Fig. 1: Top level state machine (state event diagram)

2.2 Operation status

The operation status reflects the sub status of the status defined by the top level state machines

2.2.1 Normal operation

In normal operation the operation status contains the following states:

Status	Description	Sub-Status
2,0,0,0,0	Initializing	0
2,1,0,0,0	Not ready	0
2,2,0,0,0	Cooler check	0
2,3,0,0,0	Safely ready	0
2,4,0,0,0	MAINS check	0
2,5,0,0,0	Ready	0
2,6,0,0,0	Prewarn	0
2,7,x,0,0	HV-Operation	Section 2.3.1
2,8,0,0,0	Error (e.g. irregular shutdown)	0

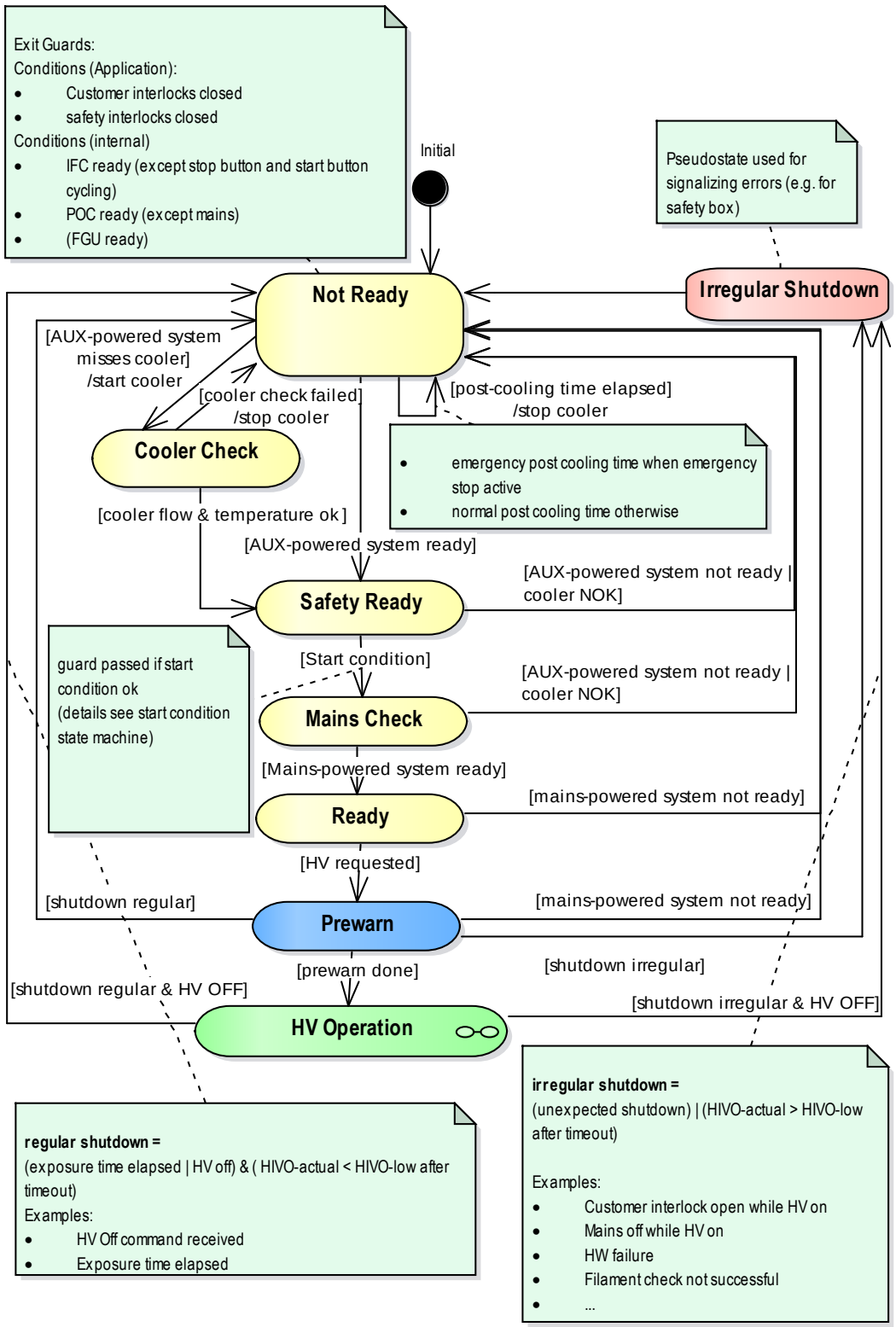

Fig. 2: Detailed main normal operating state machine (state event diagram)

2.2.2 Warm-up operation

In warm-up operation the operation status contains the following states:

Status	Description	Sub-Status
3,0,0,0,0	Initializing	0
3,1,0,0,0	Not ready	0
3,2,0,0,0	Cooler check	0
3,3,0,0,0	Safely ready	0
3,4,0,0,0	MAINS check	0
3,5,x,0,0	Ready	Section 2.3.2
3,6,0,0,0	Prewarn	0
3,7,x,0,0	HV-Operation	Section 2.3.3
3,8,0,0,0	Error (e.g. irregular shutdown)	0

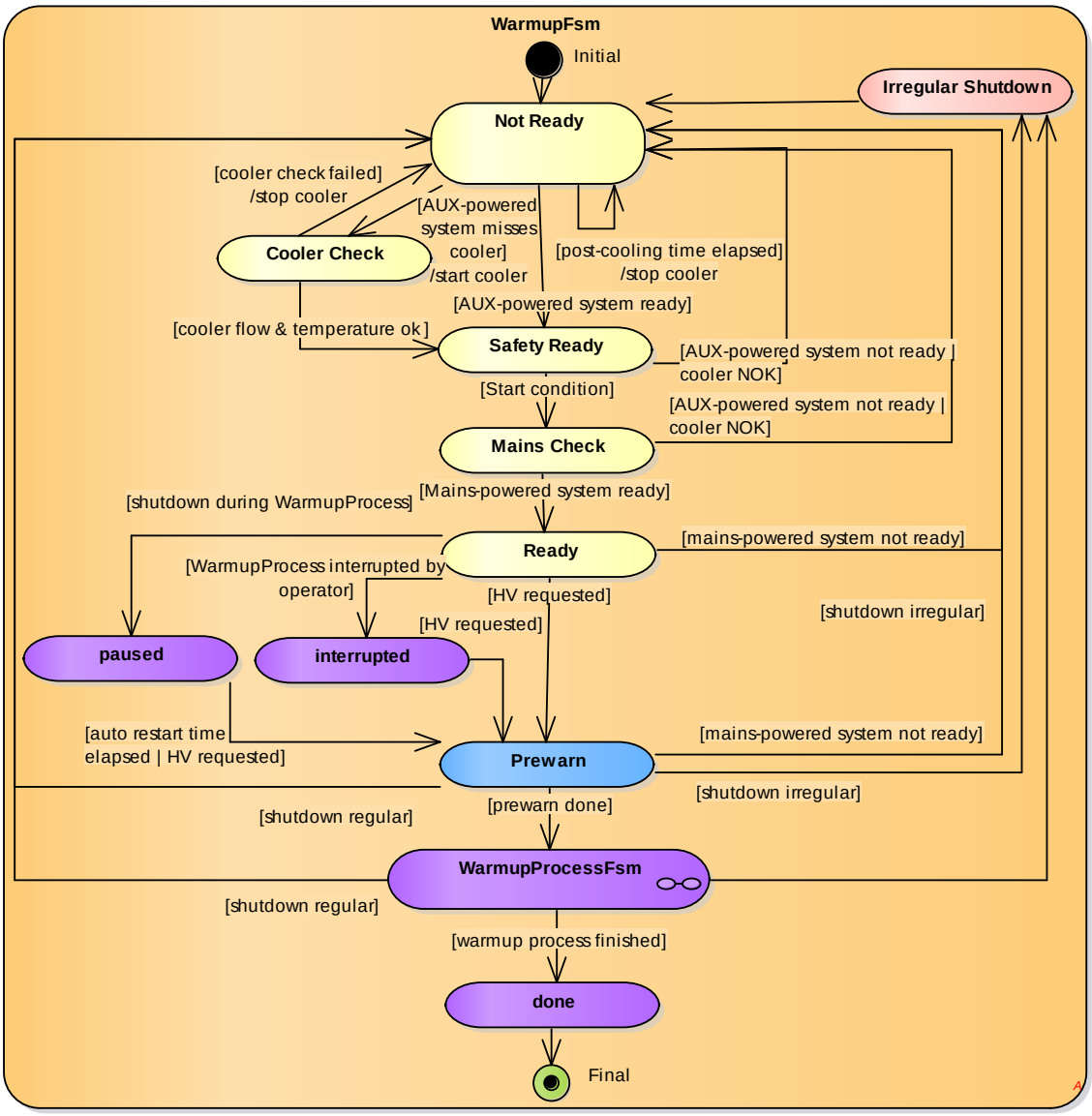

Fig. 3: Detailed main warm-up state machine (state event diagram)

2.3 Operation sub-status

The operation sub-status reflects the sub status defined by the operating state machines.

2.3.1 Normal operation (HV operation)

In “normal operation” the “Generating HV” sub-status contains the following states:

Sub-Status	Description
2,7,0,0,0	HV OFF
2,7,50,0,0	Prepared (e.g. safety check, HV pulse, etc.)
2,7,80,0,0	Ramping
2,7,100,0,0	Setpoint reached
2,7,120,0,0	Post heating
2,7,130,0,0	HV Extant (unsafe HV level)

2.3.2 Warm-up operation (ready)

In “warm-up operation” the “ready state” sub-status contains the following states:

Sub-Status	Description
3,5,0,0,0	Initializing
3,5,10,0,0	Interrupted (by command)
3,5,20,0,0	Paused (paused due to shutdown)

2.3.3 Warm-up Operation (Generating HV)

In “warm-up operation” the “generating HV” sub-status contains the following states:

Sub-Status	Description
3,7,0,0,0	Initializing
3,7,1,0,0	Starting up
3,7,2,0,0	Filament heating
3,7,3,0,0	Post filament heating
3,7,4,0,0	HV ramping
3,7,5,0,0	HV stabilization
3,7,6,0,0	Current ramping
3,7,7,0,0	Stabilization

3 Not-ready codes

3.1 General overview

The not-ready codes are hierarchically structured as shown in the following figure. They define the “not ready” condition (not-ready to drive high voltage) for the iVario generator. They can be used for a detailed analysis and finding reasons why the iVario generator is not reaching the “Ready” state and no HV can be generated (operating state is any state before “Ready” see also chapter 2.2 for more details).

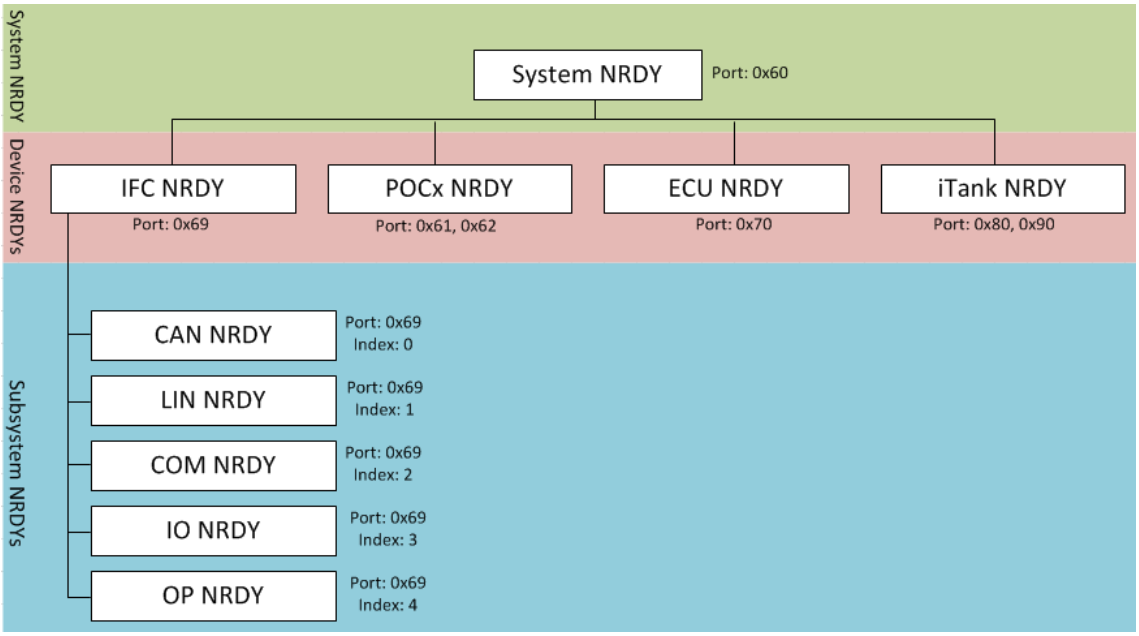

Fig. 4: General information

As top-down explanation:

- The not-ready code of the **iVario generator** signals the concerned device that is not-ready
- Each **component** signals over its not-ready code which part (if available) is not ready
- Each **part / sub-component** (if available) signals over its not-ready why it is not ready

All not-ready codes are 32-bit registers from where each bit is OR able (one or more bits can be signalized).

If a not-ready code is 0 (0x00000000) the concerned iVario generator part is ready.

3.2 Not-ready code of the iVario generator

The not-ready code of the iVario generator signals which devices are not ready.

Bit	Device	Description
0	IFC	The IFC is not ready
1	POC1	The POC1 is not ready
2	POC2	The POC2 is not ready
4	ECU	The ECU is not ready
6	Cathode iTank	The cathode tank is not ready
6	Anode iTank	The anode tank is not ready
31	general	General not-ready flag (flag is set when at least one of the other flags is set)

Example: The IFC is not ready, the component not-ready code would be `0x80000001`

3.3 Not-ready codes of the IFC

The IFC contains different sub-components. Each sub-component holds its own not-ready code. The IFC not-ready code shows in detail which sub-component in not ready.

Bit	Sub-component	Description
0	CAN	One of the CAN devices is not ready
1	LIN	The LIN sub-component is not ready
2	COM	The COM sub-component is not ready
3	IO	The Input/Output sub-component is not ready
4	OP	The operation sub-component is not ready
31	general	General IFC not-ready flag

NOTE: The general IFC not-ready flag is set when at least one of the other flags is set.

3.3.1 Not-ready codes of the IFC sub-component CAN

The sub-component CAN comprises information about the CAN communication.

Code	Description
0x00000001	Initializing
0x00000002	Missing CAN device
0x80000000	Error state

3.3.2 Not-ready codes of the IFC sub-component LIN

The sub-component LIN comprises information about the LIN communication.

Code	Description
0x00000001	Initializing
0x80000000	Error state

3.3.3 Not-ready codes of the IFC sub-component COM

The sub-component COM comprises information about the external communication, i.e. the communication over Ethernet and RS232.

Code	Description
0x00000001	Initializing
0x00000002	com-guard not ready (restrictively guarded client missing)
0x80000000	Error state

3.3.4 Not-ready codes of the IFC sub-component IO

The following table shows the not-ready register for the IFC sub-component IO with the detailed flag definition. These flags are logically ORed, i.e. when the *customer interlock 1* and *customer interlock 2* are open, the not-ready code would be `0x00000018`.

Code	Description
0x00000001	Cooler flow missing
0x00000002	Cooler temperature not available
0x00000004	Stop button active
0x00000008	Customer interlock 1 open
0x00000010	Customer interlock 2 open
0x00000020	Cycle start button
0x00000040	Press start button
0x00000100	O_Key not available (only with optional control panel)
0x00000200	O_Stop button active (only with optional control panel)
0x00000400	O_Start button cycle needed (only with optional control panel)
0x00000800	Shortcut detected in light monitoring
0x20000000	Configuration failure
0x40000000	Initializing
0x80000000	Error state

3.3.5 Not-ready codes of the IFC sub-component OP

The following table shows the not-ready register for the IFC sub-component OP with the detailed flag definition. These flags are logically ORed.

Code	Description
0x00000001	Initializing
0x00000002	Temperature too low
0x00000004	Temperature too high
0x00000008	Focal spot change on-going
0x40000000	Error during start-up
0x80000000	Error state

3.4 Not-ready codes of the POC

The following table shows the not-ready register for the POC with the detailed flag definition. These flags are logically ORed, i.e. when the circuits *safety interlock* and *emergency stop* are open, the not-ready code would be `0x00000030`.

Code	Description
0x00000001	Powercell defective
0x00000002	Mains too low or Powercell defective
0x00000004	Mains power not available
0x00000008	Arc signals not in default state
0x00000010	Safety Interlock circuit open
0x00000020	Emergency Stop circuit open
0x00000080	Mains > 330VAC, overvoltage detected
0x00000100	Filament Check failed
0x00000800	Safety CPU in error state
0x00004000	Temperature Powercell too high
0x00080000	Fan motor not turning
0x80000000	System is booting OR no communication (IFC <-> POC)

3.5 Not-ready codes of the ECU

The following table shows the not-ready register for the ECU with the detailed flag definition. These flags are logically ORed, i.e. when the *'+24V supply out of Range*' and '*Grid Voltage out of range error*' are set, the not-ready code would be `0x00000028`.

Code	Description
0x00000001	-5V supply out of range
0x00000002	+5V supply out of range
0x00000004	+12V out of range
0x00000008	+24V supply out of Range
0x00000010	ECU heater lost
0x00000020	Grid voltage out of range
0x00000040	CAN heartbeat of IFC missing
0x00000080	Oil temperature out of range
0x00000100	Board temperature out of range
0x00000200	Severe error
0x80000000	System is booting OR no communication (IFC <-> ECU)

3.6 Not-ready codes of the Cathode/Anode iTank

The Cathode/Anode iTank have the following NRDY codes.

Code	Description
0x00000001	Initializing
0x00000002	Wrong Focal Spot
0x80000000	Error state

4 Warnings

The iVario generator warns the operator when a specific measured value is running out of tolerance. A warning may increase the danger, e.g. for the iVario generator itself, the application or for the superior system where the iVario generator is built in.

The warning code contains the following information:

Code	Description
0x00000001	Arc active
0x00000002	HV too high
0x00000004	HV too low
0x00000008	Emission current too high
0x00000010	Emission current too low
0x00000020	Grid voltage too high
0x00000040	Grid voltage too low
0x00000080	POC1 temperature critical
0x00000100	POC2 temperature critical
0x00000400	IFC temperature critical
0x00000800	Cathode tank temperature critical
0x00001000	Anode tank temperature critical
0x00002000	ECU temperature critical
0x00004000	HV too high after post heating
0x00008000	Short warm-up required
0x00010000	Medium warm-up required
0x00020000	Long warm-up required
0x00080000	System unstable (CPU load, DS load, Mem Load)
0x00100000	Power supply voltage reached critical level
0x00400000	Filament check skipped
0x00800000	Arc during HV recovery

The warning code is a 32-bit register from where each bit is ORable (one or more bits can be signalized).

Example:

1. The cathode and anode tank temperatures reached a critical limit
   --> the warning code would be 0x00001800.
2. An arc is active and the iVario generator is running the arc handling process
   --> the warning code would be 0x00000001.

5 Shutdown reasons

5.1 General overview

If the iVario generator needs to switch high voltage OFF, it provides a code defining the reason of it – called shutdown reason. Currently there are regular (expected) and irregular (unexpected) shutdown reasons available.
The shutdown reason is set when the iVario generator starts switching the high voltage OFF and is cleared (all values set to 0) at next accepted HV ON command.

The shutdown reason is constructed as a coma separated triple of numbers:

```
Source, Code, Detail
```

- Source
  - The SOURCE that causes the iVario generator to switch OFF high voltage
- Code
  - The CODE of the shutdown cause
- Detail
  - The DETAIL belonging to the shutdown code (more detailed information to the cause)

This construction makes a precise diagnosis possible. The source determines which component or part / sub-component is causing the shutdown. To each source the code and detail of the shutdown reasons describe precisely why the iVario generator was shut down.

The following sections describe how to read the shutdown reason, describe which sources are available in the iVario generator and describe their shutdown codes and detail.

5.2 How to interpret the shutdown reason

The triple of numbers is interpreted as follows:

```
Source causes a shutdown because of Code, Detail
```

Example:

```
Source = 1, Code = 1, Detail = 1
```

➔ **POC1 causes a shutdown because the exposure timer elapsed**

5.3 Sources of the shutdown reason

With the information about the source causing the shutdown, it is possible to determine from where the trigger of the shutdown is coming.

Source	Name	Description
1	POC1	Shutdown triggered by the POC1 (powercell number 1)
2	POC2	Shutdown triggered by the POC2 (powercell number 2)
4	ITF	Shutdown triggered by an external interface
5	IO	Shutdown triggered by an I/O
6	OP	Shutdown triggered by operation
7	INT	Shutdown triggered by internal communication (CAN/LIN
8	ECU	Shutdown triggered by the ECU

5.4 Shutdown code and detail of “Powercell” (POC)

The source of the POC can be 1 or 2 depending on the number of available POCs and depending on their position on the iVario generator. The following table shows the possible shutdown code and detail of a POC.

Src	Code	Detail	Description	Regular Shutdown
1/2	1	1	OFF command	X
1/2	10	1 2	HV too high HV too low	
1/2	11	1 2	Emission too high Emission too low	
1	12	0	Filament current out of tolerance	
1/2	20	0	Inlet temperature out of range	
1/2	22	0	FAN current out of range	
1/2	30	0 1 2 3	Main power missing Mains too low or powercell defective Powercell defective Mains > 330VAC, overvoltage detected	
1/2	31	0	PFC voltage failure	
1/2	42	0	IFC heartbeat missing (communication loss)	
1/2	43	0	Communication reset while operating	
1/2	44	0	Operating mode changed	
1	45	1	Filament test failed	
1/2	46	10 11 13	HV pulse timed out (HV value not reached) HV pulse voltage too high HV pulse on Anode, timeout due to Cathode still in prewarn	
1/2	48	0	Rampdown failure (HV and current out of range)	
1/2	51	1 2	Primary current out of tolerance Remote POC is unbalanced with this POC	
1/2	60	1	Safety interlock open	
1/2	61	1	Emergency stop open	
1/2	64	0	Communication issue POC <-> Safety CPU	
1/2	80	10 20 30 40	Too many arcs within arc processing window Arc recovery timed out BOP restart failed ILIM restart failed	

5.5 Shutdown code and detail of “internal communication” (INT)

The following table shows the possible shutdown code and detail of this part.

Src	Code	Detail	Description	Regular Shutdown
7	1	1 2 3	POC1 heartbeat missing (communication loss) POC2 heartbeat missing (communication loss) ECU heartbeat missing (communication loss)	
7	2	1 2 3	Boot-up of POC1 while operating Boot-up of POC2 while operating Boot-up of ECU while operating	
7	3	0	Runtime reconfiguration triggered while operating	

5.6 Shutdown code and detail of “external interfaces” (ITF)

The following table shows the possible shutdown code and detail of this part.

Src	Code	Detail	Description	Regular Shutdown
4	1	0	OFF command	X
4	2	0 1 2 3	Guarded communication on tcp-port 50506 Guarded communication on tcp-port 50505 Guarded communication on tcp-port 50507 Guarded communication on serial port	

5.7 Shutdown code and detail of “I/O” (IO)

The following table shows the possible shutdown code and detail of this part.

Src	Code	Detail	Description	Regular Shutdown
5	1	1 2	Stop button pressed O_Stop button pressed	X X
5	2	1 2	Cooler flow not available Cooler temperature not available	
5	3	1 2	Customer interlock 1 opened Customer interlock 2 opened	
5	4	1 2 3 4	Warning light 1 current incorrect/out of range Warning light 2 current incorrect/out of range Warning light 3 current incorrect/out of range Warning light 4 iVario-controller defective	
5	5	0	Dynamic monitoring contact incorrect	
5	6	0	Optional key switch incorrect	

5.8 Shutdown code and detail of “operation” (OP)

The following table shows the possible shutdown code and detail of this part.

Src	Code	Detail	Description	Regular Shutdown
6	1	1	Warm-up finished	X
6	2	2 3	IFC temperature too low IFC temperature too high	
6	3	2 3	Cathode tank temperature too low Cathode tank temperature too high	
6	4	2 3	Anode tank temperature too low Anode tank temperature too high	
6	5	2 3	POC1 tank temperature too low POC1 tank temperature too high	
6	6	2 3	POC2 tank temperature too low POC2 tank temperature too high	
6	8	0	Focal spot changed while generating HV	

6	10	0	Exposure time timeout	x

5.9 Shutdown code and detail of emission control unit “ECU”

The following table shows the possible shutdown code and detail of this part.

Src	Code	Detail	Description	Regular Shutdown
8	1	0	OFF command	X
8	2	0	-5V supply out of range	
8	3	0	+5V supply out of range	
8	4	0	+12V supply out of range	
8	5	0	+24V supply out of Range	
8	6	0	Heater lost	
8	7	0	Grid voltage out of range	
8	8	0	CAN heartbeat error	
8	9	0	Oil temperature out of range	
8	10	0	Board temperature out of range	
8	11	0	Severe error	
8	12	0	Emission current out of range	

6 Errors

The iVario generator differentiates between the errors caused during boot- / start process and during operation. The iVario generator must be successfully booting to operate normal but there can be errors during start-up of a service belonging to the operating system. These start-up errors do not allow a normal operation of the iVario generator and thus they are handled differently.

6.1 Boot- / Start errors

During boot-up (boot process of the operating system) several services can cause an error. Currently we focus only on the start-up (starting of the services used for the normal operation) errors. The following errors are reported as boot error:

Error Code	Description
0x00000001	Incomplete system, e.g. no POCs found/available
0x00000002	Erroneous or not written device information
0x00000004	Tank communication failed or its data is corrupt
0x00000008	Tube data corrupt or inconsistent
0x00000010	Cable data corrupt or inconsistent
0x00000020	Version mismatch
0x00000040	Configuration error
0x00000080	Hardware compatibility error
0x00000100	Genesis time detected, i.e. RTC cannot be read
0x00000200	Special Operating mode mismatch
0x00000400	IFC replacement case detected
0x00000800	Internal error (unexpected / unknown reason)
0x00001000	Software compatibility error
0x00002000	No mesofocus config file is found for specified serial number

6.2 Severe operating errors

During normal operation a severe error may occur. The following errors are reported as severe error:

Error Code	Description
0x00000001	Configuration error
0x00000002	Unsupported device detected
0x00000004	Lost a device (communication loss)
0x00000008	Re-announced device while already operating
0x00000010	Lost service/application (missing process)
0x00000020	Software version mismatch
0x00000040	Internal error
0x00000080	System unstable (Data-server load too high)
0x00000100	System unstable (CPU utilization too high)
0x00000200	System unstable (Memory load too high)
0x00000400	Cooler flow available but shouldn’t

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