Actel SmartFusion™ MSS GPIO Driver User's Guide

Version 2.0

Actel
POWER MATTERS

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Introduction

The SmartFusion™ microcontroller subsystem (MSS) includes a block of 32 general purpose input/outputs (GPIO). This software driver provides a set of functions for controlling the MSS GPIO block as part of a bare metal system where no operating system is available. This driver can be adapted for use as part of an operating system but the implementation of the adaptation layer between this driver and the operating system's driver model is outside the scope of this driver.

Features

The MSS GPIO driver provides the following features:

- Support for configuring the operating modes of each individual GPIO port
- Support for setting and reading the state of the GPIO outputs
- Support for reading the state of the GPIO inputs
- Support for enabling, disabling and clearing GPIO interrupts

The MSS GPIO driver is provided as C source code.

Supported Hardware IP

The MSS GPIO bare metal driver can be used with Actel's MSS_GPIO IP version 0.6 or higher, included in the SmartFusion MSS.

Files Provided

The files provided as part of the MSS GPIO driver fall into three main categories: documentation, driver source code, and example projects. The driver is distributed via the Actel Firmware Catalog, which provides access to the documentation for the driver, generates the driver's source files into an application project, and generates example projects that illustrate how to use the driver. The Actel Firmware Catalog is available from the Actel website: www.actel.com/products/software/firmwarecat/default.aspx.

Documentation

The Actel Firmware Catalog provides access to these documents for the driver:

- User's guide (this document)
- A copy of the license agreement for the driver source code
- Release notes

Driver Source Code

The Actel Firmware Catalog generates the driver's source code into the *drivers\mss_gpio* subdirectory of the selected software project directory. The files making up the driver are detailed below.

mss_gpio.h

This header file contains the public application programming interface (API) of the MSS GPIO software driver. This file should be included in any C source file that uses the MSS GPIO software driver.

mss_gpio.c

This C source file contains the implementation of the MSS GPIO software driver.

Example Code

The Actel Firmware Catalog provides access to example projects illustrating the use of the driver. Each example project is self-contained and is targeted at a specific processor and software toolchain combination. The example projects are targeted at the FPGA designs in the hardware development tutorials supplied with Actel's development boards. The tutorial designs may be found on the Actel Development Kit web page (www.actel.com/products/hardware).

Driver Deployment

This driver is intended to be deployed from the Actel Firmware Catalog into a software project by generating the driver's source files into the project directory. The driver uses the SmartFusion Cortex Microcontroller Software Interface Standard – Peripheral Access Layer (CMSIS-PAL) to access MSS hardware registers. You must ensure that the SmartFusion CMSIS-PAL is either included in the software toolchain used to build your project or is included in your project. The most up-to-date SmartFusion CMSIS-PAL files can be obtained using the Actel Firmware Catalog.

The following example shows the intended directory structure for a SoftConsole ARM® Cortex™-M3 project targeted at the SmartFusion MSS. This project uses the MSS GPIO and MSS Watchdog drivers. Both of these drivers rely on SmartFusion CMSIS-PAL for accessing the hardware. The contents of the *drivers* directory result from generating the source files for each driver into the project. The contents of the *CMSIS* directory result from generating the source files for the SmartFusion CMSIS-PAL into the project.

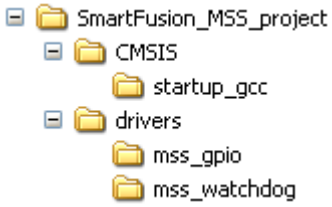

Figure 1 · SmartFusion MSS Project Example

Driver Configuration

The configuration of all features of the MSS GPIOs is covered by this driver with the exception of the SmartFusion IOMUX configuration. SmartFusion allows multiple non-concurrent uses of some external pins through IOMUX configuration. This feature allows optimization of external pin usage by assigning external pins for use by either the microcontroller subsystem or the FPGA fabric. The MSS GPIO ports 0 to 15 share SmartFusion device external pins with the FPGA fabric via an IOMUX. The MSS GPIO ports 0 to 15 can alternatively be routed to the FPGA fabric. The MSS GPIO ports 16 to 31 share external pins with other MSS peripherals via an IOMUX. The MSS GPIO ports 16 to 31 can alternatively be routed to the FPGA fabric through a separate IOMUX. These IOMUXes are configured using the MSS configurator tool. You must ensure that the MSS GPIOs are enabled and configured in the MSS configurator tool if you wish to use them. For more information on IOMUXes, refer to the IOMUX section of the *SmartFusion Microcontroller Subsystem (MSS) User's Guide*.

The base address, register addresses, and interrupt number assignment for the MSS GPIO block are defined as constants in the SmartFusion CMSIS-PAL You must ensure that the SmartFusion CMSIS-PAL is either included in the software toolchain used to build your project or is included in your project.

Application Programming Interface

This section describes the driver's API. The functions and related data structures described in this section are used by the application programmer to control the MSS GPIO peripheral from the user's application.

Theory of Operation

The MSS GPIO driver functions are grouped into the following categories:

- Initialization
- Configuration
- Reading and setting GPIO state
- Interrupt control

Initialization

The MSS GPIO driver is initialized through a call to the *MSS_GPIO_init()* function. The *MSS_GPIO_init()* function must be called before any other MSS GPIO driver functions can be called.

Configuration

Each GPIO port is individually configured through a call to the *MSS_GPIO_config()* function. Configuration includes deciding if a GPIO port will be used as an input, an output or both. GPIO ports configured as inputs can be further configured to generate interrupts based on the input's state. Interrupts can be level or edge sensitive.

Reading and Setting GPIO State

The state of the GPIO ports can be read and set using the following functions:

- *MSS_GPIO_get_inputs()*
- *MSS_GPIO_get_outputs()*
- *MSS_GPIO_set_outputs()*
- *MSS_GPIO_set_output()*
- *MSS_GPIO_drive_inout()*

Interrupt Control

Interrupts generated by GPIO ports configured as inputs are controlled using the following functions:

- *MSS_GPIO_enable_irq()*
- *MSS_GPIO_disable_irq()*
- *MSS_GPIO_clear_irq()*

Types

mss_gpio_id_t

Prototype

```
typedef enum __mss_gpio_id_t {
    MSS_GPIO_0 = 0,
    MSS_GPIO_1 = 1,
    MSS_GPIO_2 = 2,
    MSS_GPIO_3 = 3,
    MSS_GPIO_4 = 4,
    MSS_GPIO_5 = 5,
    MSS_GPIO_6 = 6,
    MSS_GPIO_7 = 7,
    MSS_GPIO_8 = 8,
    MSS_GPIO_9 = 9,
    MSS_GPIO_10 = 10,
    MSS_GPIO_11 = 11,
    MSS_GPIO_12 = 12,
    MSS_GPIO_13 = 13,
    MSS_GPIO_14 = 14,
    MSS_GPIO_15 = 15,
    MSS_GPIO_16 = 16,
    MSS_GPIO_17 = 17,
    MSS_GPIO_18 = 18,
    MSS_GPIO_19 = 19,
    MSS_GPIO_20 = 20,
    MSS_GPIO_21 = 21,
    MSS_GPIO_22 = 22,
    MSS_GPIO_23 = 23,
    MSS_GPIO_24 = 24,
    MSS_GPIO_25 = 25,
    MSS_GPIO_26 = 26,
    MSS_GPIO_27 = 27,
    MSS_GPIO_28 = 28,
    MSS_GPIO_29 = 29,
    MSS_GPIO_30 = 30,
    MSS_GPIO_31 = 31
} mss_gpio_id_t;
```

Description

The *mss_gpio_id_t* enumeration is used to identify individual GPIO ports as an argument to functions:

- *MSS_GPIO_config()*
- *MSS_GPIO_set_output()* and *MSS_GPIO_drive_inout()*
- *MSS_GPIO_enable_irq()*, *MSS_GPIO_disable_irq()* and *MSS_GPIO_clear_irq()*

mss_gpio_inout_state_t

Prototype

```
typedef enum mss_gpio_inout_state {
    MSS_GPIO_DRIVE_LOW = 0,
    MSS_GPIO_DRIVE_HIGH,
    MSS_GPIO_HIGH_Z
} mss_gpio_inout_state_t;
```

Description

The *mss_gpio_inout_state_t* enumeration is used to specify the output state of an INOUT GPIO port as an argument to the *MSS_GPIO_drive_inout()* function.

Constant Values

GPIO Port Masks

These constant definitions are used as an argument to the *MSS_GPIO_set_outputs()* function to identify GPIO ports. A logical OR of these constants can be used to specify multiple GPIO ports.

These definitions can also be used to identify GPIO ports through logical operations on the return value of the *MSS_GPIO_get_inputs()* function.

Constant	Description
MSS_GPIO_0_MASK	GPIO port 0-bit mask
MSS_GPIO_1_MASK	GPIO port 1-bit mask
MSS_GPIO_2_MASK	GPIO port 2-bit mask
MSS_GPIO_3_MASK	GPIO port 3-bit mask
MSS_GPIO_4_MASK	GPIO port 4-bit mask
MSS_GPIO_5_MASK	GPIO port 5-bit mask
MSS_GPIO_6_MASK	GPIO port 6-bit mask
MSS_GPIO_7_MASK	GPIO port 7-bit mask
MSS_GPIO_8_MASK	GPIO port 8-bit mask
MSS_GPIO_9_MASK	GPIO port 9-bit mask
MSS_GPIO_10_MASK	GPIO port 10-bit mask
MSS_GPIO_11_MASK	GPIO port 11-bit mask

Constant	Description
MSS_GPIO_12_MASK	GPIO port 12-bit mask
MSS_GPIO_13_MASK	GPIO port 13-bit mask
MSS_GPIO_14_MASK	GPIO port 14-bit mask
MSS_GPIO_15_MASK	GPIO port 15-bit mask
MSS_GPIO_16_MASK	GPIO port 16-bit mask
MSS_GPIO_17_MASK	GPIO port 17-bit mask
MSS_GPIO_18_MASK	GPIO port 18-bit mask
MSS_GPIO_19_MASK	GPIO port 19-bit mask
MSS_GPIO_20_MASK	GPIO port 20-bit mask
MSS_GPIO_21_MASK	GPIO port 21-bit mask
MSS_GPIO_22_MASK	GPIO port 22-bit mask
MSS_GPIO_23_MASK	GPIO port 23-bit mask
MSS_GPIO_24_MASK	GPIO port 24-bit mask
MSS_GPIO_25_MASK	GPIO port 25-bit mask
MSS_GPIO_26_MASK	GPIO port 26-bit mask
MSS_GPIO_27_MASK	GPIO port 27-bit mask
MSS_GPIO_28_MASK	GPIO port 28-bit mask
MSS_GPIO_29_MASK	GPIO port 29-bit mask
MSS_GPIO_30_MASK	GPIO port 30-bit mask
MSS_GPIO_31_MASK	GPIO port 31-bit mask

Table 1 · GPIO Port Mask Constants

GPIO Port I/O Mode

These constant definitions are used as an argument to the *MSS_GPIO_config()* function to specify the I/O mode of each GPIO port.

Constant	Description
MSS_GPIO_INPUT_MODE	Input port only
MSS_GPIO_OUTPUT_MODE	Output port only
MSS_GPIO_INOUT_MODE	Both input and output port

Table 2 · GPIO Port I/O Mode

GPIO Interrupt Mode

These constant definitions are used as an argument to the *MSS_GPIO_config()* function to specify the interrupt mode of each GPIO port.

Constant	Description
MSS_GPIO_IRQ_LEVEL_HIGH	Interrupt on GPIO input level High
MSS_GPIO_IRQ_LEVEL_LOW	Interrupt on GPIO input level Low
MSS_GPIO_IRQ_EDGE_POSITIVE	Interrupt on GPIO input positive edge
MSS_GPIO_IRQ_EDGE_NEGATIVE	Interrupt on GPIO input negative edge
MSS_GPIO_IRQ_EDGE_BOTH	Interrupt on GPIO input positive and negative edges

Table 3 · GPIO Interrupt Mode

Data Structures

There are no MSS GPIO driver specific data structures.

Functions

MSS_GPIO_init

Prototype

```
void
MSS_GPIO_init
(
        void
);
```

Description

The *MSS_GPIO_init()* function initializes the SmartFusion MSS GPIO block. It resets the MSS GPIO hardware block and it also clears any pending MSS GPIO interrupts in the ARM® Cortex™-M3 interrupt controller. When the function exits, it takes the MSS GPIO block out of reset.

Parameters

This function has no parameters.

Return Value

This function does not return a value.

Example

```
MSS_GPIO_init();
```

MSS_GPIO_config

Prototype

```
void
MSS_GPIO_config
(
        mss_gpio_id_t port_id,
        uint32_t config
);
```

Description

The *MSS_GPIO_config()* function is used to configure an individual GPIO port.

Parameters

port_id

The *port_id* parameter identifies the GPIO port to be configured. An enumeration item of the form MSS_GPIO_n, where *n* is the number of the GPIO port, is used to identify the GPIO port. For example, MSS_GPIO_0 identifies the first GPIO port and MSS_GPIO_31 is the last one.

config

The *config* parameter specifies the configuration to be applied to the GPIO port identified by the *port_id* parameter. It is a logical OR of the required I/O mode and the required interrupt mode. The interrupt mode is not relevant if the GPIO is configured as an output only.

These I/O mode constants are allowed:

- MSS_GPIO_INPUT_MODE
- MSS_GPIO_OUTPUT_MODE
- MSS_GPIO_INOUT_MODE

These interrupt mode constants are allowed:

- MSS_GPIO_IRQ_LEVEL_HIGH
- MSS_GPIO_IRQ_LEVEL_LOW
- MSS_GPIO_IRQ_EDGE_POSITIVE
- MSS_GPIO_IRQ_EDGE_NEGATIVE
- MSS_GPIO_IRQ_EDGE_BOTH

Return Value

This function does not return a value.

Example

The following call will configure GPIO 4 as an input generating interrupts on a Low to High transition of the input:

```
MSS_GPIO_config( MSS_GPIO_4, MSS_GPIO_INPUT_MODE | MSS_GPIO_IRQ_EDGE_POSITIVE );
```

MSS_GPIO_set_outputs

Prototype

```
void
MSS_GPIO_set_outputs
(
        uint32_t value
);
```

Description

The *MSS_GPIO_set_outputs()* function is used to set the state of all GPIO ports configured as outputs.

Parameters

value

The value parameter specifies the state of the GPIO ports configured as outputs. It is a bit mask of the form (MSS_GPIO_n_MASK | MSS_GPIO_m_MASK) where *n* and *m* are numbers identifying GPIOs. For example, (MSS_GPIO_0_MASK | MSS_GPIO_1_MASK | MSS_GPIO_2_MASK) specifies that the first, second and third GPIO outputs must be set High and all other GPIO outputs set Low. The driver provides 32 mask constants, MSS_GPIO_0_MASK to MSS_GPIO_31_MASK inclusive, for this purpose.

Return Value

This function does not return a value.

Example

Example 1: Set GPIO outputs 0 and 8 High and all other GPIO outputs Low.

```
MSS_GPIO_set_outputs( MSS_GPIO_0_MASK | MSS_GPIO_8_MASK );
```

Example 2: Set GPIO outputs 2 and 4 Low without affecting other GPIO outputs.

```
uint32_t gpio_outputs;
gpio_outputs = MSS_GPIO_get_outputs();
gpio_outputs &= ~( MSS_GPIO_2_MASK | MSS_GPIO_4_MASK );
MSS_GPIO_set_outputs( gpio_outputs );
```

MSS_GPIO_set_output

Prototype

```
void
MSS_GPIO_set_output
(
       mss_gpio_id_t port_id,
       uint8_t value
);
```

Description

The *MSS_GPIO_set_output()* function is used to set the state of a single GPIO port configured as an output.

Parameters

port_id

The *port_id* parameter identifies the GPIO port that is to have its output set. An enumeration item of the form MSS_GPIO_n, where *n* is the number of the GPIO port, is used to identify the GPIO port. For example, MSS_GPIO_0 identifies the first GPIO port and MSS_GPIO_31 is the last one.

value

The value parameter specifies the desired state for the GPIO output. A value of 0 will set the output Low and a value of 1 will set the output High.

Return Value

This function does not return a value.

Example

The following call will set GPIO output 12 High, leaving all other GPIO outputs unaffected:

```
MSS_GPIO_set_output( MSS_GPIO_12, 1 );
```

MSS_GPIO_get_outputs

Prototype

```
uint32_t
MSS_GPIO_get_outputs
(
        void

);
```

Description

The *MSS_GPIO_get_outputs()* function is used to read the current state all GPIO ports configured as outputs.

Parameters

This function has no parameters.

Return Value

This function returns a 32-bit unsigned integer where each bit represents the state of a GPIO output. The least significant bit represents the state of GPIO output 0 and the most significant bit the state of GPIO output 31.

Example

Read and assign the current state of the GPIO outputs to a variable.

```
uint32_t gpio_outputs;
gpio_outputs = MSS_GPIO_get_outputs();
```

MSS_GPIO_get_inputs

Prototype

```
uint32_t
MSS_GPIO_get_inputs
(
        void

);
```

Description

The *MSS_GPIO_get_inputs()* function is used to read the current state all GPIO ports configured as inputs.

Parameters

This function has no parameters.

Return Value

This function returns a 32-bit unsigned integer where each bit represents the state of a GPIO input. The least significant bit represents the state of GPIO input 0 and the most significant bit the state of GPIO input 31.

Example

Read and assign the current state of the GPIO inputs to a variable.

```
uint32_t gpio_inputs;
gpio_inputs = MSS_GPIO_get_inputs();
```

MSS_GPIO_drive_inout

Prototype

```
void
MSS_GPIO_drive_inout
(
        mss_gpio_id_t port_id,
        mss_gpio_inout_state_t inout_state
);
```

Description

The *MSS_GPIO_drive_inout()* function is used to set the output state of a single GPIO port configured as an INOUT. An INOUT GPIO can be in one of three states:

- High
- Low
- High impedance

An INOUT output would typically be used where several devices can drive the state of a shared signal line. The High and Low states are equivalent to the High and Low states of a GPIO configured as an output. The High impedance state is used to prevent the GPIO from driving its output state onto the signal line, while at the same time allowing the input state of the GPIO to be read.

Parameters

port_id

The *port_id* parameter identifies the GPIO port for which you want to change the output state. An enumeration item of the form MSS_GPIO_n, where *n* is the number of the GPIO port, is used to identify the GPIO port. For example, MSS_GPIO_0 identifies the first GPIO port and MSS_GPIO_31 is the last one.

inout_state

The *inout_state* parameter specifies the state of the GPIO port identified by the *port_id* parameter. Allowed values of type *mss_gpio_inout_state_t* are as follows:

- MSS_GPIO_DRIVE_HIGH
- MSS_GPIO_DRIVE_LOW
- MSS_GPIO_HIGH_Z (High impedance)

Return Value

This function does not return a value.

Example

The call to *MSS_GPIO_drive_inout()* below will set the GPIO 7 output to the High impedance state.

```
MSS_GPIO_drive_inout( MSS_GPIO_7, MSS_GPIO_HIGH_Z );
```

MSS_GPIO_enable_irq

Prototype

```
void
MSS_GPIO_enable_irq
(
        mss_gpio_id_t port_id

);
```

Description

The *MSS_GPIO_enable_irq()* function is used to enable interrupt generation for the specified GPIO input. Interrupts are generated based on the state of the GPIO input and the interrupt mode configured for it by *MSS_GPIO_config()*.

Parameters

port_id

The *port_id* parameter identifies the GPIO port for which you want to enable interrupt generation. An enumeration item of the form MSS_GPIO_n, where *n* is the number of the GPIO port, is used to identify the GPIO port. For example, MSS_GPIO_0 identifies the first GPIO port and MSS_GPIO_31 is the last one.

Return Value

This function does not return a value.

Example

The call to *MSS_GPIO_enable_irq()* below will allow GPIO 8 to generate interrupts.

```
MSS_GPIO_enable_irq( MSS_GPIO_8 );
```

MSS_GPIO_disable_irq

Prototype

```
void
MSS_GPIO_disable_irq
(
        mss_gpio_id_t port_id

);
```

Description

The *MSS_GPIO_disable_irq()* function is used to disable interrupt generation for the specified GPIO input.

Parameters

port_id

The *port_id* parameter identifies the GPIO port for which you want to disable interrupt generation. An enumeration item of the form MSS_GPIO_n, where *n* is the number of the GPIO port, is used to identify the GPIO port. For example, MSS_GPIO_0 identifies the first GPIO port and MSS_GPIO_31 is the last one.

Return Value

This function does not return a value.

Example

The call to *MSS_GPIO_disable_irq()* below will prevent GPIO 8 from generating interrupts.

```
MSS_GPIO_disable_irq( MSS_GPIO_8 );
```

MSS_GPIO_clear_irq

Prototype

```
void
MSS_GPIO_clear_irq
(
       mss_gpio_id_t port_id

);
```

Description

The *MSS_GPIO_clear_irq()* function is used to clear a pending interrupt from the specified GPIO input.

Note: The *MSS_GPIO_clear_irq()* function must be called as part of any GPIO interrupt service routine (ISR) in order to prevent the same interrupt event retriggering a call to the GPIO ISR. The function also clears the interrupt in the Cortex-M3 interrupt controller through a call to NVIC_ClearPendingIRQ().

Parameters

port_id

The *port_id* parameter identifies the GPIO port for which you want to clear the interrupt. An enumeration item of the form MSS_GPIO_n, where *n* is the number of the GPIO port, is used to identify the GPIO port. For example, MSS_GPIO_0 identifies the first GPIO port and MSS_GPIO_31 is the last one.

Return Value

This function does not return a value.

Example

The example below demonstrates the use of the *MSS_GPIO_clear_irq()* function as part of the GPIO 9 interrupt service routine.

```
void GPIO9_IRQHandler( void )
{
    do_interrupt_processing();
    MSS_GPIO_clear_irq( MSS_GPIO_9 );
}
```

Product Support

Actel backs its products with various support services including Customer Service, a Customer Technical Support Center, a web site, an FTP site, electronic mail, and worldwide sales offices. This appendix contains information about contacting Actel and using these support services.

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From Canada, call **650.318.4480**
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Visit the Actel Customer Support website (http://www.actel.com/support/search/default.aspx) for more information and support. Many answers available on the searchable web resource include diagrams, illustrations, and links to other resources on the Actel web site.

Website

You can browse a variety of technical and non-technical information on Actel's home page, at http://www.actel.com/.

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Highly skilled engineers staff the Technical Support Center from 7:00 A.M. to 6:00 P.M., Pacific Time, Monday through Friday. Several ways of contacting the Center follow:

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You can communicate your technical questions to our email address and receive answers back by email, fax, or phone. Also, if you have design problems, you can email your design files to receive assistance. We constantly monitor the email account throughout the day. When sending your request to us, please be sure to include your full name, company name, and your contact information for efficient processing of your request.

The technical support email address is tech@actel.com.

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Our Technical Support Center answers all calls. The center retrieves information, such as your name, company name, phone number and your question, and then issues a case number. The Center then forwards the information to a queue where the first available application engineer receives the data and returns your call. The phone hours are from 7:00 A.M. to 6:00 P.M., Pacific Time, Monday through Friday. The Technical Support numbers are:

650.318.4460
800.262.1060

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Actel Corporation *• 2061 Stierlin Court • Mountain View, CA 94043 • USA*
Phone 650.318.4200 • Fax 650.318.4600 • Customer Service: 650.318.1010 • Customer Applications Center: 800.262.1060

Actel Europe Ltd*. • River Court, Meadows Business Park • Station Approach, Blackwater • Camberley Surrey GU17 9AB • United Kingdom*
Phone +44 (0) 1276 609 300 • Fax +44 (0) 1276 607 540

Actel Japan *• EXOS Ebisu Building 4F • 1-24-14 Ebisu Shibuya-ku • Tokyo 150 • Japan*
Phone +81.03.3445.7671 • Fax +81.03.3445.7668 • http://jp.actel.com

Actel Hong Kong *• Room 2107, China Resources Building • 26 Harbour Road • Wanchai • Hong Kong*
Phone +852 2185 6460 • Fax +852 2185 6488 • www.actel.com.cn

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