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## SAI device tree configuration



## Contents

1. SAI device tree configuration .....	3
2. SAI internal peripheral .....	12
3. ALSA overview .....	12
4. Device tree .....	12
5. SAI Linux driver .....	12
6. How to assign an internal peripheral to a runtime context .....	12
7. Soundcard configuration .....	12
8. Category: Getting started with STM32MP1 boards .....	13
9. STM32CubeMX .....	13



## Contents

1 Article purpose .....	4
2 DT bindings documentation .....	5
3 DT configuration .....	6
3.1 DT configuration (STM32 level) .....	7
3.2 DT configuration (board level) .....	7
3.3 DT configuration examples .....	7
3.3.1 Setting SAI as a master clock provider .....	7
3.3.2 Sharing master clock between two SAIs .....	8
3.3.3 Sharing the codec interface between two SAIs .....	8
4 How to configure the DT using STM32CubeMX .....	11
5 References .....	12



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## 1 Article purpose

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This article explains how to configure the SAI internal peripheral when it is assigned to the **Linux®OS**. In that case, it is controlled by the **ALSA** framework.

The configuration is performed using the **device tree** mechanism that provides a hardware description of the SAI peripheral, used by the **SAI linux driver**.

If the peripheral is assigned to another execution context, refer to [How to assign an internal peripheral to a runtime context](#) article for guidelines on peripheral assignment and configuration.



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## 2 DT bindings documentation

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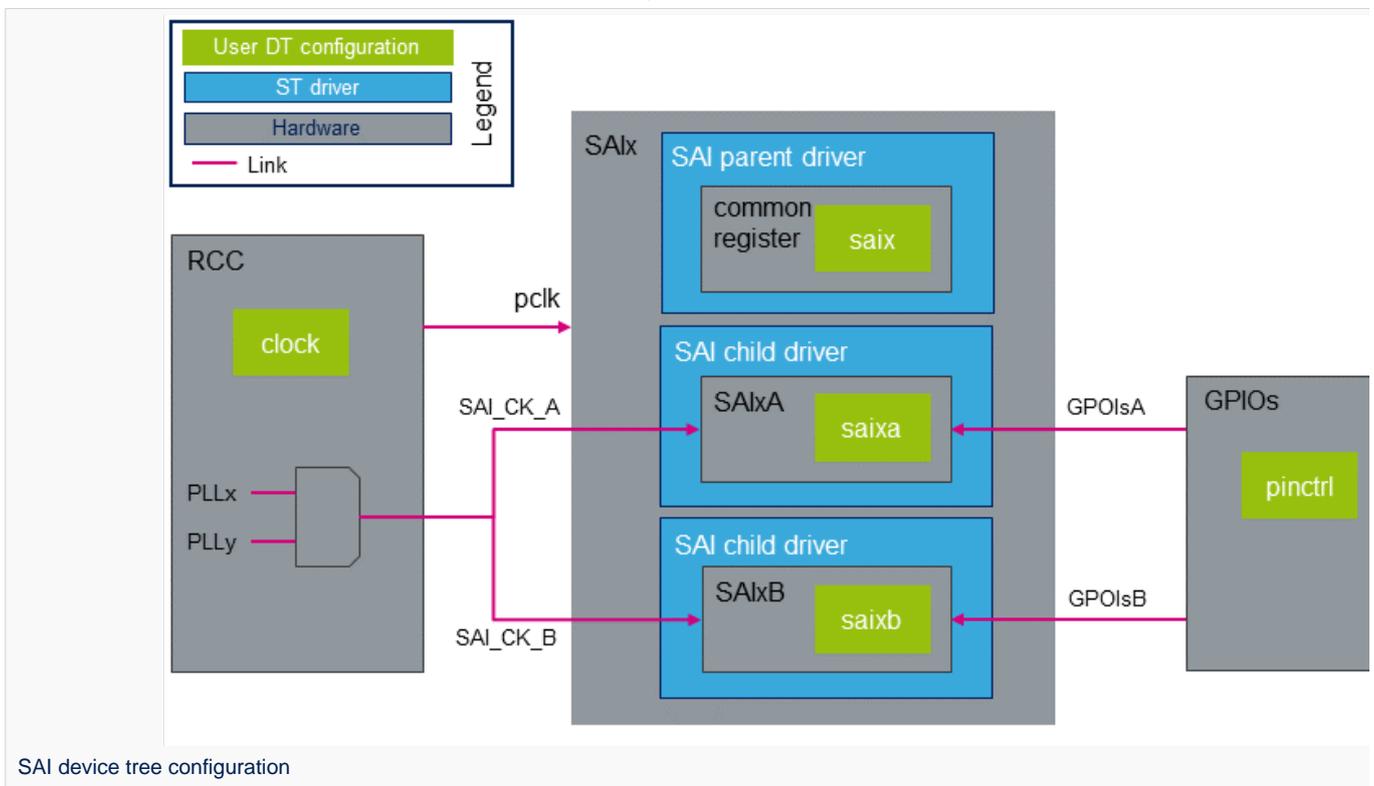
STM32 SAI device tree bindings <sup>[1]</sup> document describes all the required and optional configuration properties.

### 3 DT configuration

This hardware description is a combination of the **STM32 microprocessor** device tree files (*.dtsi* extension) and **board** device tree files (*.dts* extension). See the [Device tree](#) for an explanation of the device tree file split.

The SAI is used as a component of a sound card through Linux<sup>®</sup> kernel ALSA framework. The device tree nodes related to the sound card are described in [board device tree](#).

The STM32 SAI peripheral includes two independent audio subblocks that share common resources. The SAI device tree nodes reflects this architecture, as shown in the SAI DT sample below.



```
&saix {
    /* SAIx parent node. Configure common resources */
    clock-names = "pclk", "x8k", "x11k"; /* Peripheral and parent clock
configuration. */
    ...
    saixa {
        /* child node. Configure resources dedicated to SAIxA subblock */
        clock-names = "sai_ck"; /* SAIxA kernel clock configuration. */
        pinctrl-names = "default"; /* GPIOsA configuration. */
        ...
    };
    saixb {
```



```

        /* child node. Configure ressources dedicated to SAIxB subblock */
        clock-names = "sai_ck"; /* SAIxB kernel clock configuration. */
        pinctrl-names = "default"; /* GPIOsB configuration. */
        ...
    };
};

```

The **STM32CubeMX** can be used to generate the board device tree. Refer to [How to configure the DT using STM32CubeMX](#) for more details.

### 3.1 DT configuration (STM32 level)

The SAI nodes are declared in STM32 microprocessor device tree. They describe hardware parameters such as registers address, interrupt and DMA. This set of properties may not vary for a given STM32MPU. For STM32MP1, the corresponding DT file is `stm32mp151.dtsi`<sup>[2]</sup>.



**This device tree part is related to STM32 microprocessors. It should be kept as is, without being modified by the end-user.**

### 3.2 DT configuration (board level)

The SAI configuration is board dependent, whether is it connected or not to an external component such as an audio codec. The links between the SAI and the other components define a soundcard. This soundcard has to be configured in the board device tree. Refer to [soundcard configuration](#) for examples of SAI configuration on various STM32MPU boards.

### 3.3 DT configuration examples

This chapter describes in details advanced SAI configurations. These examples are based on STM32MP1 boards SAI use cases. The corresponding device trees can be found in [soundcard](#) article.



In this chapter, "SAI" stands for an SAI subblock, SAIxA or SAIxB.

#### 3.3.1 Setting SAI as a master clock provider

The SAI peripheral can provide a clock to an external component (such as a codec) through the `mclk` output pin. In this case, it acts as master clock (`mclk`) provider. The below DT sample gives an example of SAI configuration as `mclk` provider.

In this example the codec driver supports `mclk` input based on ASoC DAPM mechanism. If this is not the case, the codec driver has to be adapted. This can be achieved by adding a DAPM clock supply widget to the codec driver. An example of the required DAPM clock supply widget can be found in Cirrus CS42L51 codec source code<sup>[3]</sup>. In the below device tree example, the codec DAPM clock widget is named "MCLKX".

To allow `mclk` activation/deactivation, a DAPM route must be defined in the DT. This route is defined in the sound node, as shown below.

```

soundcard {
    routing =
        "Playback" , "MCLKX", /* Set a route between "MCLKX" and "playback"
widgets */
        "Capture" , "MCLKX";
    ...
}

```



```

};
codec: {
  clocks = <&sai2a>; /* The codec is a consumer of SAI2A master clock */
  clock-names = "MCLKX"; /* Feed MCLKX codec clock with SAI2A master clock provider
*/
  ...
};
&sai2 {
  ...
  sai2a: audio-controller@4400b004 {
    #clock-cells = <0>; /* Set SAI2A as master clock provider */
    ...
    sai2a_endpoint: endpoint {
      mclk-fs = <256>; /* Set mclk/fs ratio. (256 or 512) */
    };
  };
};

```

### 3.3.2 Sharing master clock between two SAIs

When an SAI is set as a master clock provider, another SAI can share this master clock. This can be achieved by setting the SAI as a mclk consumer through DT configuration. This means that the mclk consumer SAI can request to change the mclk rate, according to its own audio stream sampling rate. This implies that audio sampling rates must be identical when both SAI subblocks are used.

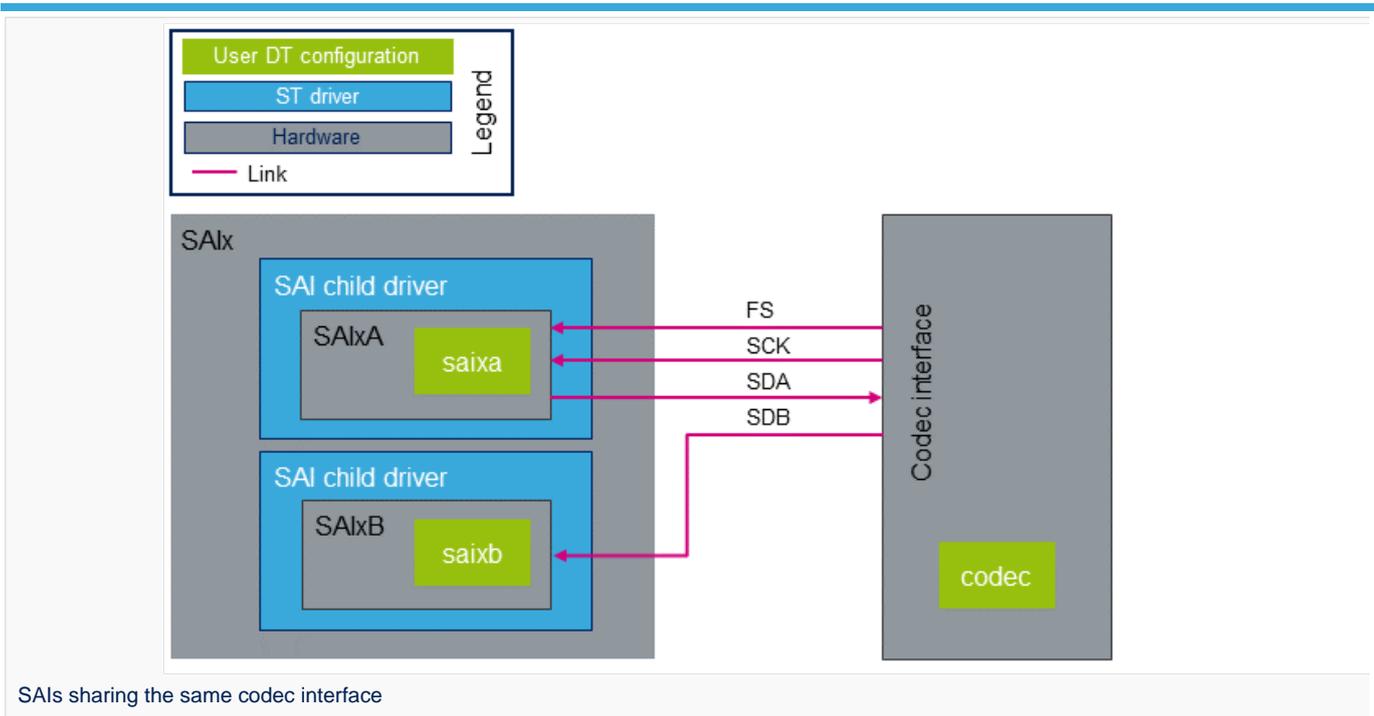
```

&sai2 {
  ...
  sai2a: audio-controller@4400b004 {
    #clock-cells = <0>; /* Set SAI2A as master clock provider */
    ...
  };
  sai2b: audio-controller@4400b024 {
    clocks = <&rcc SAI2_K>, <&sai2a>; /* SAI2B is a consumer of SAI2A master
clock */
    clock-names = "sai_ck", "MCLK"; /* Feed SAI2B MCLK clock with SAI2A
master clock provider */
    ...
    sai2b_endpoint: endpoint {
      mclk-fs = <256>; /* Set mclk/fs ratio. (256 or 512) */
    };
  };
};

```

### 3.3.3 Sharing the codec interface between two SAIs

Two SAIs can be connected to the same codec interface, by sharing the I2S bus (i.e. FS and SCK clocks).



In such case:

- The codec has to be master on the I2S bus.
- Only one SAI is connected to the bus clocks. The other SAI has to be configured as a slave of the SAI connected to the bus.
- The I2S bus I/O pins must be managed at parent level, so that the corresponding pins are activated whatever the running SAI.

From ASoC point of view:

Two CPU DAIs have to be connected to the same codec DAI. Such topology is not supported natively by the ASoC audio graph card. Indeed, when the audio graph card parses the codec nodes, it expects to find DAI interface indexes, matching the endpoints indexes. A workaround consists in implementing the `of_xlate_dai_id` callback in the codec driver, to allow using the same DAI interface for both endpoints. An example of code can be found below or in the Cirrus CS42L51 codec source code<sup>[3]</sup>.

- Code example

```
static int codec_of_xlate_dai_id(struct snd_soc_component *component,
                                struct device_node *endpoint)
{
    /* return dai id 0, whatever the endpoint index */
    return 0;
}
```

- DT example

```
codec {
    ...
    codec_port {
        codec_tx_endpoint {
            remote-endpoint = <&sai2a_endpoint>;
            frame-master; /* Set codec as master of SAI2A for FS clock. */
            bitclock-master; /* Set codec as master of SAI2A for SCK clock. */
        };
    };
}
```



```

        codec_rx_endpoint { /* Second endpoint mapped on codec DAI 0 via of_xlate
*/
            remote-endpoint = <&sai2b_endpoint>;
            frame-master; /* Set codec as master of SAI2B for FS clock. */
            bitclock-master; /* Set codec as master of SAI2B for SCK clock. */
        };
};

&sai2 {
    pinctrl-names = "default", "sleep"; /* Defines SAI2A/B GPIOs at parent level. */
    pinctrl-0 = <&sai2a_pins_a>, <&sai2b_pins_b>;
    pinctrl-1 = <&sai2a_sleep_pins_a>, <&sai2b_sleep_pins_b>;
    ...

    sai2a: audio-controller@4400b004 {
        remote-endpoint = <&codec_tx_endpoint>;
        ...
    };

    sai2b: audio-controller@4400b024 {
        remote-endpoint = <&codec_rx_endpoint>;
        st, sync = <&sai2a 2>; /* Set SAI2B as slave of SAI2A. */
    };
};

```



---

## 4 How to configure the DT using STM32CubeMX

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The STM32CubeMX tool can be used to configure the STM32MPU device and get the corresponding platform configuration device tree files.

The STM32CubeMX may not support all the properties described in the above DT bindings documentation paragraph. If so, the tool inserts **user sections** in the generated device tree. These sections can then be edited to add some properties and they are preserved from one generation to another. Refer to STM32CubeMX user manual for further information.



**The STM32CubeMX does not allow the generation of all the nodes required to configure a soundcard. The soundcard node and the codec nodes have to be filled manually through user sections.**



## 5 References

- STM32 SAI bindings
- arch/arm/boot/dts/stm32mp151.dtsi
- <sup>3.03.1</sup> sound/soc/codecs/cs42l51.c

Operating System

Serial Audio Interface (Mechanism used to transfer non-buffered audio data between processors and/or audio converters.)

Device Tree

Advanced Linux sound architecture

Direct Memory Access

ALSA System on Chip

Dynamic Audio Power Management

Integrated Interchip Sound

Central processing unit

Digital Audio Interface

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