

**pSIF2 TN003**  
**Extending the number of Temperature Sensors**  
**in the pSIF2 ASIC**

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REVISION HISTORY

Revision	Date	Comments
Version 1A	June 27, 2013	Original version
Version 1B	August 6, 2013	Fig. 3 updated so as to clarify that one voltage divider ( $R_{D3}, R_{D4}$ ) is used for all pressure channels.
		Fig. 3 updated so as to use the internal reference voltage as input to the voltage divider ( $R_{D3}, R_{D4}$ ) to minimize noise effects.
		Updated with information regarding the power supply connections. See section 3.
		Full analytical configuration example added to describe the extended temperature sensor functionality. See section 2.5.
		Information on how to use the reference voltage for many ASICs connected in parallel added. See section 4.
Version 1C	October 29, 2013	Updated with clarification on the achieved temperature measurement resolution. See section 2.5.3.

APPLICABLE DOCUMENTS

[1] pSIF2 ASIC Data Sheet, *D-SA-pSIF2-D8.3.4, V2A*

## Contents

<b>1</b>	<b>Background information for measuring up to 6 temperature sensors</b>	<b>6</b>
1.1	Connections . . . . .	6
1.2	Returned data . . . . .	7
<b>2</b>	<b>Using the Pressure transducer bias pads for biasing temperature sensors</b>	<b>8</b>
2.1	Configuration . . . . .	8
2.2	Information on sampling of the single ended channels . . . . .	9
2.3	Reading the data from the I2C . . . . .	10
2.4	Selecting between Single Ended (SE) Channels . . . . .	11
2.5	Example in the Extended Configuration . . . . .	11
2.5.1	Front End Configuration . . . . .	11
2.5.2	Readout of the 12 temperature sensors. . . . .	12
2.5.3	Achieved resolution . . . . .	12
<b>3</b>	<b>Power supply configuration</b>	<b>12</b>
<b>4</b>	<b>Voltage Reference Configuration for multiple devices</b>	<b>12</b>
4.1	Example of multiple ASICS using the same core reference voltage . . . . .	14

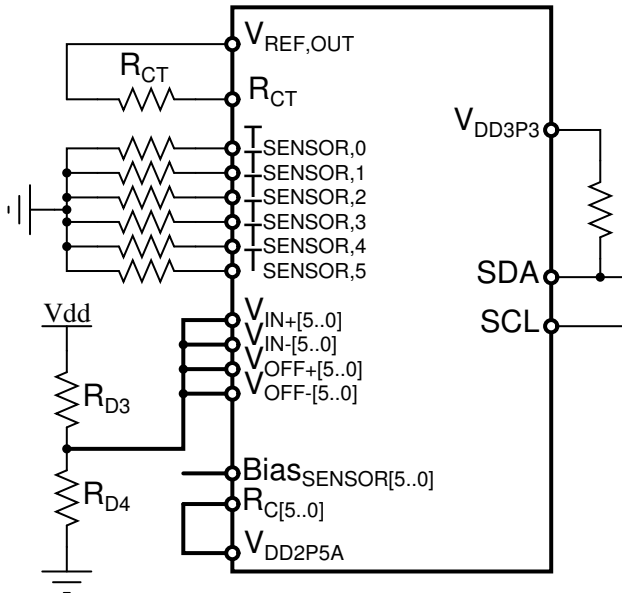
## **Preface**

In this document information is provided on how to extend the number of temperature sensors that can be connected to the pSIF2 ASIC.

# 1 Background information for measuring up to 6 temperature sensors

## 1.1 Connections

The pSIF2 ASIC can be used to measure temperatures. In scan configuration the pSIF2 device scans through channels 0-5 and writes the results into the memory. The setup is shown in Fig. 1



- The current is defined as: [1]

$$I_{SENSOR} = \frac{0.2V_{REF,OUT}}{R_{CT}} \quad (1)$$

- The differential inputs of the device are set to a mid voltage defined by resistors  $R_{D3}$  and  $R_{D4}$ .
- The pressure transducer biasing unit is deactivated by shorting pads  $R_{C[5..0]}$  to  $V_{DD2P5A}$ .

Figure 1: Setup for measuring up to 6 temperatures with the pSIF2 ASIC.

## 1.2 Returned data

In order to read the data from the I2C the user shall do the following steps as shown in Fig. 2

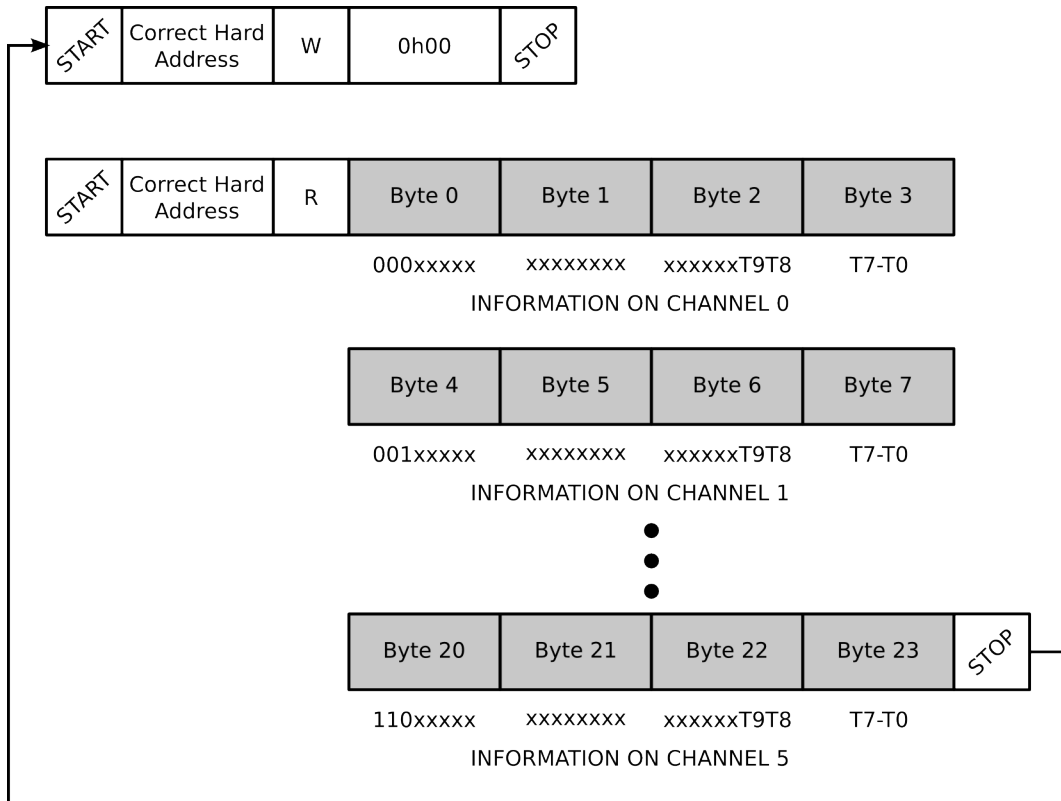


Figure 2: I2C flow for reading temperature data from the pSIF2 ASIC.

The user sets the I2C pointer to zero (this step is not needed after reset). Afterwards, the user reads data from the I2C. Each channel contains 4 bytes. The temperature information is contained in bytes 3 and 4 for channel 0, bytes 6 and 7 for channel 1 and so on.



## 2 Using the Pressure transducer bias pads for biasing temperature sensors

### 2.1 Configuration

In order to extend the number of channels the user can connect temperature sensors through pads  $BIAS_{SENSOR}[0..5]$ , as shown in Fig. 3. It should be noted that the nominal 6 temperature measurement channels (described in section 1.1) are not depicted for simplicity reasons. The theory of operation lies to the fact that

- temperature sensors are connected to the pressure transducer bias outputs and
- the developed voltage is read from the single ended channels ( $Vin_{SE}[7..0]$ ) that are available.

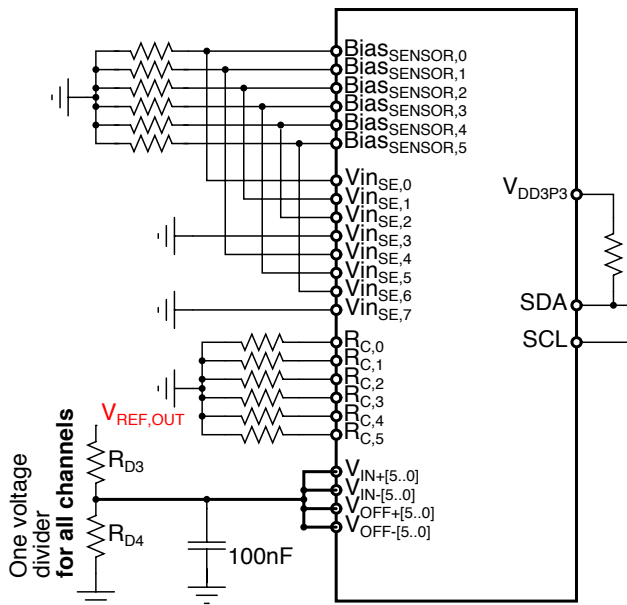


Figure 3: Setup for measuring 6 additional temperatures with the pSIF2 ASIC.

- The current is defined as for each temperature sensor independently according to

$$I_{SENSOR,i} = \frac{V_{BG}}{R_{C,i}} \quad (2)$$

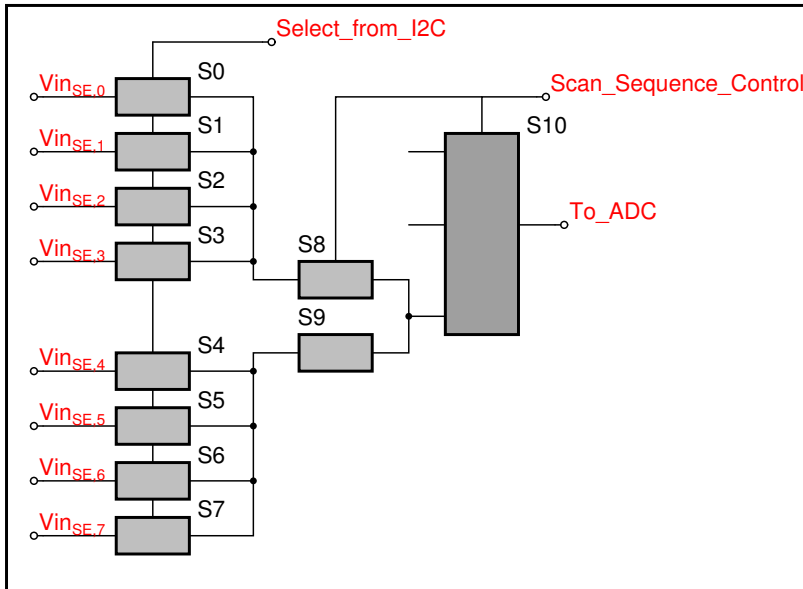
where  $V_{BG}$  is an internal reference voltage and is close to 1.2V. The user can access this voltage on pad *Ext.Ref* [1]. Depending on input pad *Int\_Ext.Ref*, the user can also apply a voltage on this node and by pass the pSIF2 ASIC voltage reference subsystem. This will be described in an updated data sheet.

- The developed voltage on the sensors is fed to the single ended channels through external connections.
- The differential inputs of the device are set to a mid voltage defined by resistors  $R_{D3}$  and  $R_{D4}$ .

## 2.2 Information on sampling of the single ended channels

The pSIF2 ASIC has the capability to sample 2 out of 8 available single ended channels in the scan sequence as shown in Fig. 4.

The selection on which channels to sample is performed through an I2C command that is described in section 2.4.



- Switches S0-S7 control which 2 out of the 8 inputs are fed into the pSIF2 ASIC as channel 6 and channel 7
- Switches S8-S9 and S10 control the scan sequence flow of the ASIC.
- The user can program switches S0-S7, through the I2C interface, to select the single ended channels that will be quantized.

Figure 4: The single ended (SE) channels selection subsystem of the pSIF2 ASIC.

### 2.3 Reading the data from the I2C

In order to read the data from the I2C the user shall do the following steps as shown in Fig. 5.

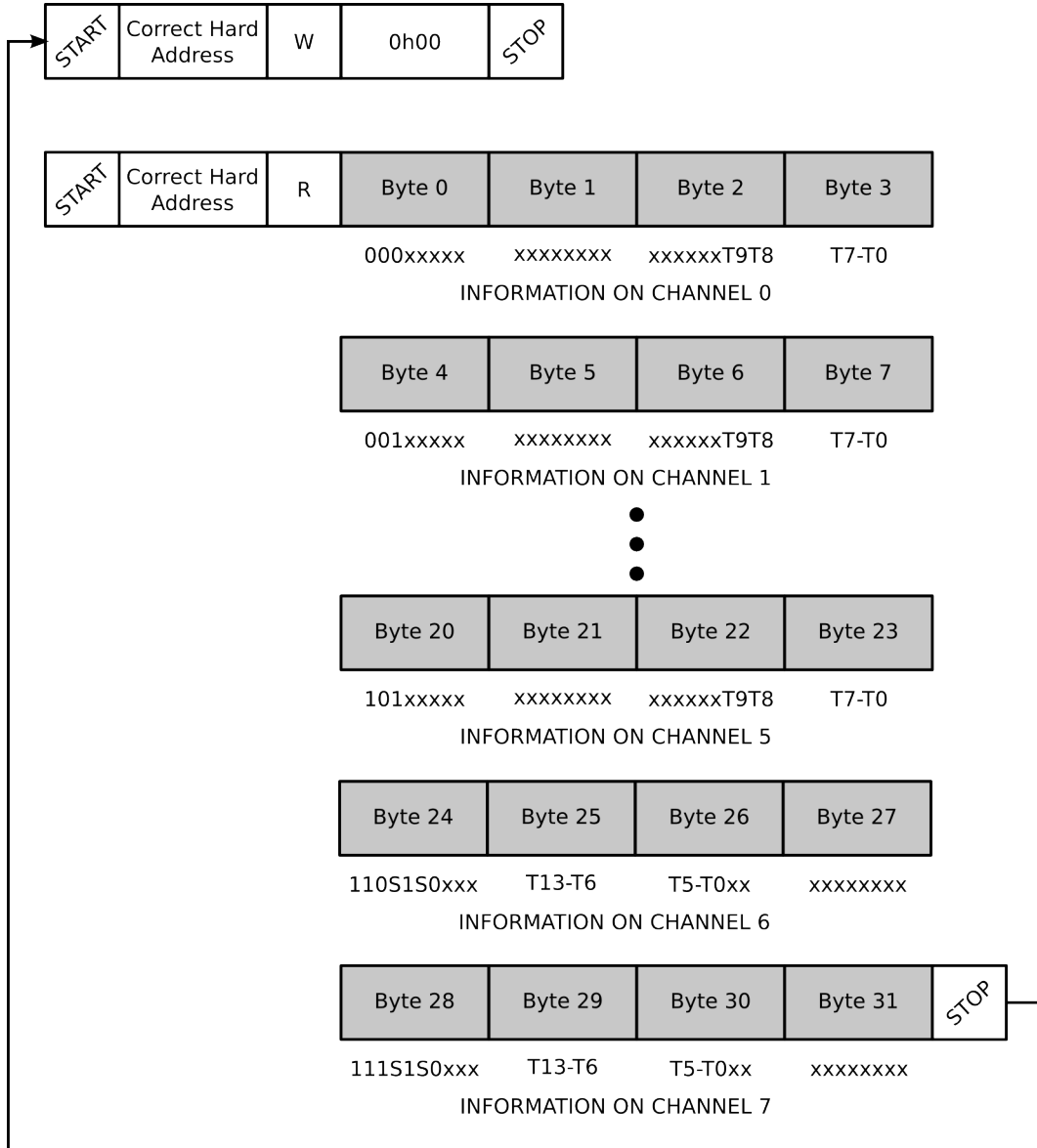


Figure 5: I2C flow for reading temperature data from the pSIF2 ASIC.

The user sets the I2C pointer to zero (this step is not needed after a reset). Afterwards, the user reads data from the I2C. Each channel contains 4 bytes. The temperature information is contained in bytes 3 and 4 for channel 0, bytes 6 and 7 for channel 1 and so on.

For the single ended channels (channels 6 and 7) the temperature information is contained in bytes 25-26 and 29-30. It should be noted that for these channels 14 bits of resolution is available.

For channels 6 and 7 the selected single ended input is also depicted in bytes 24 and 28 (fields S1S0).

## 2.4 Selecting between Single Ended (SE) Channels

The pSIF2 device can select 2 out of the 8 SE channels for conversion. This is accomplished through an I2C command as shown in table 1.

Table 1: Selection of active SE channels through the I2C interface.

Address	Data	Comments
F9h	0x00h-0x03h	0x0h selects SE channels 0 and 4. 0x1h selects SE channels 1 and 5. 0x2h selects SE channels 2 and 6. 0x3h selects SE channels 3 and 7.

## 2.5 Example in the Extended Configuration

### 2.5.1 Front End Configuration

In Fig. 6 the entire front end configuration for measuring 12 temperature sensors is shown.

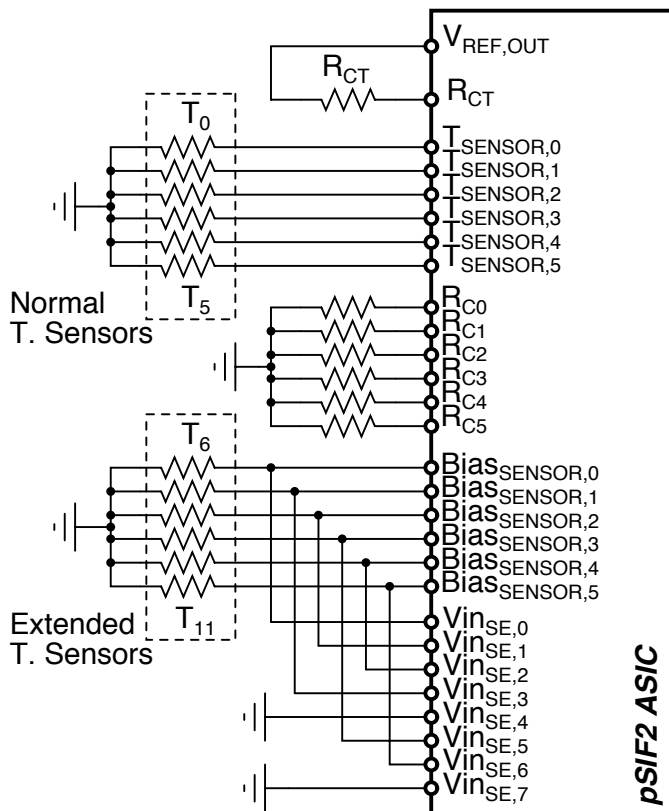


Figure 6: Analog front end configuration of the pSIF ASIC for interfacing 12 temperature sensors.

- This configuration is the combination of the normal and extended setups shown in Figs. 1 and 3.
- Temperature sensors T0-T5 are connected on the nominal inputs. For these sensors:

$$I_{SENSOR} = \frac{0.2V_{REF,OUT}}{R_{CT}}$$

- Temperature sensors T6-T11 are connected on the extended inputs. For these sensors:

$$I_{SENSOR,i} = \frac{V_{BG}}{R_{C,i}}$$

- As it can be seen the sensor current for temperature sensors T0-T5 is the same. Thus, these sensors have to be of the same type (PT1000 or NTC)
- The sensor current for temperature sensors T6-T11 is independently defined for each one. Thus the user can connect either a PT100 or an NTC independently on these inputs.

## 2.5.2 Readout of the 12 temperature sensors.

In the configuration of Fig. 6 to read out all the channels the following I2C commands need to be issued. To read out the 12 sensors the following sequence has to be executed.

1. Assuming that the device comes after reset the user starts reading through I2C sensors
  - (a) Temperature sensors T0-T5 as shown in Fig. 6.
  - (b) Extended temperature sensors T6 and T7 as shown in Fig. 6.
  - (c) The sequence described here is the one depicted in Fig. 5.
2. Afterwards, the user issues a command to the ASIC to select the extended temperature sensors T8 and T9 (see table 1). Afterwards the user waits for some time for the ASIC to scan on all channels. Afterwards he reads:
  - (a) Temperature sensors T0-T5 as shown in Fig. 6.
  - (b) Extended temperature sensors T8 and T9 as shown in Fig. 6.
  - (c) The sequence described here is the one depicted in Fig. 5.
3. Afterwards, the user issues a command to the ASIC to select the extended temperature sensors T10 and T11 (see table 1). Afterwards the user waits for some time for the ASIC to scan on all channels. Afterwards he reads:
  - (a) Temperature sensors T0-T5 as shown in Fig. 6.
  - (b) Extended temperature sensors T10 and T11 as shown in Fig. 6.
  - (c) The sequence described here is the one depicted in Fig. 5.

**As it can be seen the readout frequency of Temperature sensors T0-T5 will be 3 times higher than that of T6-T11.**

## 2.5.3 Achieved resolution

- For temperature sensors T0-T5 (see Fig. 6), 10 bits of resolution is achieved.
- For temperature sensors T6-T11 (see Fig. 6), 14 bits of resolution is achieved.

## 3 Power supply configuration

The suggested power supply configuration is shown in Fig. 7. Only 5V are provided to the device. One electrolytic  $10\mu\text{F}$  capacitor ( $C_0$ ) is connected at the point where the power supply enters the board.  $100\text{nF}$  decoupling capacitors ( $C_{1,2,3,4,5,6}$ ) are placed at each Vdd pad of the ASIC. All ground terminals are shorted in the PCB.

## 4 Voltage Reference Configuration for multiple devices

The simplified schematic of the voltage reference subsystem of the pSIF2 ASIC is shown in Fig. 8. The internal voltage reference (iVREF) is applied to the amplification network through a switch controlled through pad *Int\_Ext\_Ref*.

- If *Int\_Ext\_Ref*=1 the internal voltage reference appears on pad *Ext\_Ref*.
- If *Int\_Ext\_Ref*=0 the internal voltage reference is not fed internally to the ASIC and the user can apply a voltage at pad *Ext\_Ref*.

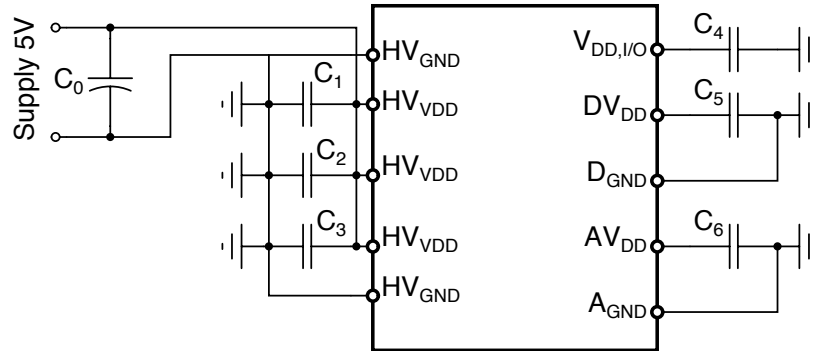


Figure 7: Power supply delivery to the pSIF2 ASIC.  $C_0=10\mu\text{F}$ ,  $C_{1,2,3,4,5,6}=100\text{nF}$ .

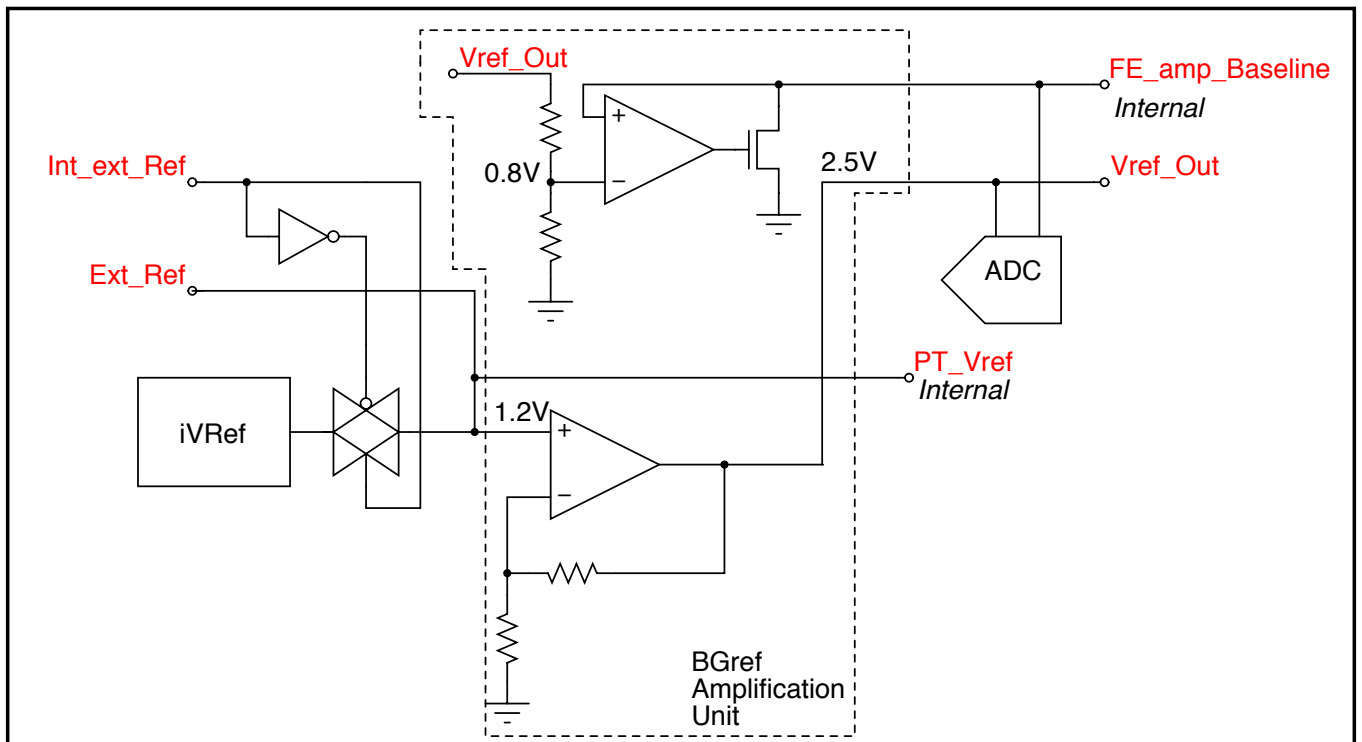


Figure 8: pSIF2 Voltage Reference Subsystem

#### 4.1 Example of multiple ASICS using the same core reference voltage

Thus it is possible to use the internal voltage reference of one pSIF ASIC as an input to other devices as shown in Fig. 9. In this configuration the voltage reference of device U0 is used as input to devices U1, U2 U3 and U4.

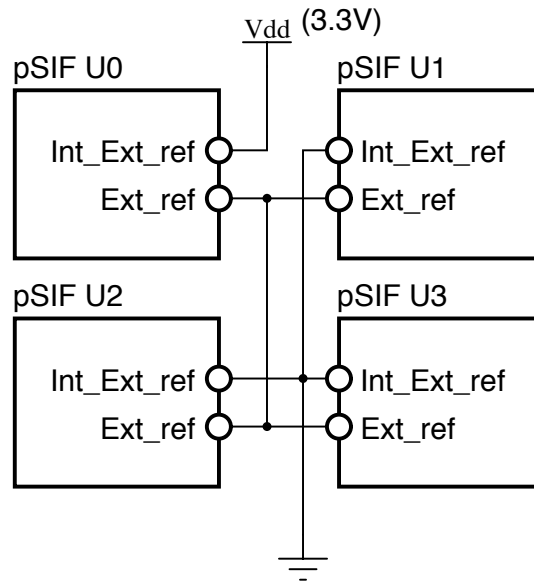


Figure 9: Many pSIF2 devices using a voltage reference coming from one device.