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# HY313X Configurations (For HY3131-AK02)

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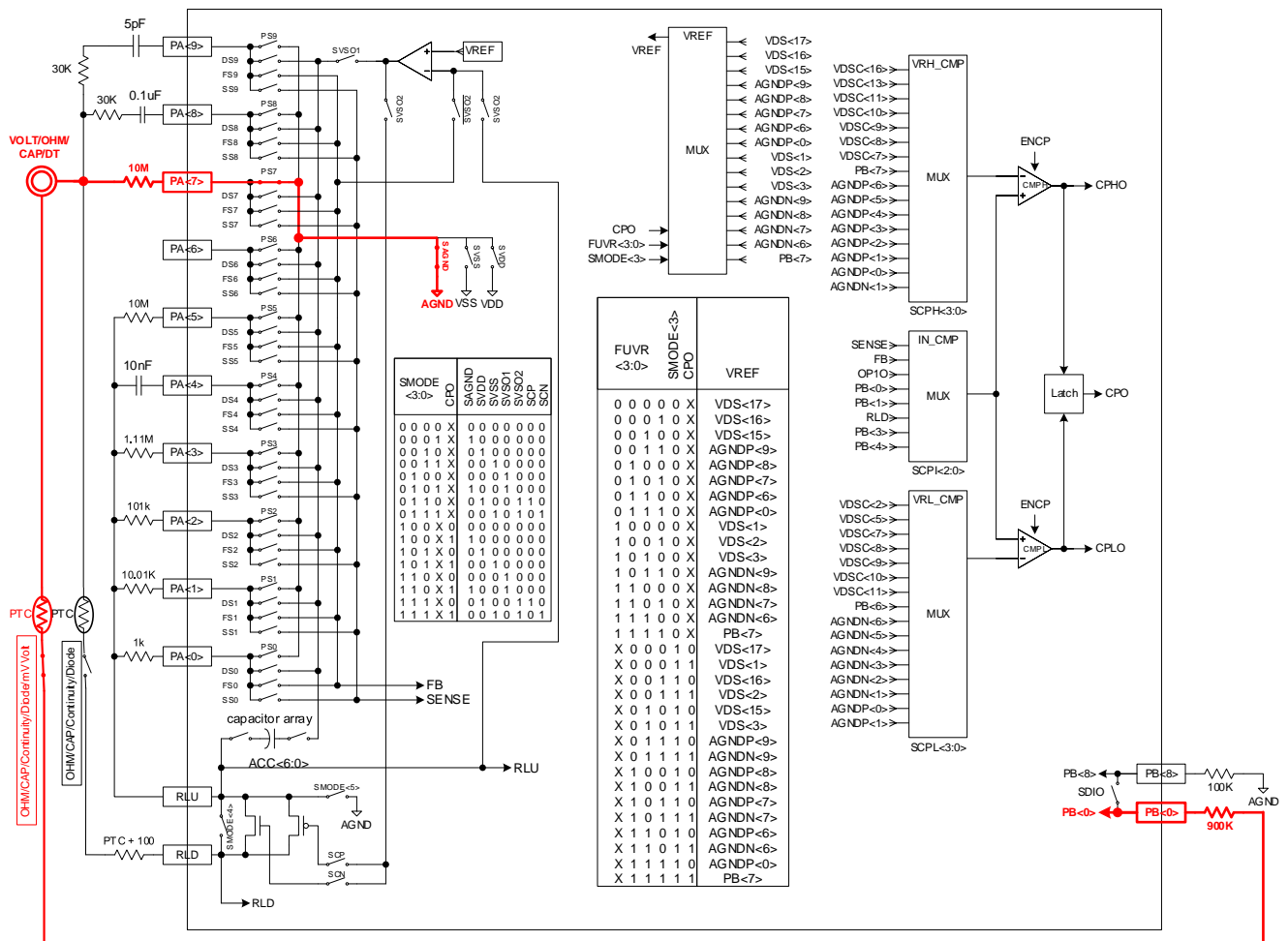
## 1. DCmV

Due to high ADC input impedance, it is easy to sense 50/60Hz signal of the air that leads to unstable reading value after the testing probe was connected. It is recommended to connect input 10MΩ to ground to reduce input impedance of DMM mV range.

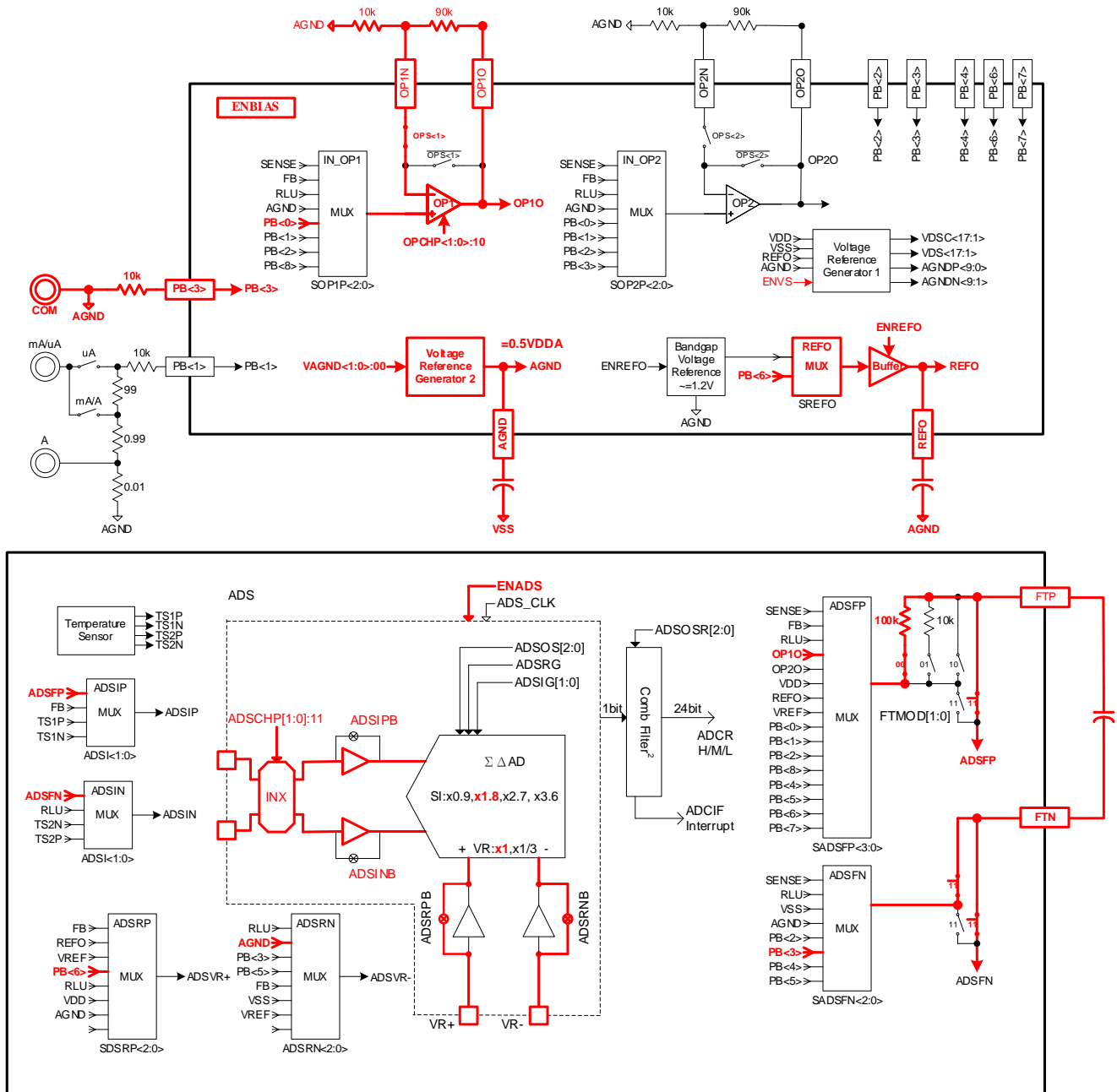
The network configuration of 50mV and 500mV is similar. When measuring 50mV, it uses built-in OPA to amplify signal for 10 times then processing it in ADC.

Main function of chopper is to reduce DC Offset. When OPA measures DC, it is advised to open ADC1 Pre-Filter.

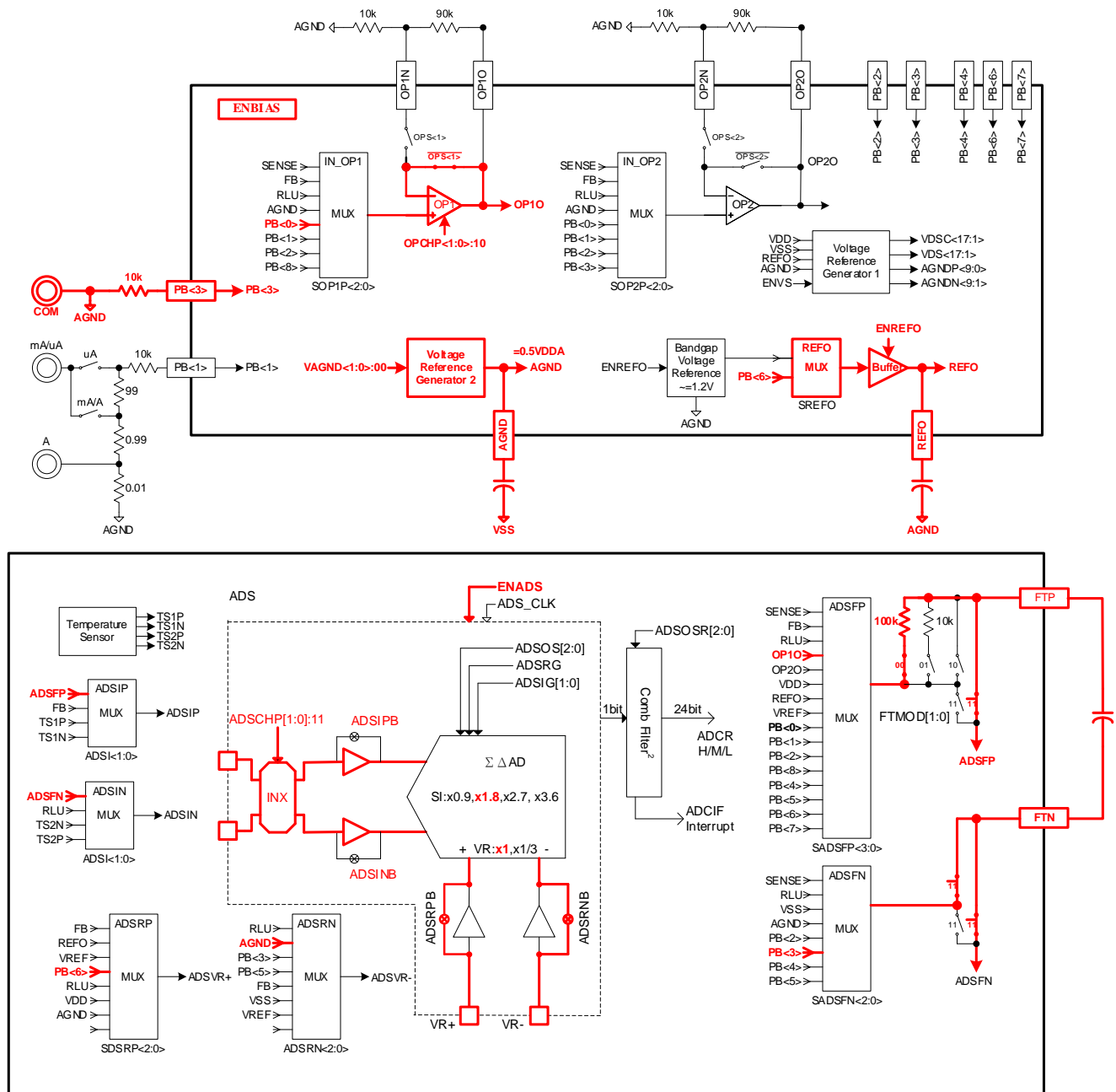
### 1.1. Input Network Configuration



## 1.2. DC50mV Measurement Network Configuration



## 1.3. DC500mV Measurement Network Configuration

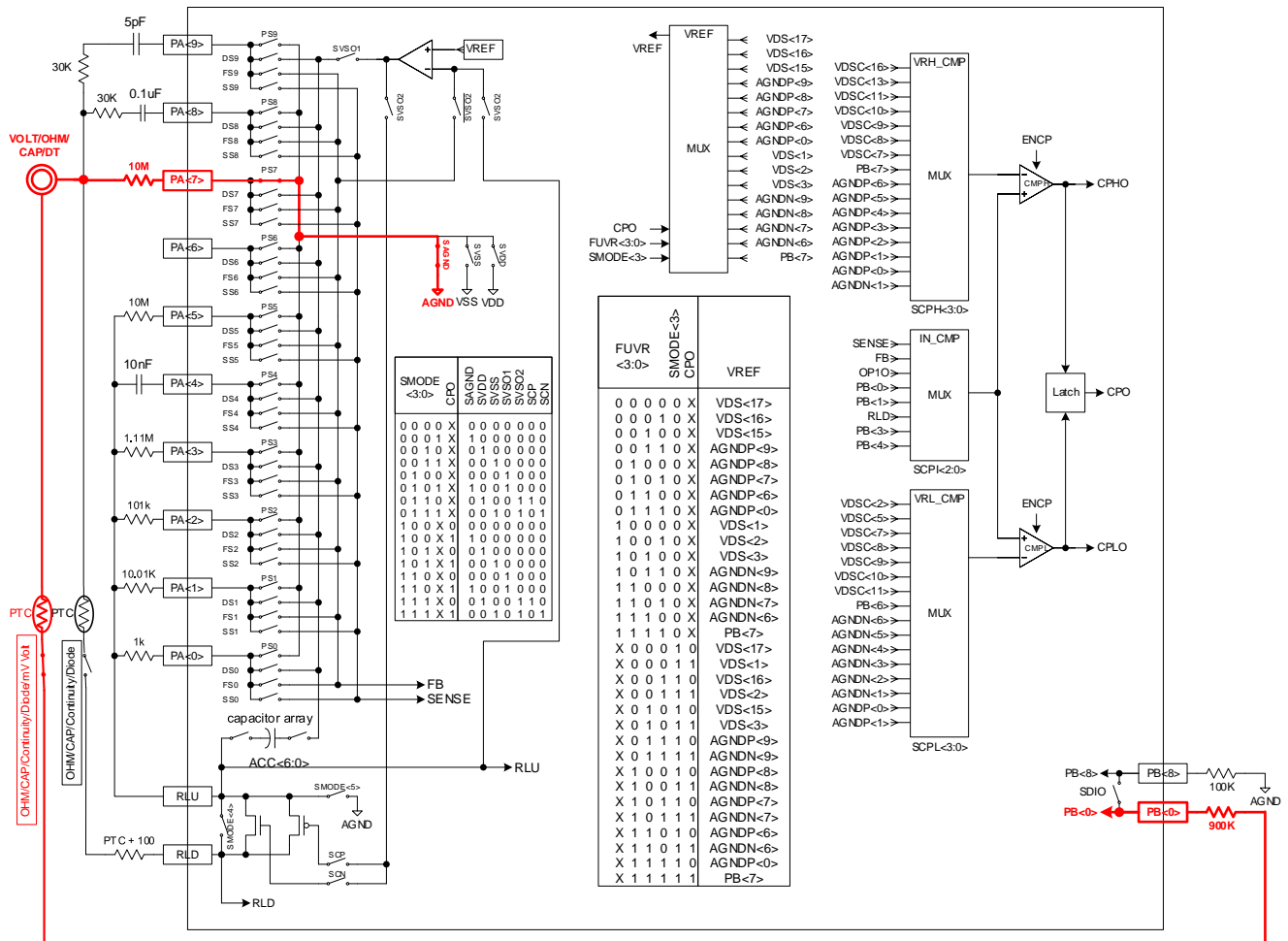


## 2. ACmV

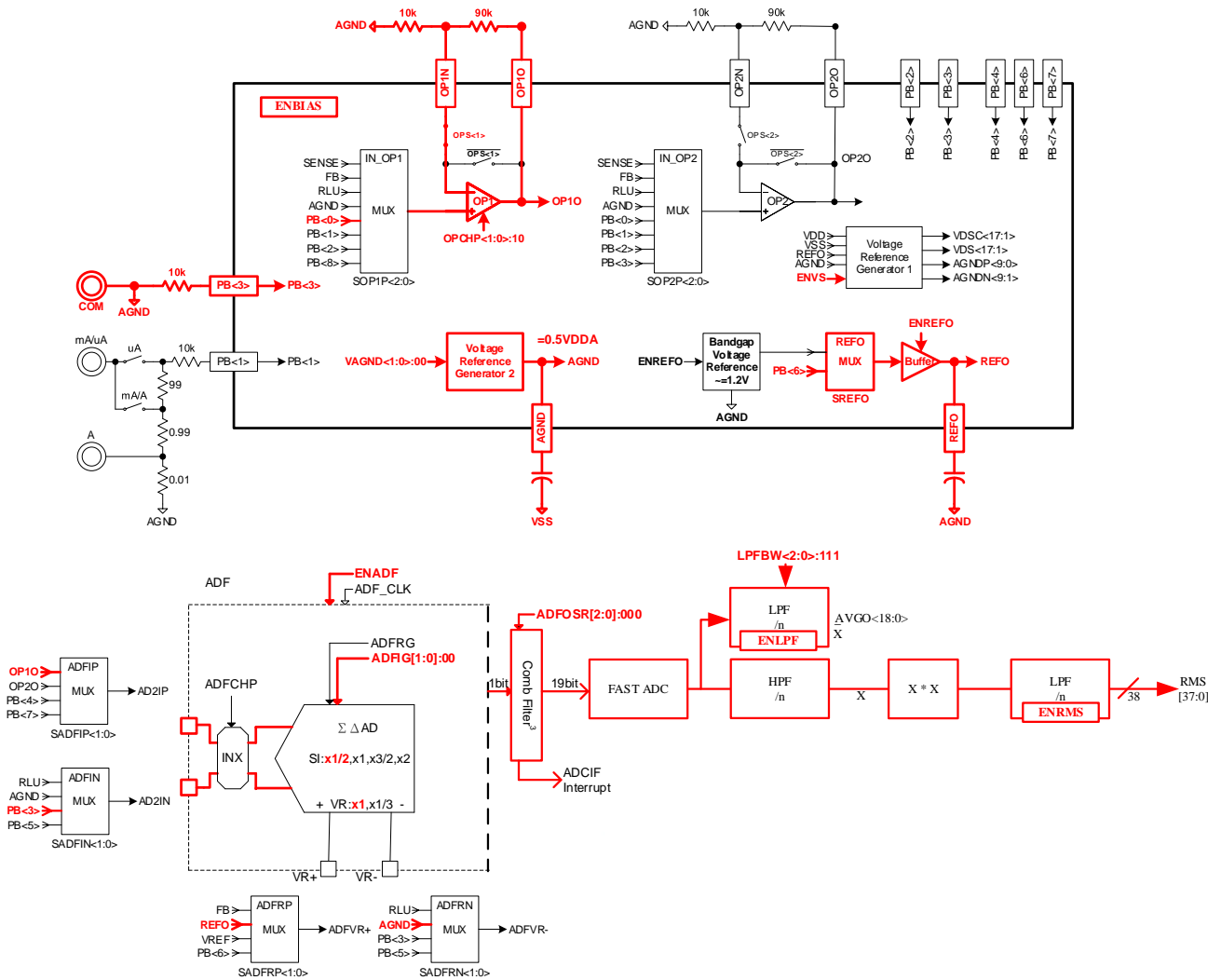
Due to high ADC input impedance, it is easily to sense 50/60Hz signal of the air that leads to unstable reading value after the testing probe was connected. It is recommended to connect input  $10M\Omega$  to ground to reduce input impedance of DMM mV range.

The network configuration of 50mV and 500mV is similar. When measuring 50mV, it uses built-in OPA to amplify signal for 10 times then processing it in ADC.

### 2.1. Input Network Configuration



## 2.2. AC50mV Measurement Network Configuration





## 3. DCV

30KΩ resistor and 5pF capacitor of the input end is for the use of ACV frequency compensation. When DCV is not in use, it is recommended to connect to ground and its input divider of voltage range is shown in below equation :

$$5V\_Range \Rightarrow V_{in} \times \frac{1.111M\Omega}{1.111M\Omega + 10M\Omega} = \frac{V_{in}}{10}$$

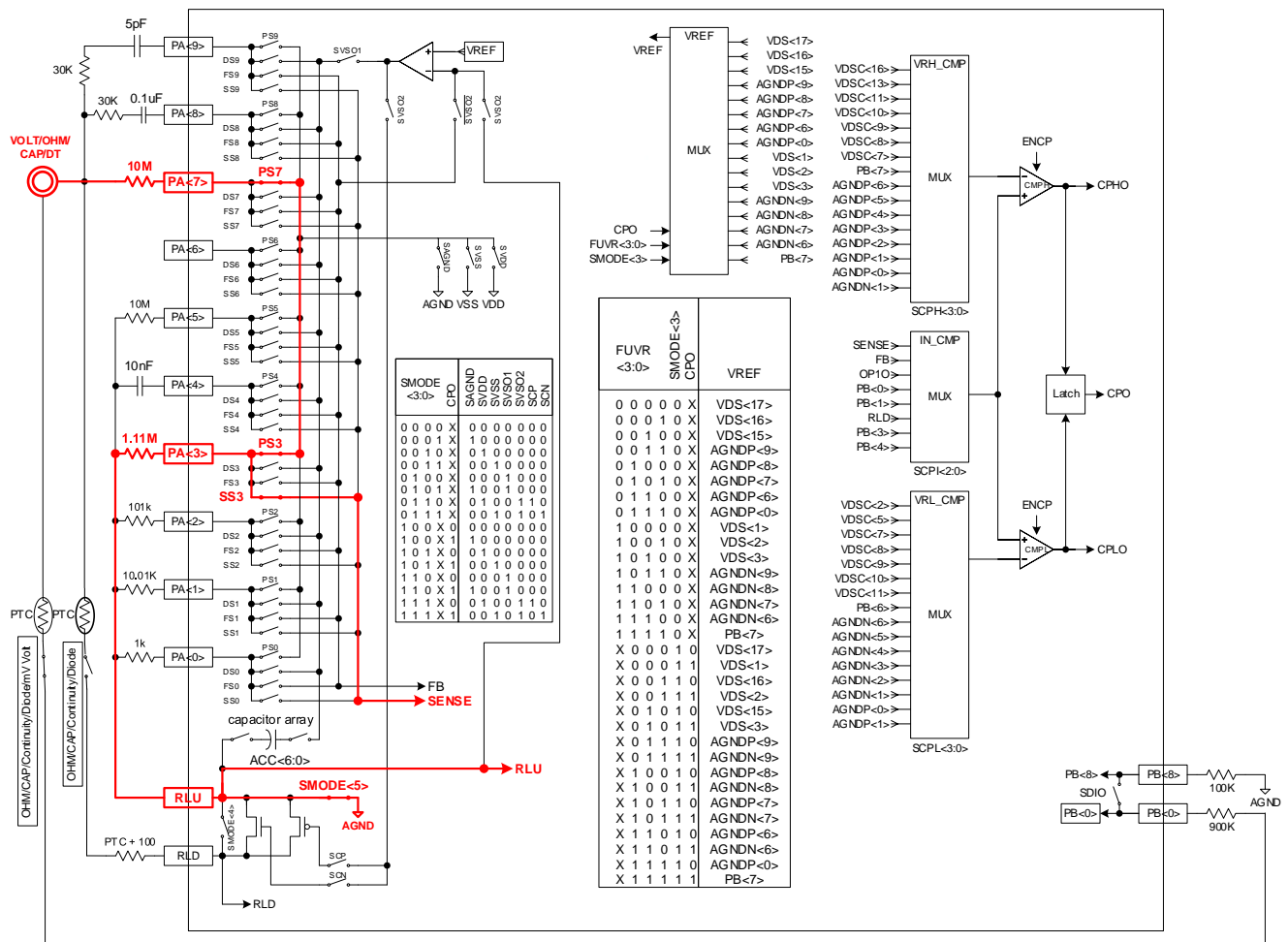
$$50V\_Range \Rightarrow V_{in} \times \frac{101.01k\Omega}{101.01k\Omega + 10M\Omega} = \frac{V_{in}}{100}$$

$$500V\_Range \Rightarrow V_{in} \times \frac{10.01k\Omega}{10.01k\Omega + 10M\Omega} = \frac{V_{in}}{1000}$$

$$1000V\_Range \Rightarrow V_{in} \times \frac{1k\Omega}{1k\Omega + 10M\Omega} = \frac{V_{in}}{10000}$$

HY313x has two sets OPA that can be used to amplify 10 times of signal, realizing 500mV measurement by collocating with 5V network configurations.

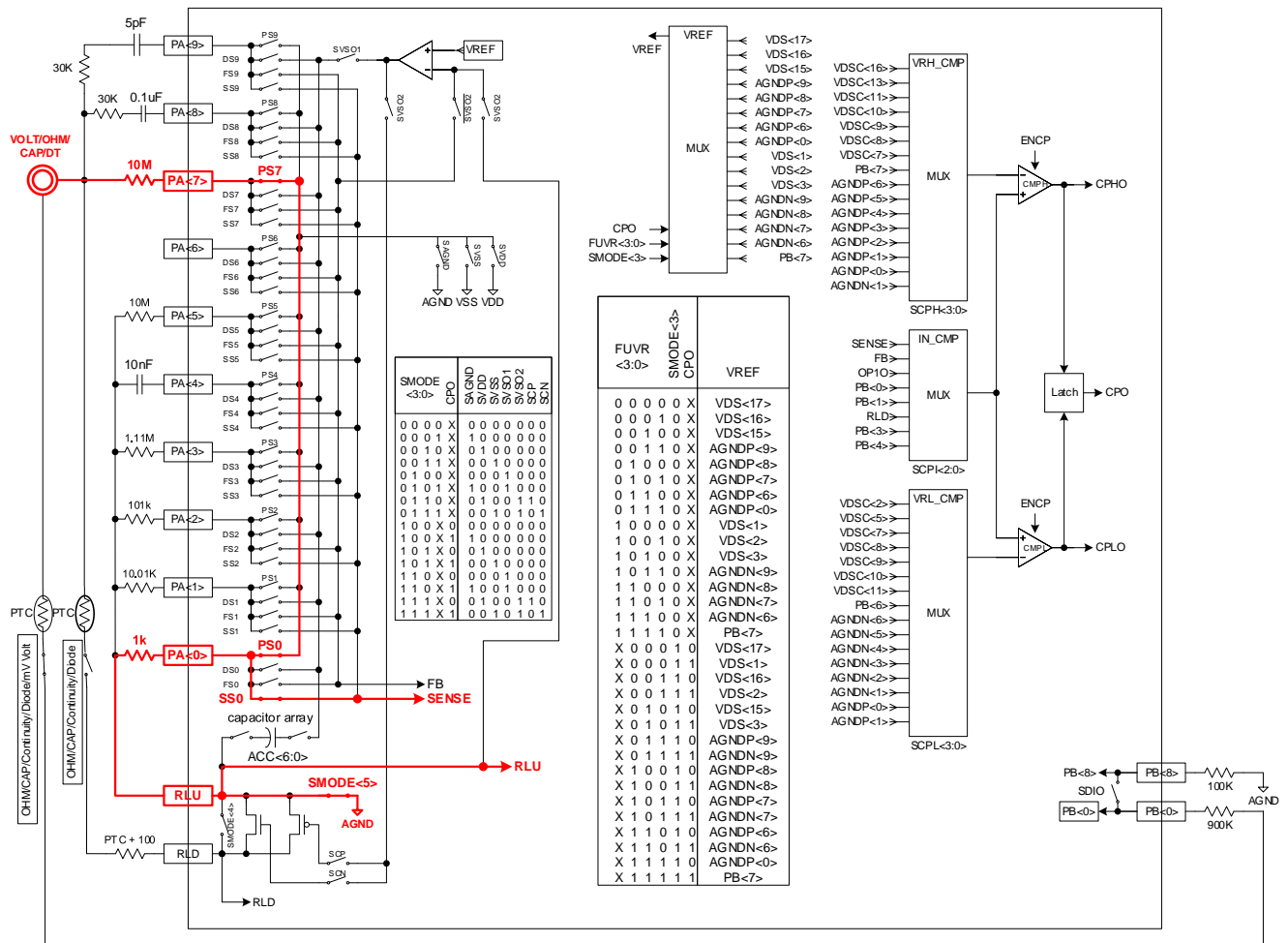
### 3.1. 5V Input Network Configuration





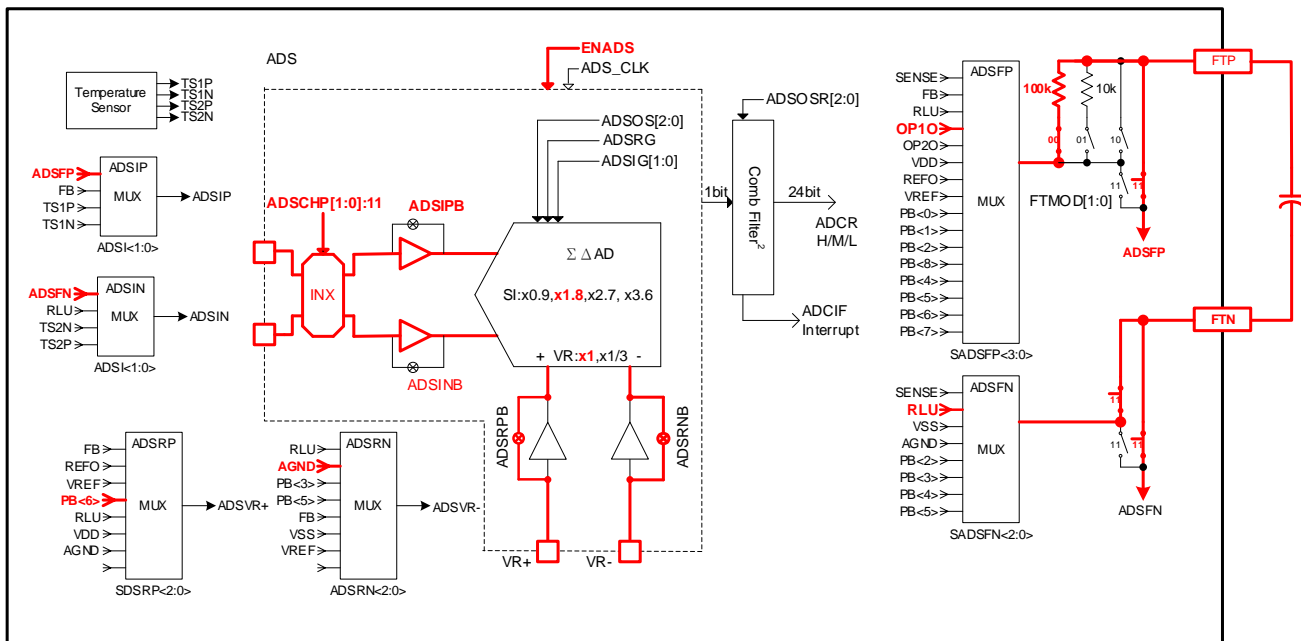
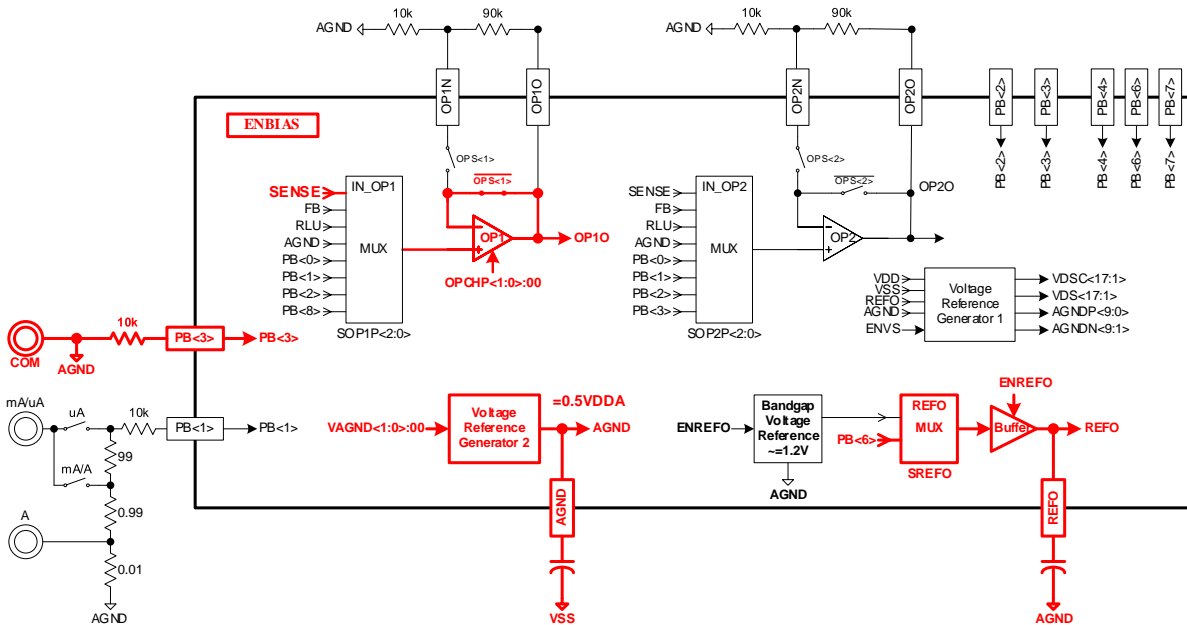


## 3.4. 1000V Input Network Configuration



## 3.5. DC5V~1000V Measurement Network Configuration

Main function of Chopper is to reduce DC Offset.



## 4. ACV

30KΩ resistor and 5pF capacitor of the input end is to compensate ACV frequency. When a part of ranges are not in use, it is recommended to connect to ground and its input divider of voltage range is shown in below equation :

$$5V \_ Range \Rightarrow V_{IN} \times \frac{1.111M\Omega}{10M\Omega + 1.111M\Omega} = \frac{V_{IN}}{10}$$

$$50V \_ Range \Rightarrow V_{IN} \times \frac{101.01K\Omega}{10M\Omega + 101.01K\Omega} = \frac{V_{IN}}{100}$$

$$500V \_ Range \Rightarrow V_{IN} \times \frac{10.01K\Omega}{10M\Omega + 10.01K\Omega} = \frac{V_{IN}}{1000}$$

$$1000V \_ Range \Rightarrow V_{IN} \times \frac{1K\Omega}{10M\Omega + 1K\Omega} = \frac{V_{IN}}{10000}$$

HY313x has two sets OPA that can be used to amplify 10 times of signal, realizing 500mV measurement by collocating with 5V network configurations.

Digital ACV bandwidth compensation capacitor equation is as follows :

$$Capacitor \ array = \sum_{n=0}^6 ACC \langle n \rangle \times 2^n \times 0.2 \ pF$$

Capacitance value of every Bit: (Bit = 0 or 1) x 2<sup>n</sup> x 0.2pF. Calculated capacitance value result of every Bit is shown in below table.

(unit : pF)

ACC<6:0> = n	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
ACC<n>	0/1	0/1	0/1	0/1	0/1	0/1	0/1
Capacitance Value	12.8	6.4	3.2	1.6	0.8	0.4	0.2

Example 1:

Supposed ACC<6:0>=1010101,

Then total compensation capacitance value:

$$= (1 \times 2^6 \times 0.2) + (0 \times 2^5 \times 0.2) + (1 \times 2^4 \times 0.2) + (0 \times 2^3 \times 0.2) + (1 \times 2^2 \times 0.2) + (0 \times 2^1 \times 0.2) + (1 \times 2^0 \times 0.2)$$

$$= 12.8 + 0 + 3.2 + 0 + 0.8 + 0 + 0.2$$

$$= 17 \ pF$$

Example 2:

Supposed ACC<6:0>=1100011 ,

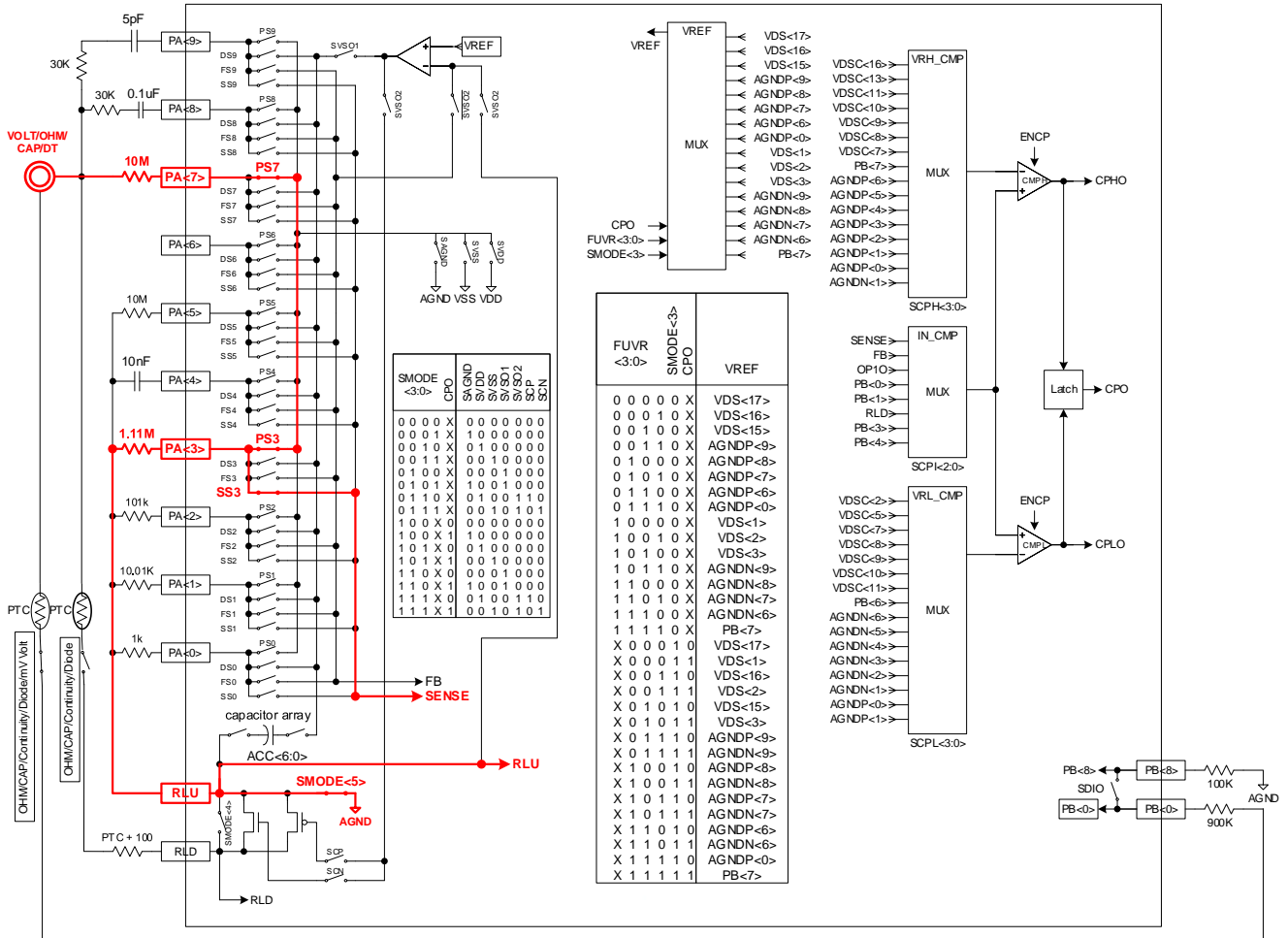
Then total compensation capacitance value:

$$= (1 \times 2^6 \times 0.2) + (1 \times 2^5 \times 0.2) + (0 \times 2^4 \times 0.2) + (0 \times 2^3 \times 0.2) + (0 \times 2^2 \times 0.2) + (1 \times 2^1 \times 0.2) + (1 \times 2^0 \times 0.2)$$

$$= 12.8 + 6.4 + 0 + 0 + 0 + 0.4 + 0.2$$

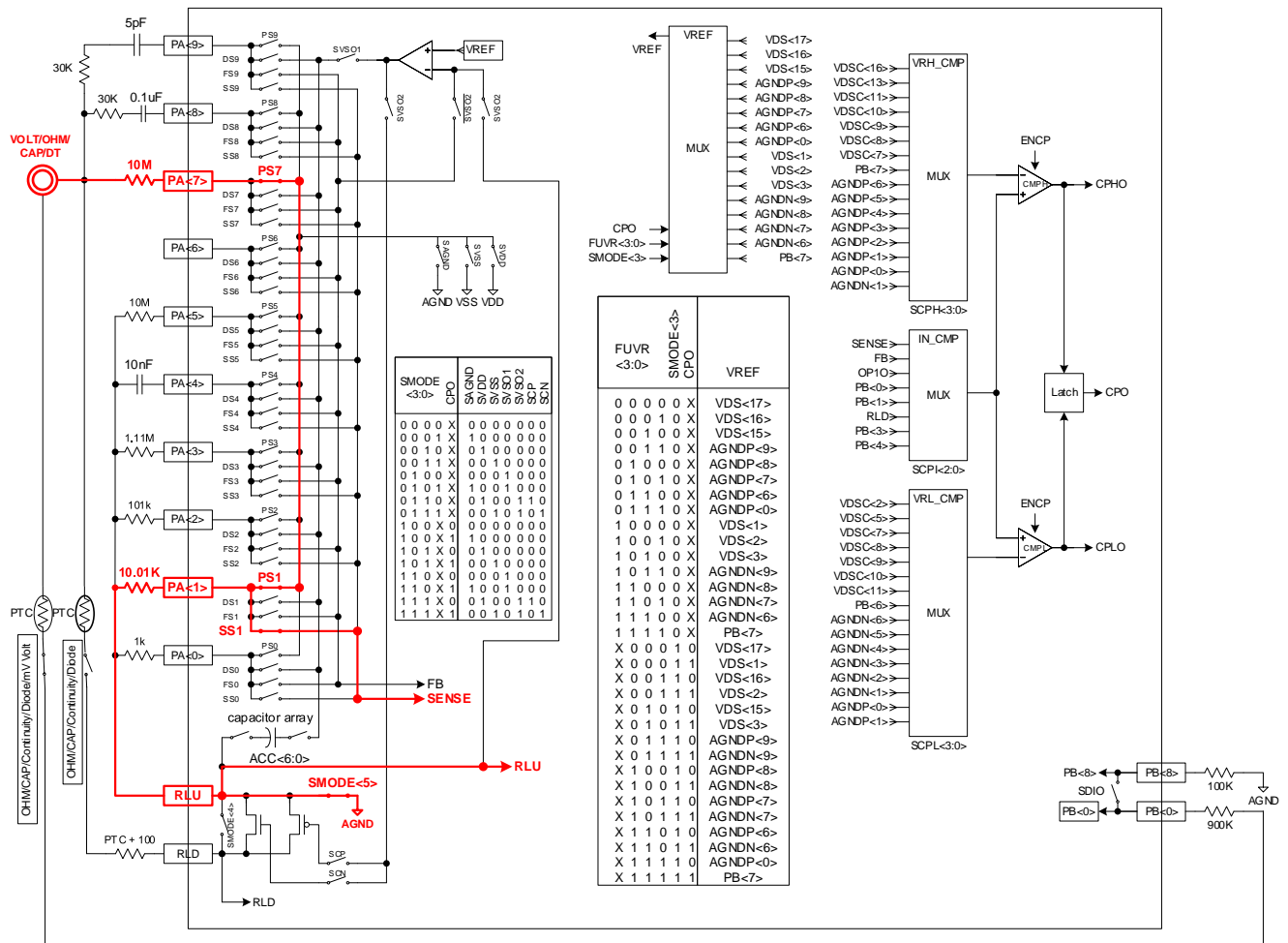
$$= 19.8 \ pF$$

### 4.1. 5V Input Network Configuration



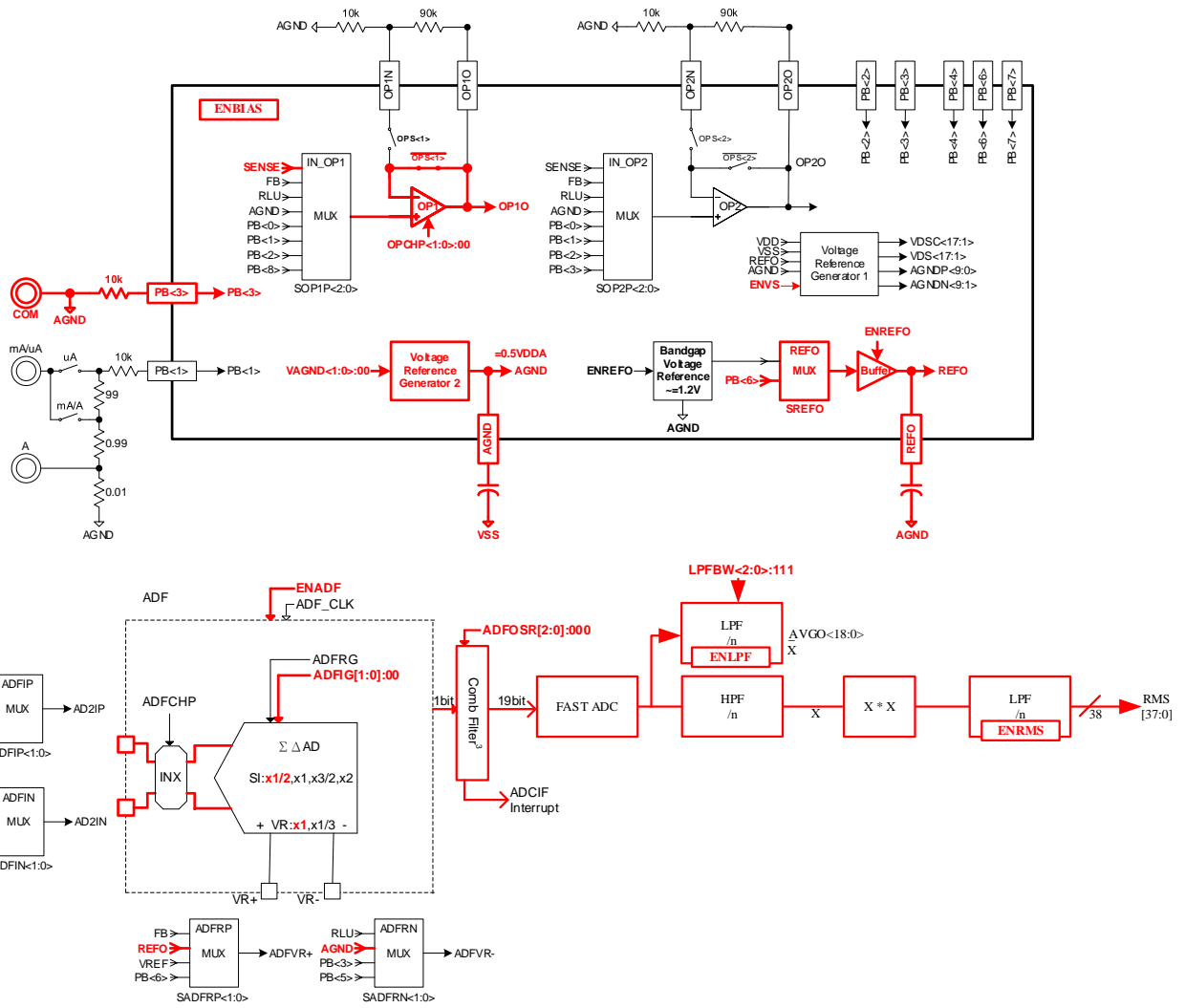


## 4.3. 500V Input Network Configuration



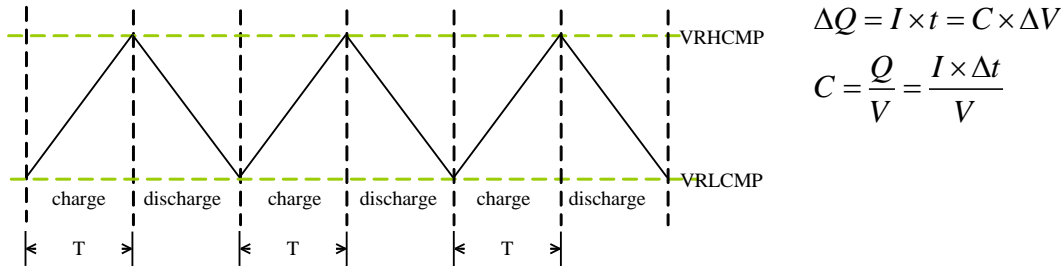


## 4.5. AC5V~1000V Measurement Network Configuration



## 5. Capacitance

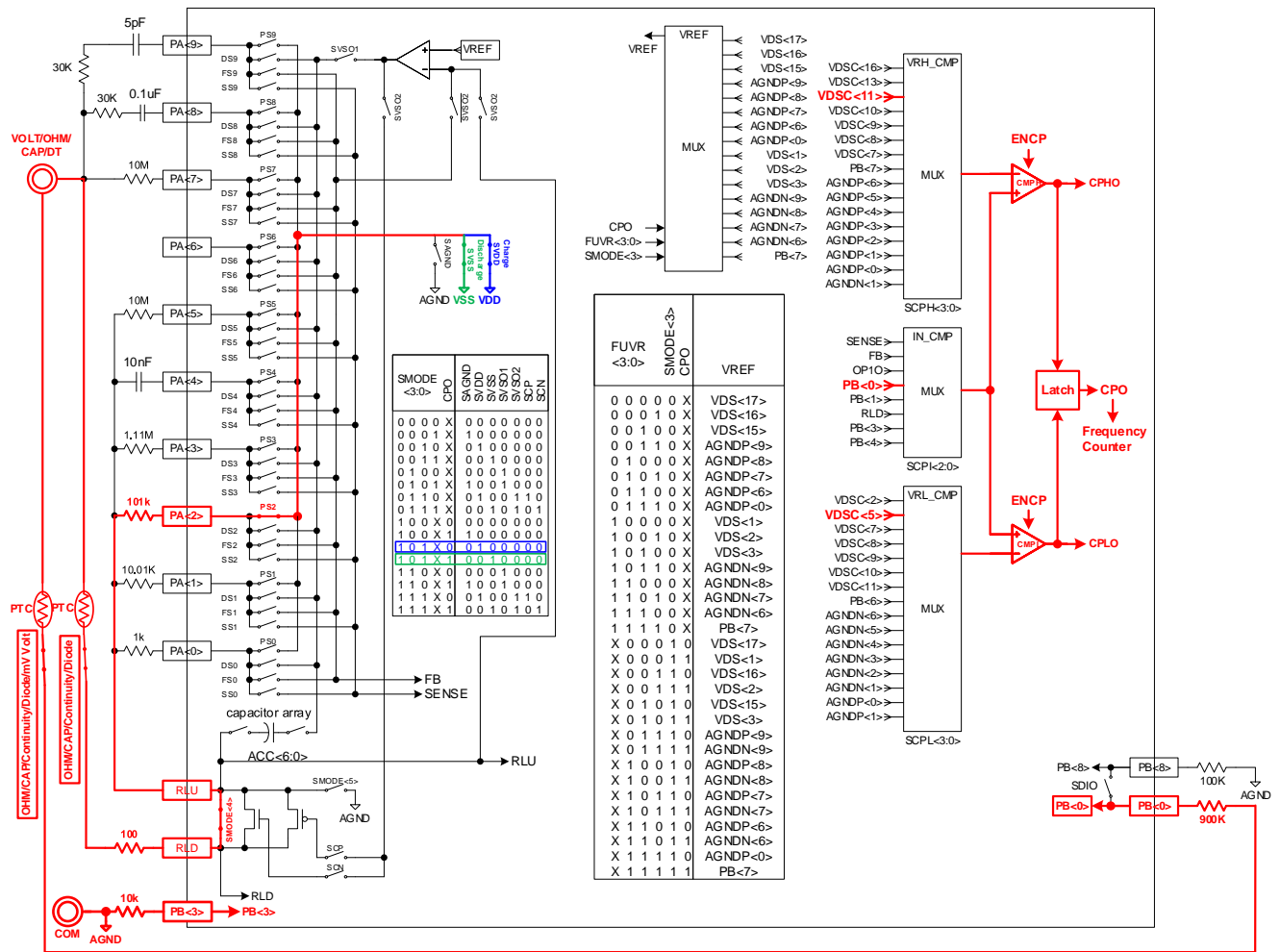
There are two ways to measure capacitance, constant voltage and constant current output mode. Under low capacitance (<math><1 \mu\text{F}</math>), users need to use constant voltage output mode for testing whereas using constant current output mode to test high capacitance (>1  $\mu\text{F}$ ). Capacitance measurement uses charge/discharge test cycle to gain the value.



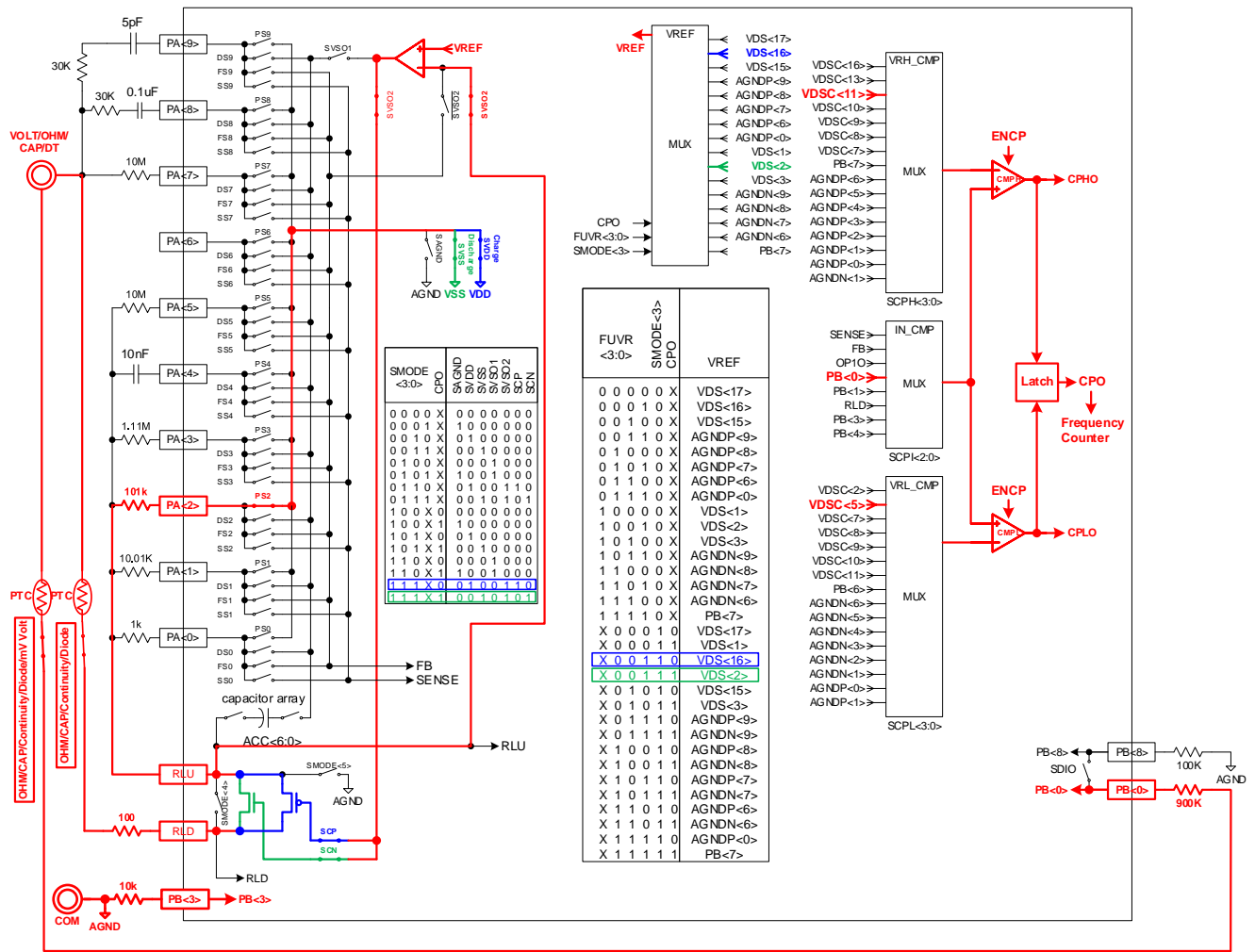
Capacitance measurement test procedure :

1. Select constant voltage (SMODE<5:0>=011010b) and constant current (SMODE<5:0>=001110b) test mode output.
2. Configure capacitor charge/discharge comparison voltage (VRHCMP 、 VRLCMP) and the actual charge/discharge of capacitor is decided by comparator, ACPO.
3. Configure CTA<23:8> initial value of Frequency Counter. When INTF2 register, CTF bit is 1, CTC<23:0> divided by CTB<23:0> to gain the cycle length.

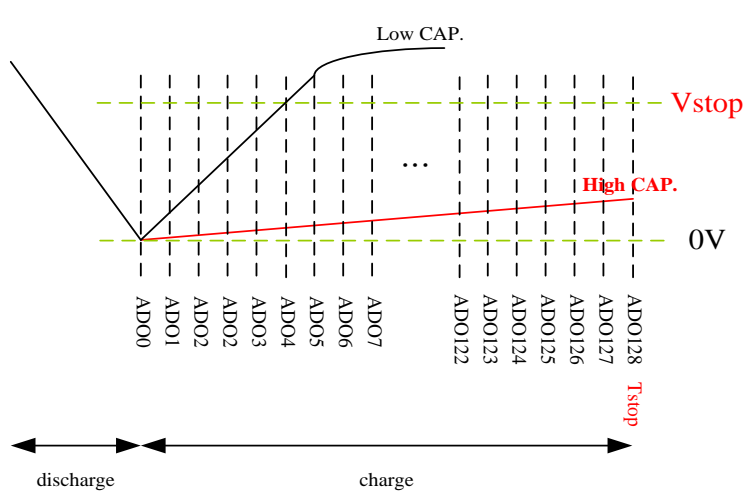
## 5.1. 50-500nF (Constant Voltage Charge/Discharge Measurement)



## 5.2. 5uF-50uF (Constant Current Charge/Discharge Measurement)



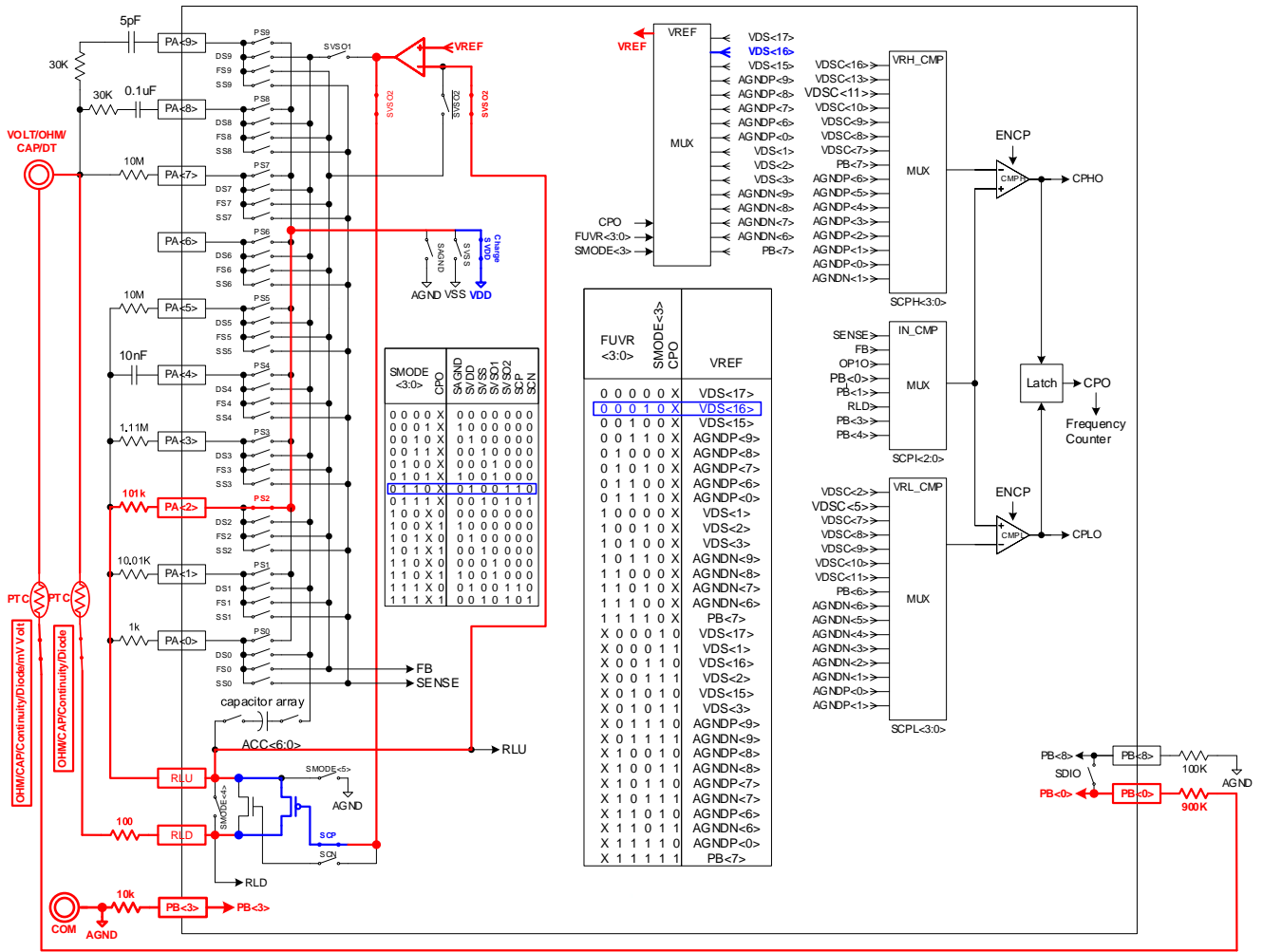
500uF~50mF capacitors require longer charge/discharge time, the only change of different ranges is the output current. Users can take the voltage difference under a fixed time (t) to gain capacitor value. The change of capacitor value and voltage value is an inverse ratio.



$$C = \frac{Q}{V} = I \times \frac{\Delta t}{\Delta V}$$

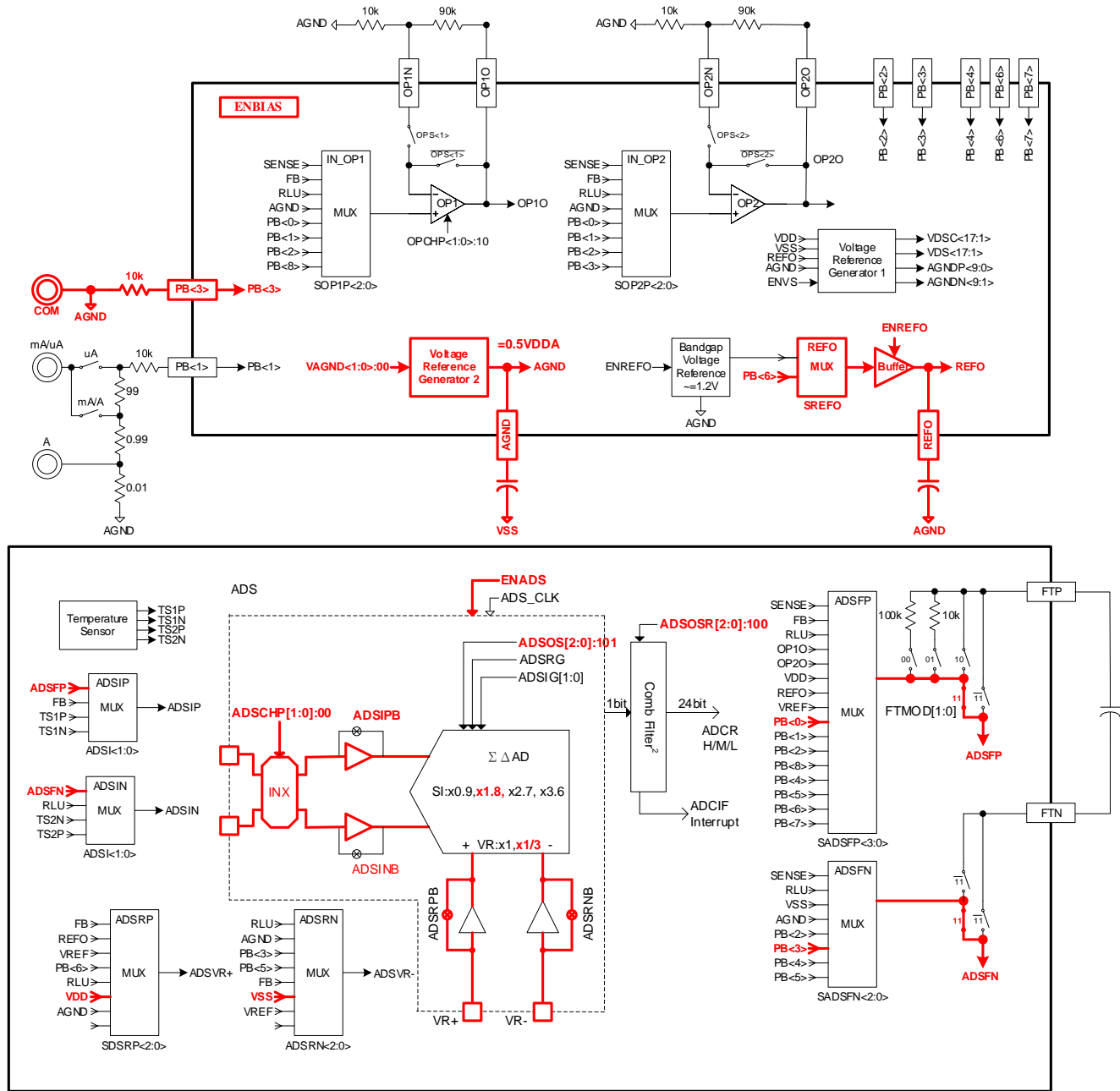
## 5.3. 500uF(Charge)

# HY313X Configurations (For HY3131-AK02)



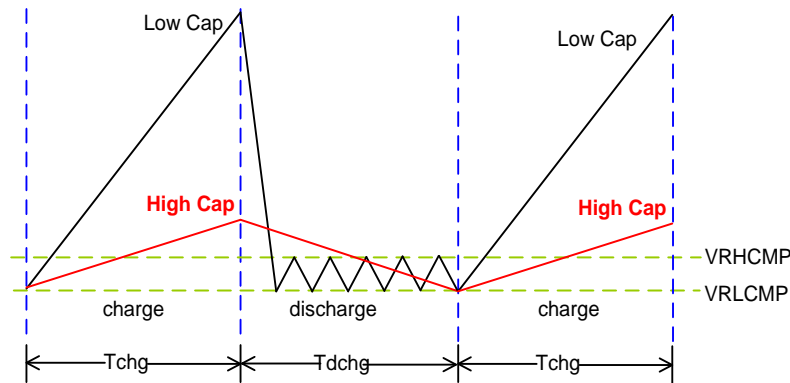


## 5.5. 500uF~50mF Measurement Network Configuration

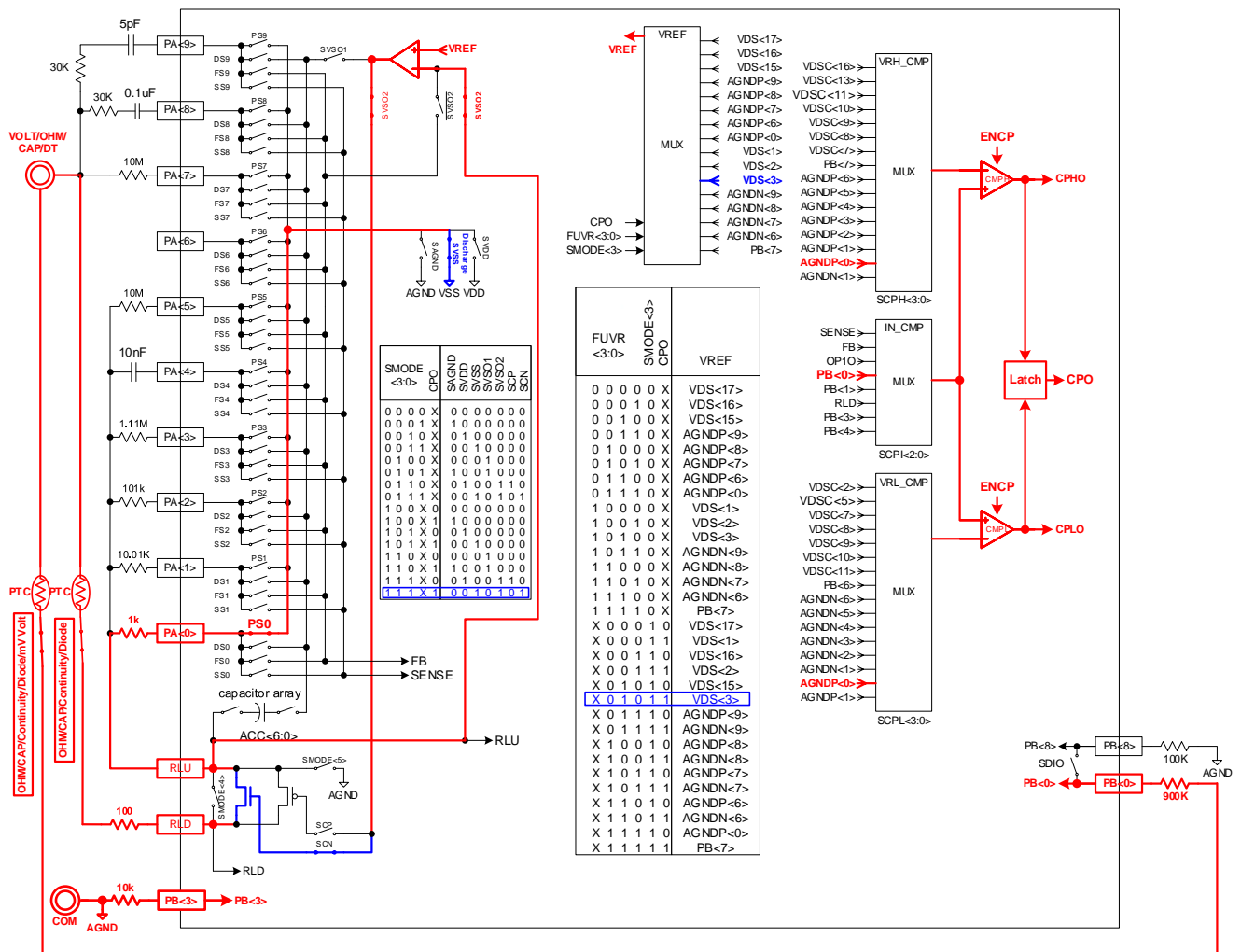


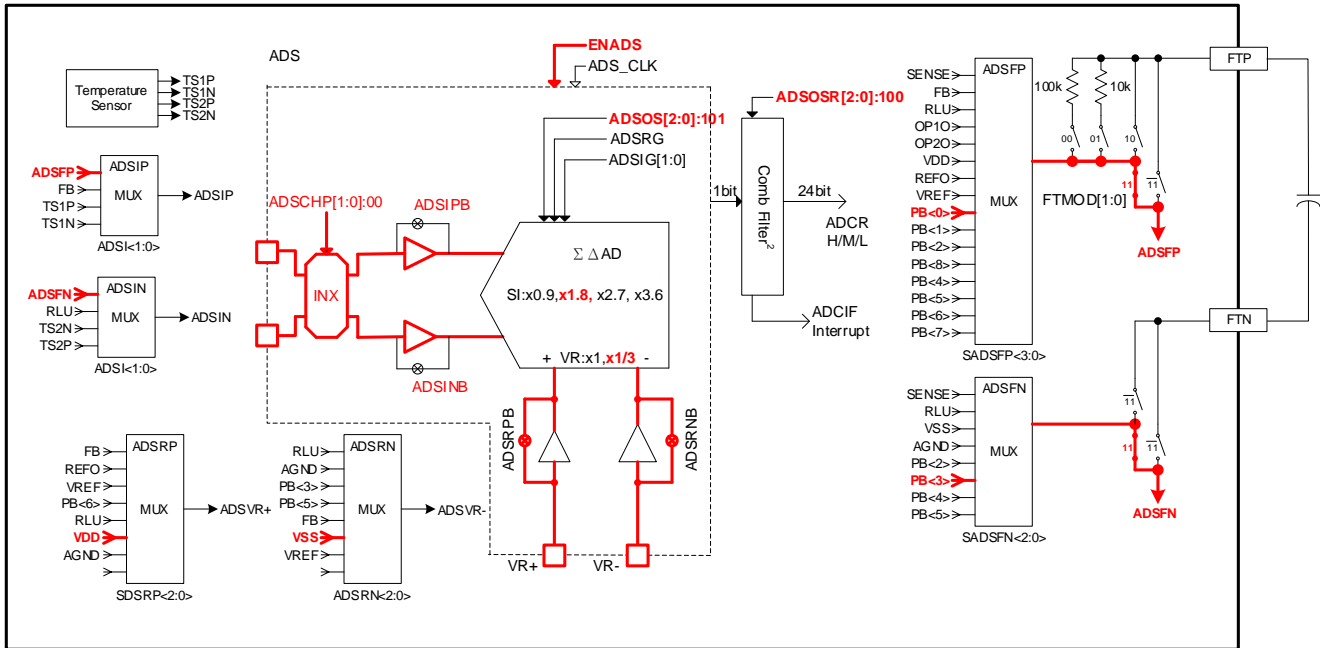
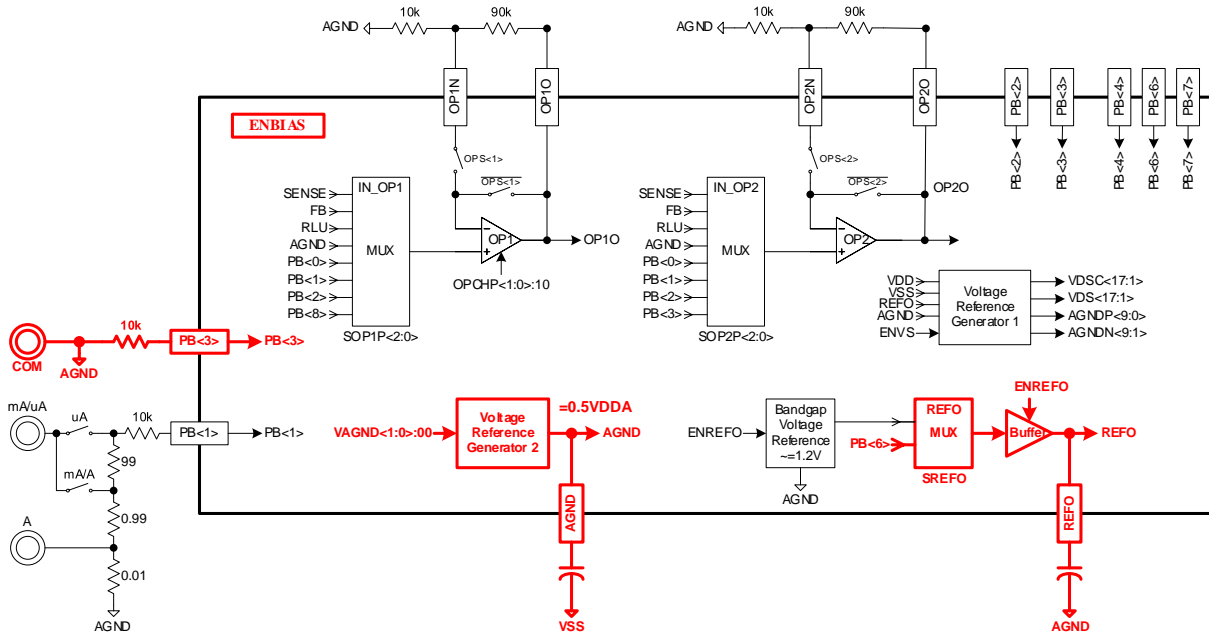
## 5.6. Discharge (500uF~50mF)

When discharging, set  $SMODE<5:0>$  to 001110b and the comparator to be close to AGND, so that the capacitor discharges itself to 0V. Regardless of the capacitance, the charging and discharging times are fixed.



◀ Charging and discharging diagram

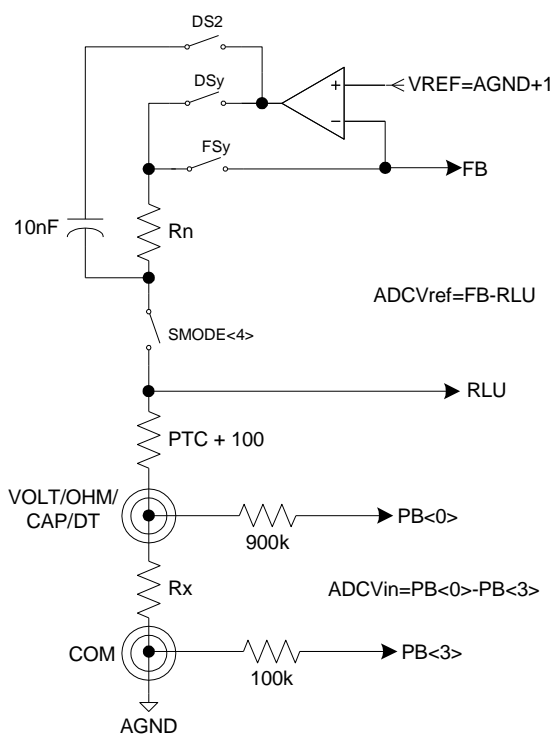




## 6. Resistor

The chip offers two ways to measure resistor, constant voltage and constant current measurement and different methods lead to diverse results.

Constant voltage or ratio resistor measurement design must input ADC signal and open reference voltage input buffer when measuring high resistor. 3MΩ parallel connection impedance will be generated if ADC input was not opened. It is suggested to use constant current resistor measurement when design 500kΩ to 50MΩ application. The measurement equation is given below :

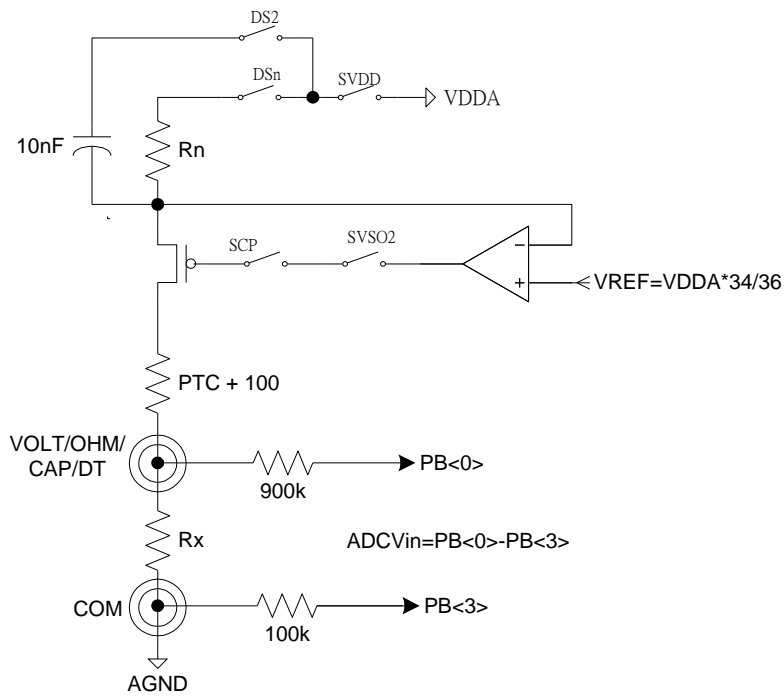


$$I_{Rx} = I_{Rn}$$

$$V_{Rx} = I_{Rx} \times R_x = \frac{V_{Rn}}{R_n} \times R_x$$

$$R_{READ} = \frac{V_{Rx}}{V_{Rn}} \times Full\ Scale = \frac{ADCV_{in}}{ADCV_{ref}} \times Full\ Scale$$

Constant current resistor measurement design has higher internal impedance of DS<sub>n</sub> and SVDD electrical switches; it will have parallel connection with R<sub>n</sub> resistor and to cause output current deviation. It is recommended to use constant voltage resistor measurement when designing 500kΩ or below applications. The measurement equation is given below :

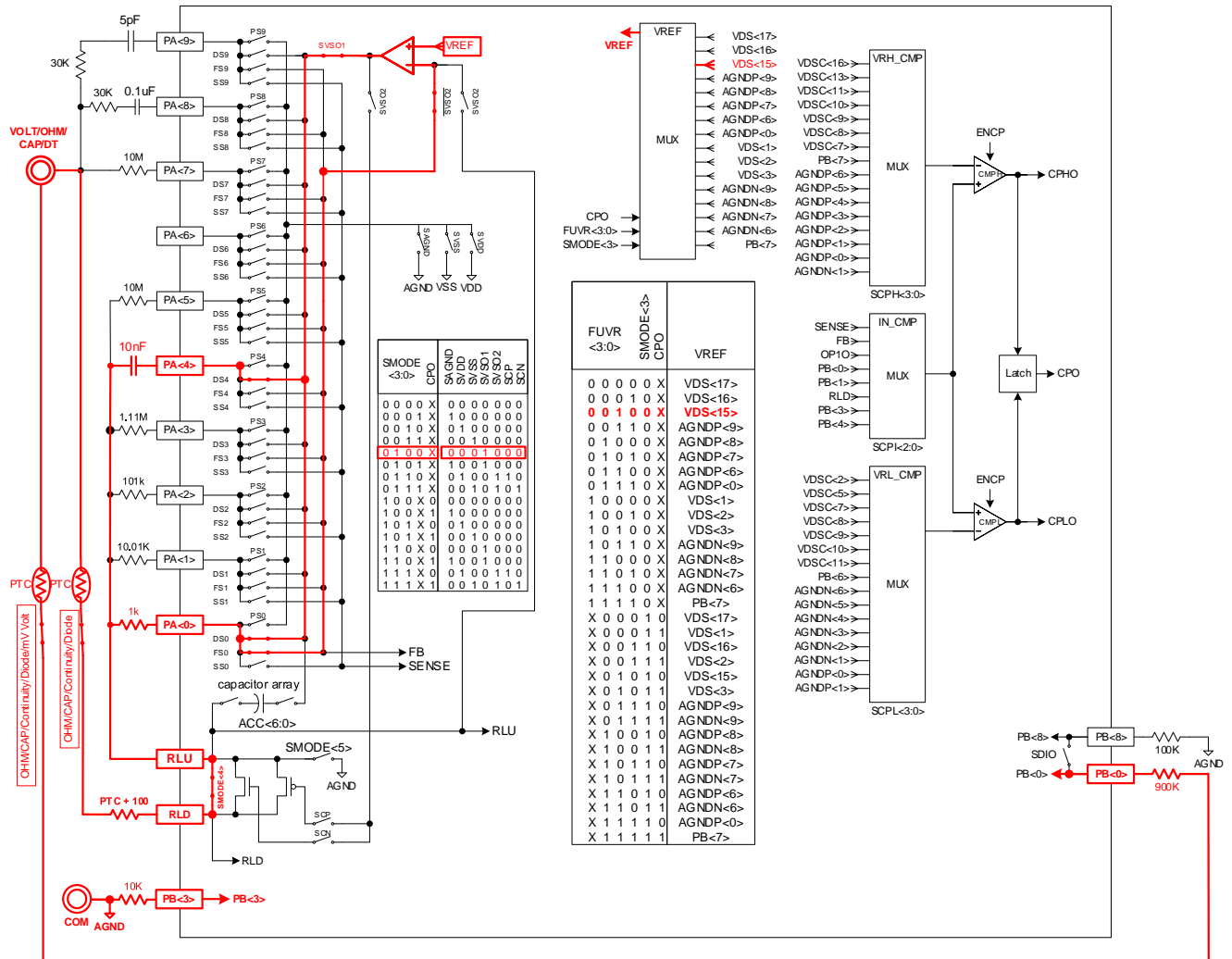


$$I_{Rx} = I_{Rn} = \frac{VDDA - VREF}{Rn}$$

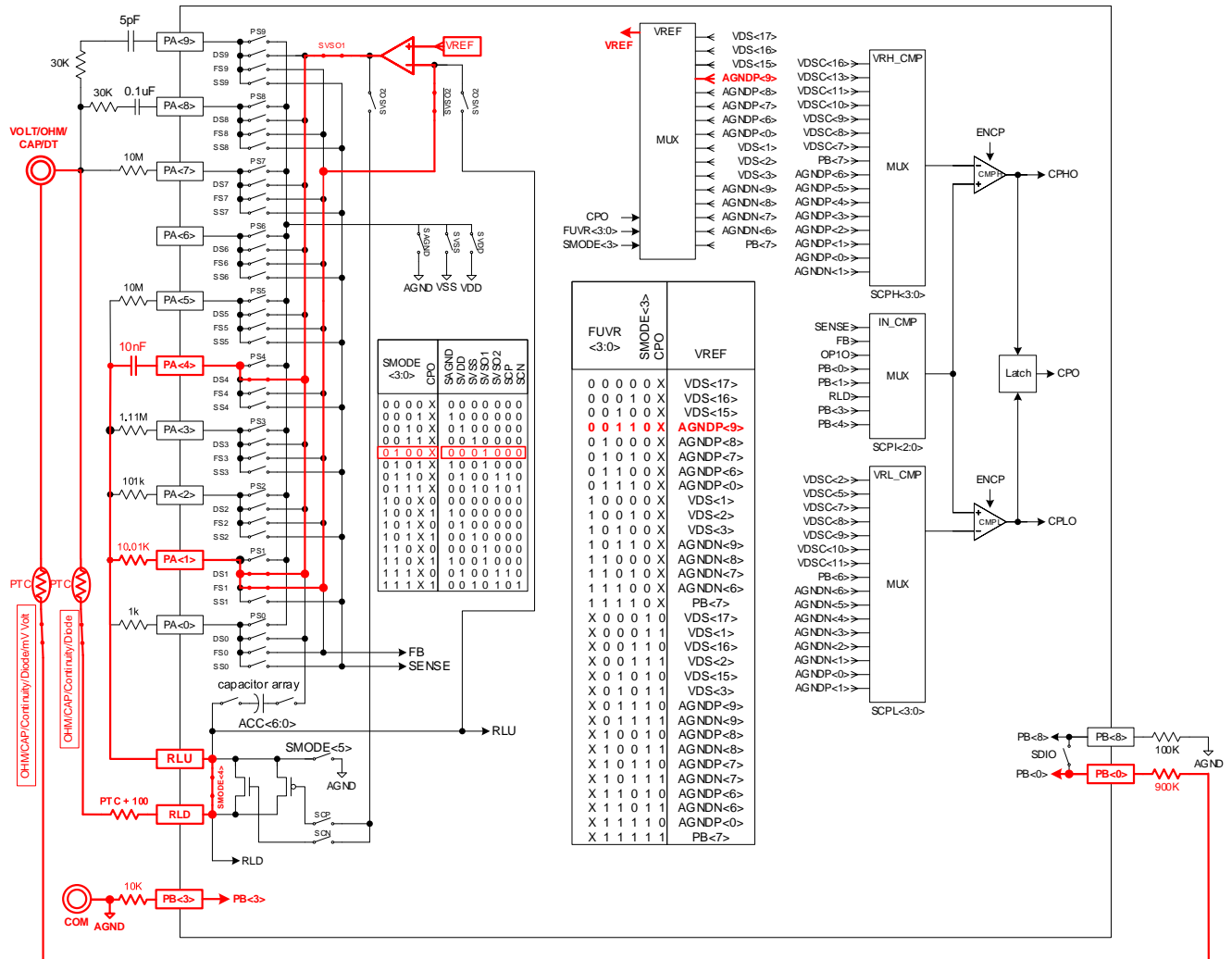
$$R_{READ} = \frac{ADCV_{in}}{ADCV_{ref}} \times Full\ Scale$$

$$R_{READ} = \frac{Rx \times I_{Rx}}{ADCV_{ref}} \times Full\ Scale$$

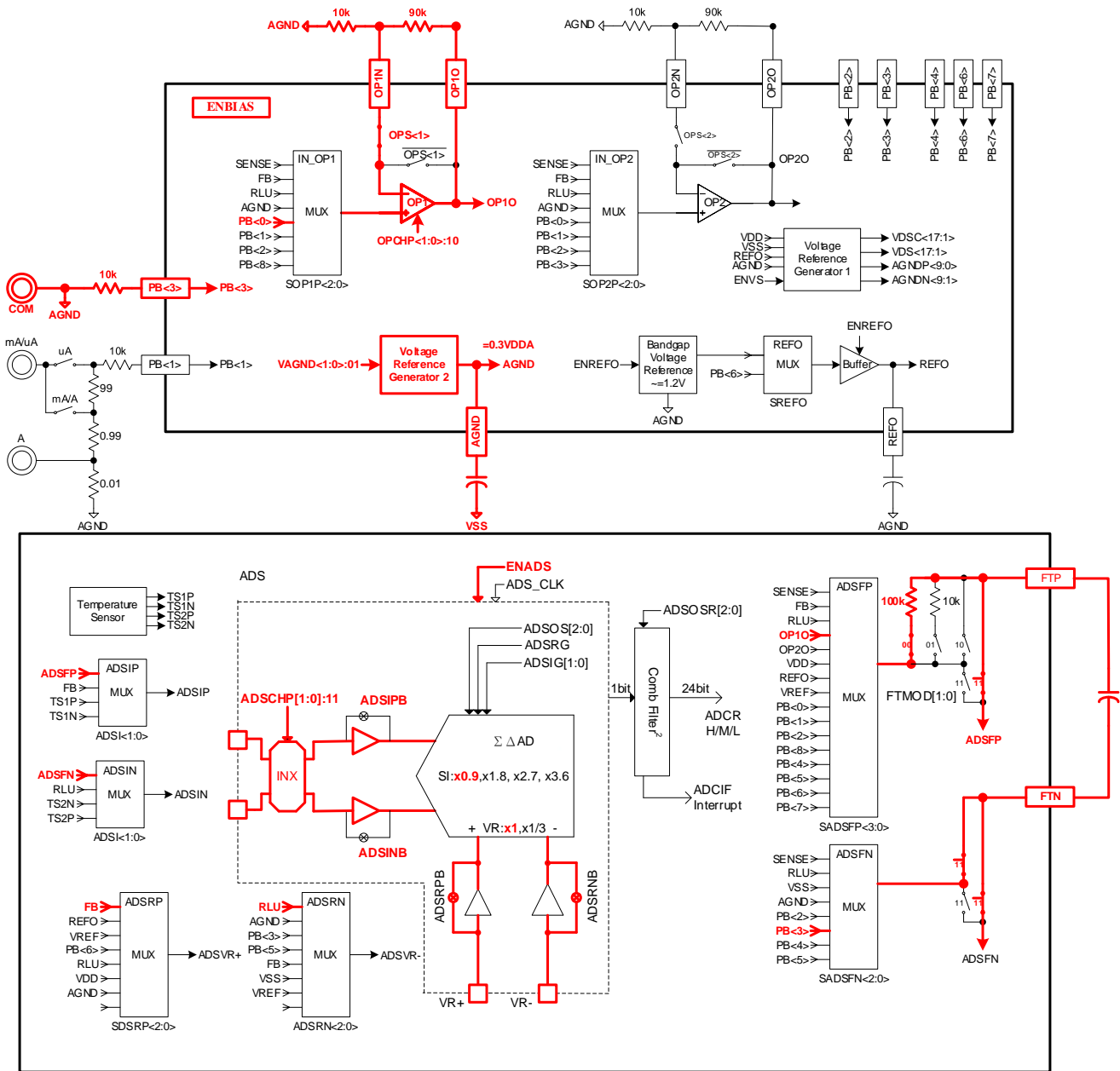
## 6.1. 50ohm/500ohm Input Network Configuration



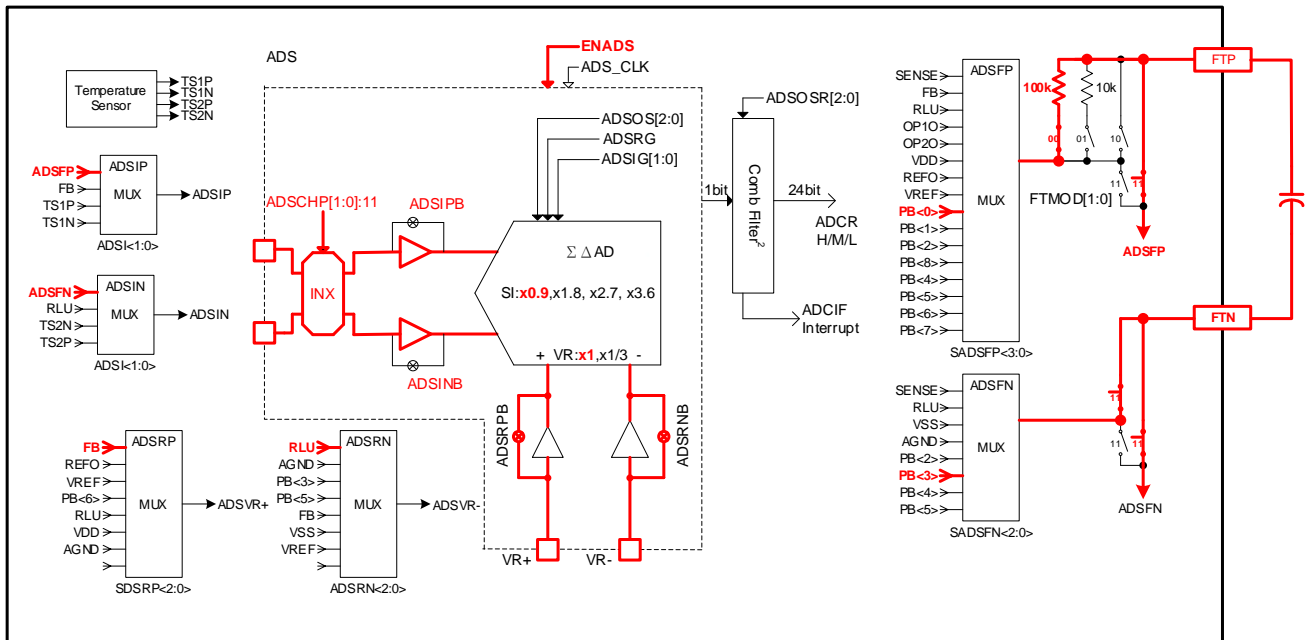
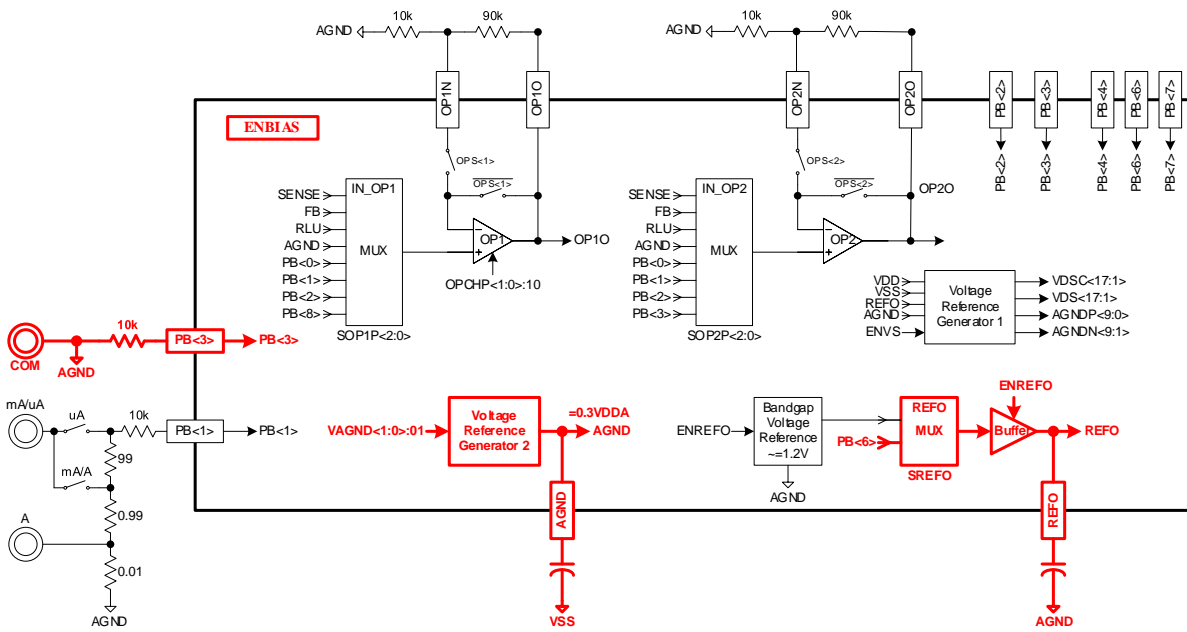
## 6.2. 5K ohm Input Network Configuration



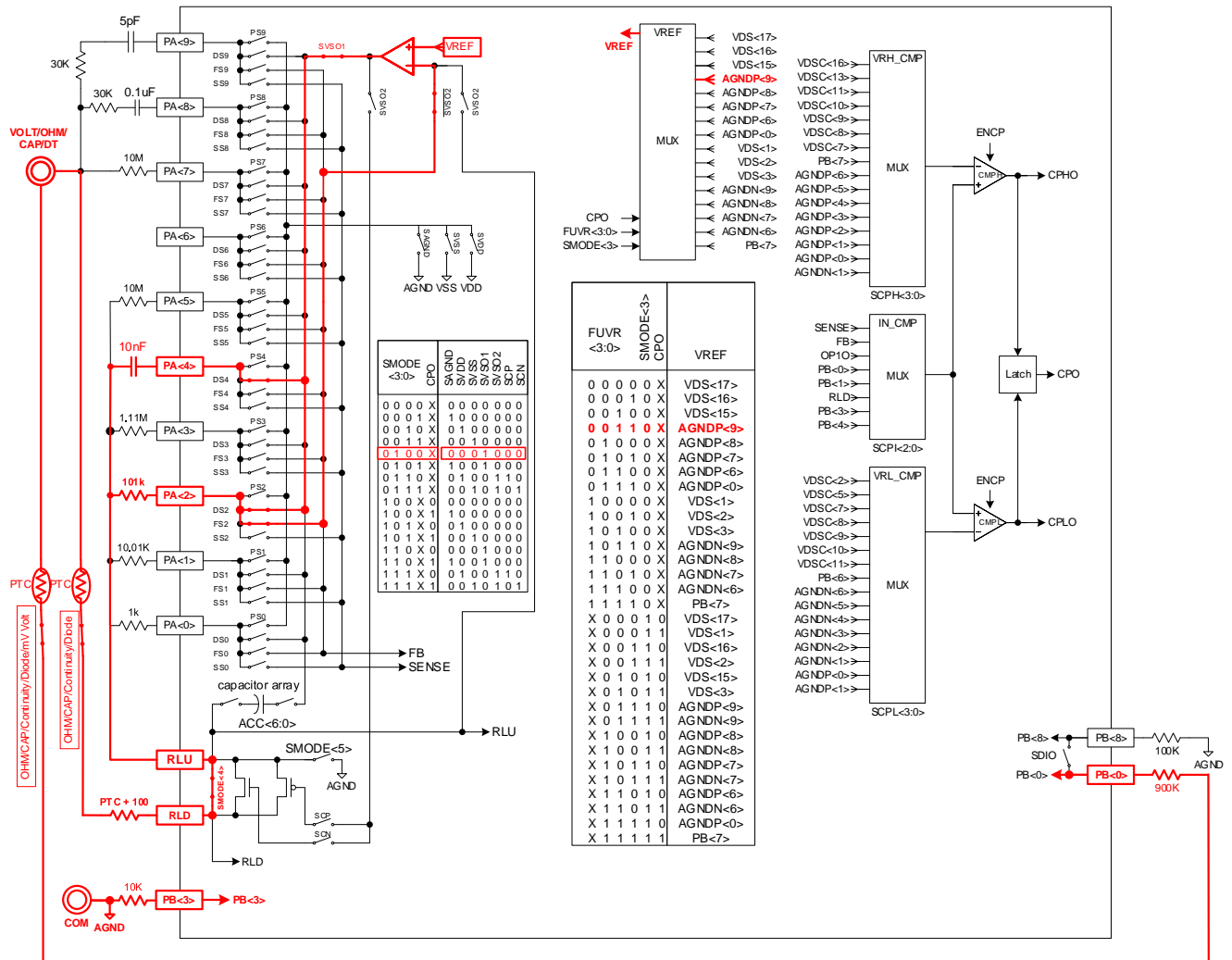
## 6.3. 50ohm Measurement Network Configuration



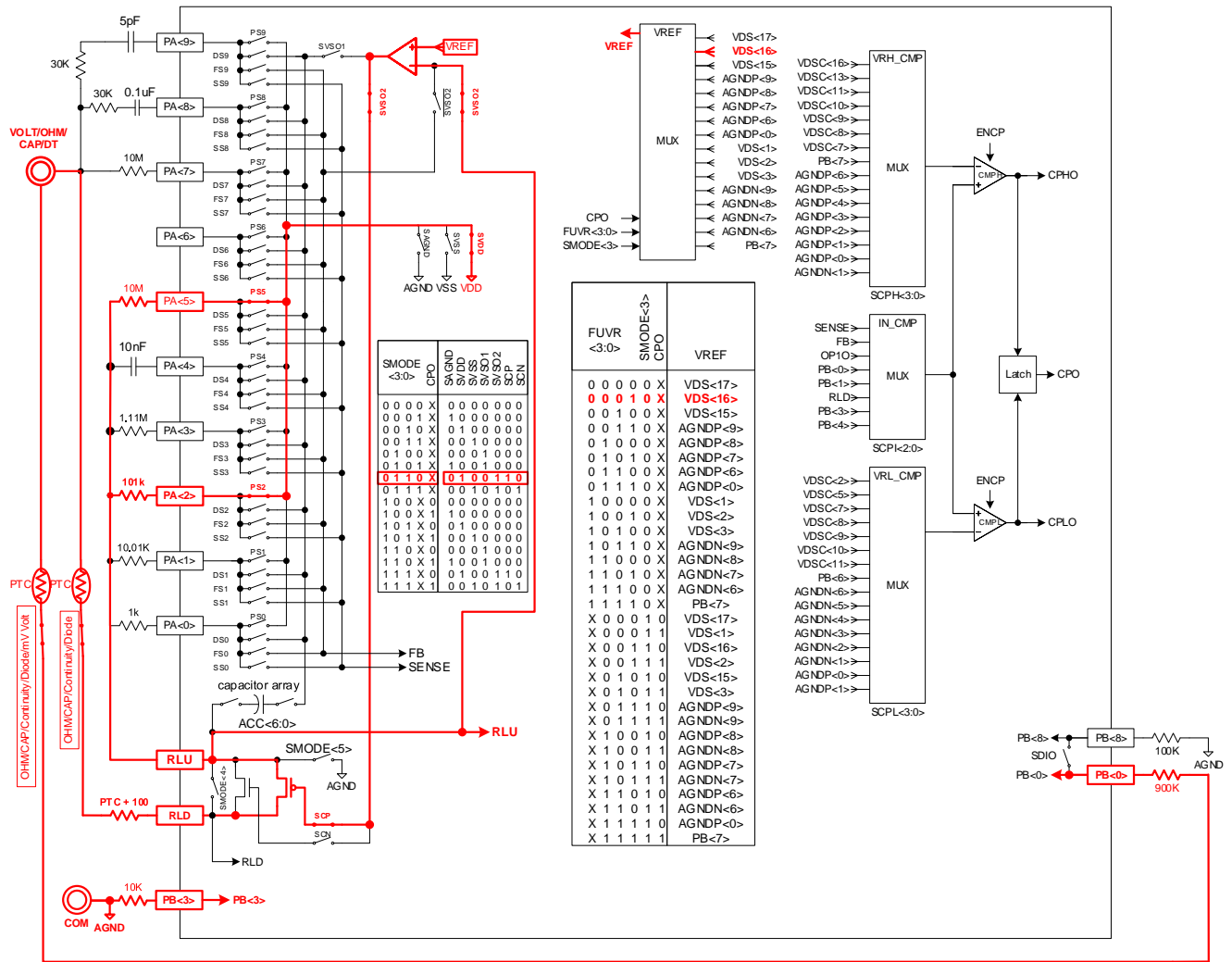
## 6.4. 500 ohm~50K ohm Measurement Network Configuration



## 6.5. 50Kohm Input Network Configuration

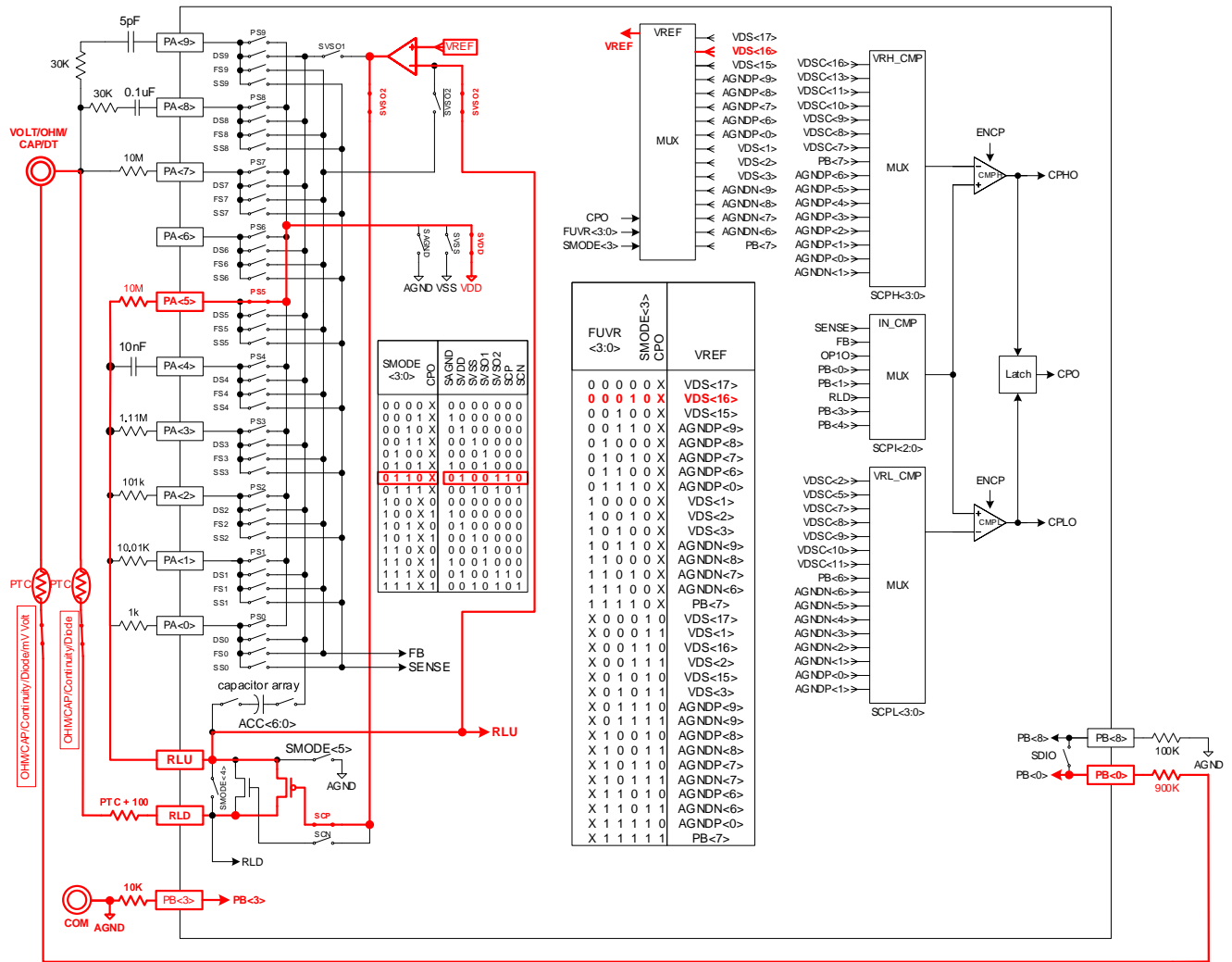


## 6.6. 500Kohm Input Network Configuration

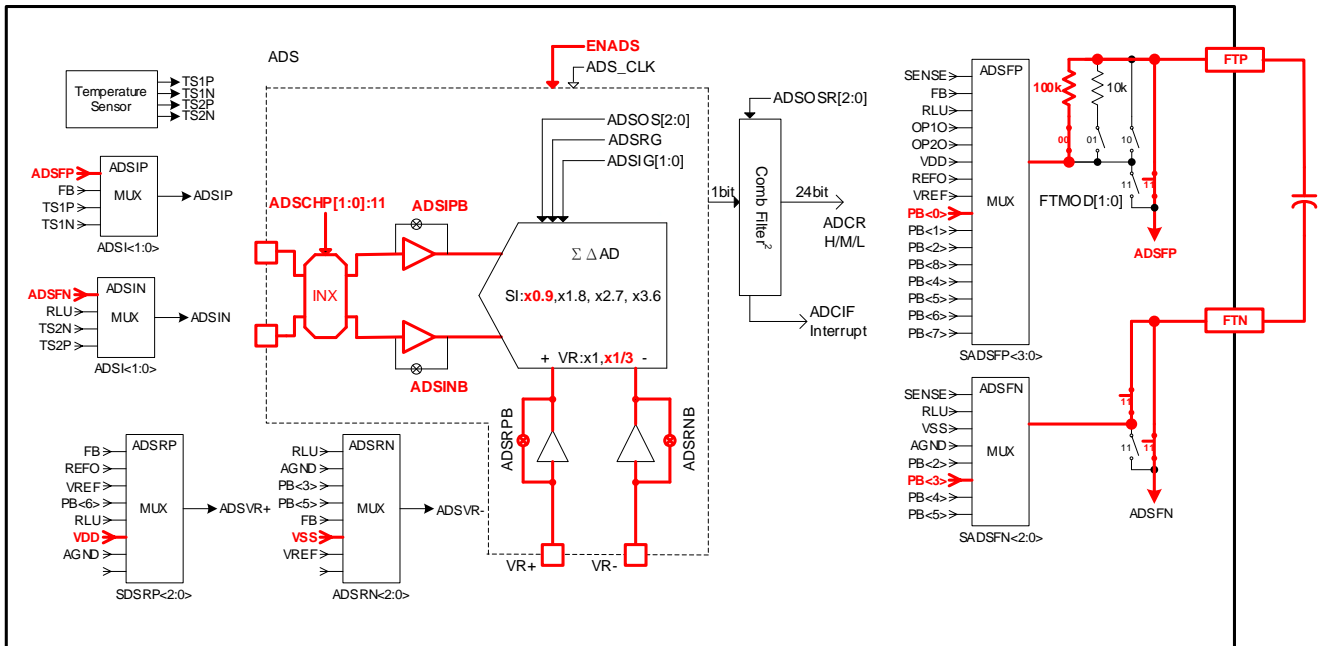
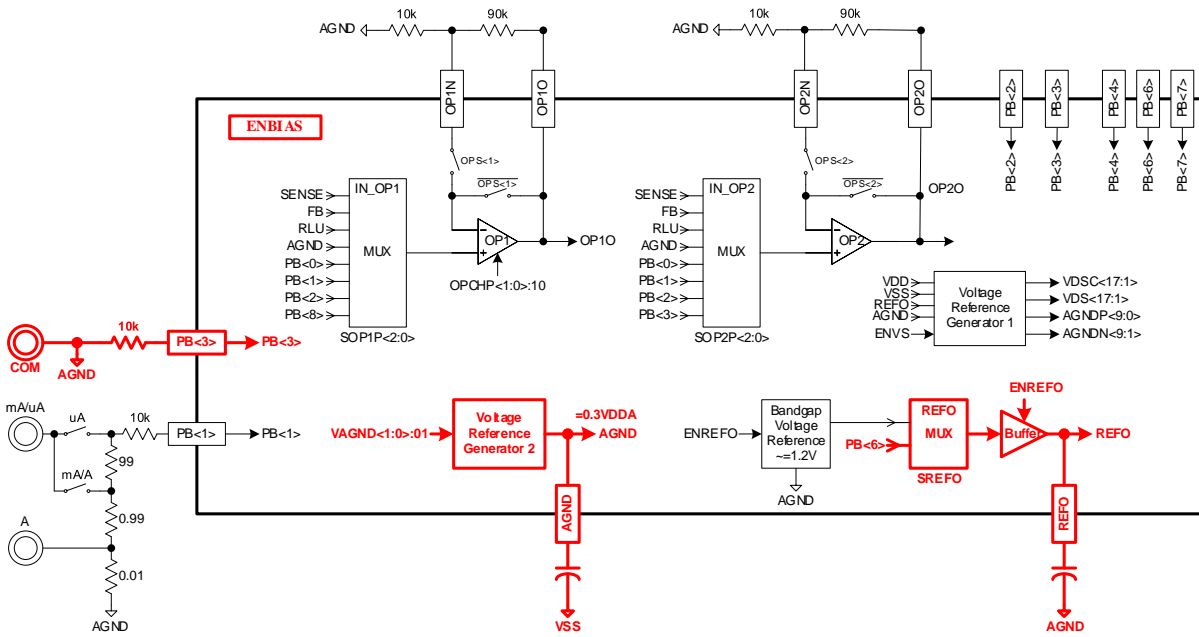




## 6.8. 50Mohm Input Network Configuration



## 6.9. 500Kohm~50Mohm Measurement Network Configuration

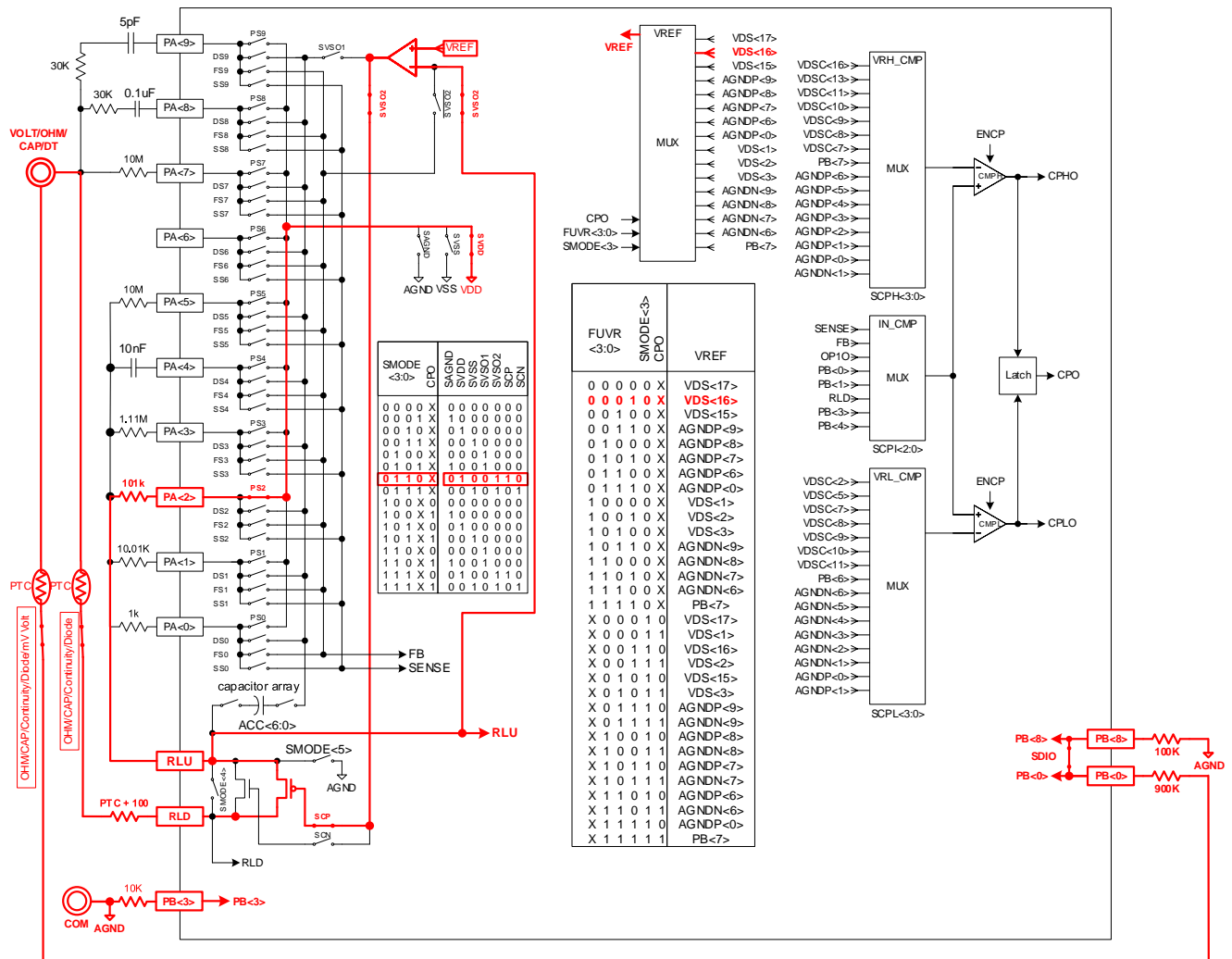


## 7. Diode

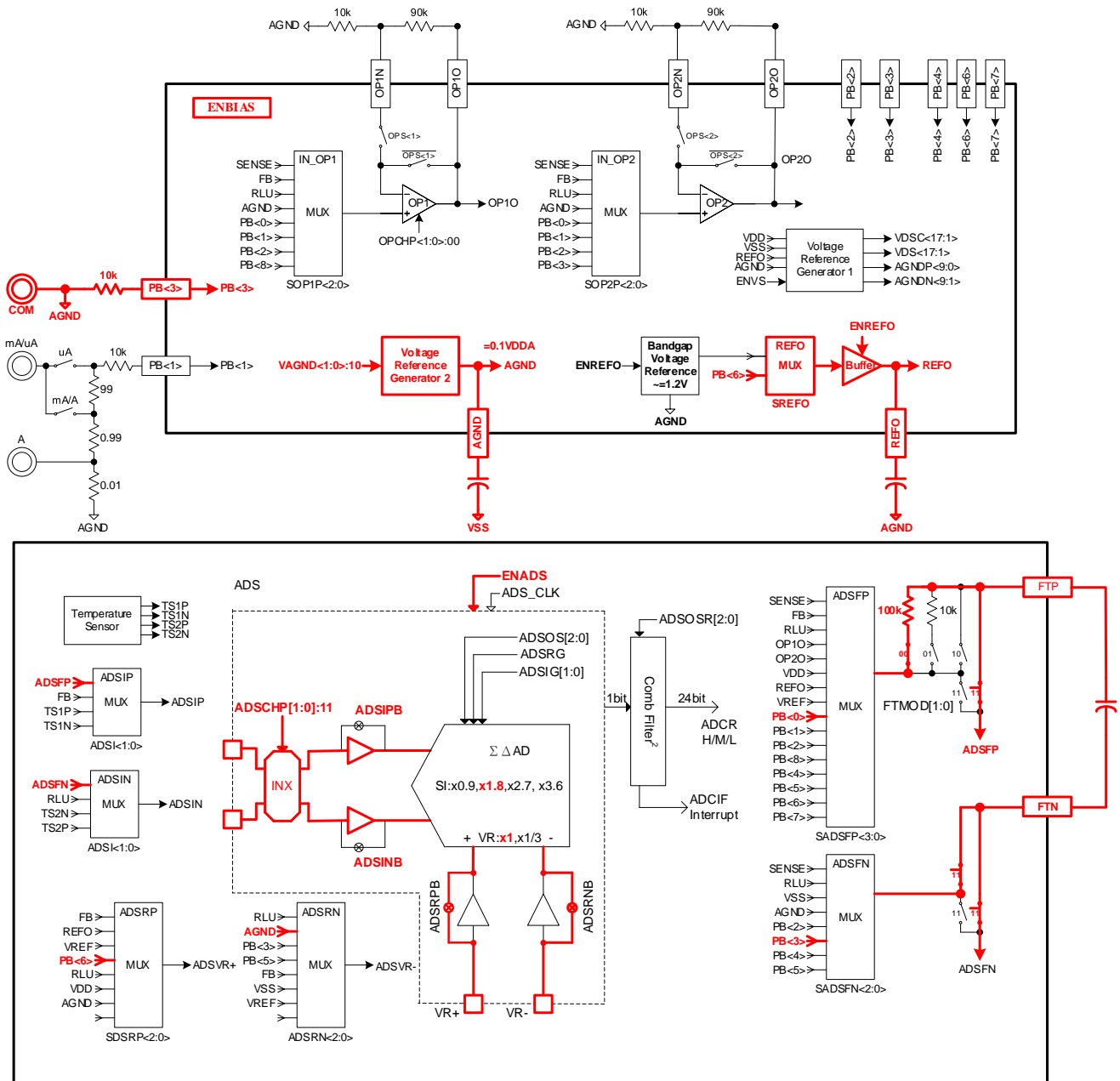
Diode function is to measure Forward Voltage or called PN Barrier Potential. This chip offers positive/negative constant current source or positive/negative constant voltage source measurement. This example illustrates positive constant current measurement.

When constant current passed through diode, both edges of component will have voltage difference. The voltage is around 0.2V~1.5V, to prevent exceeding full scale. Thus, taking 900kΩ and 100kΩ to form 10 times attenuation.

### 7.1. Diode Input Network Configuration

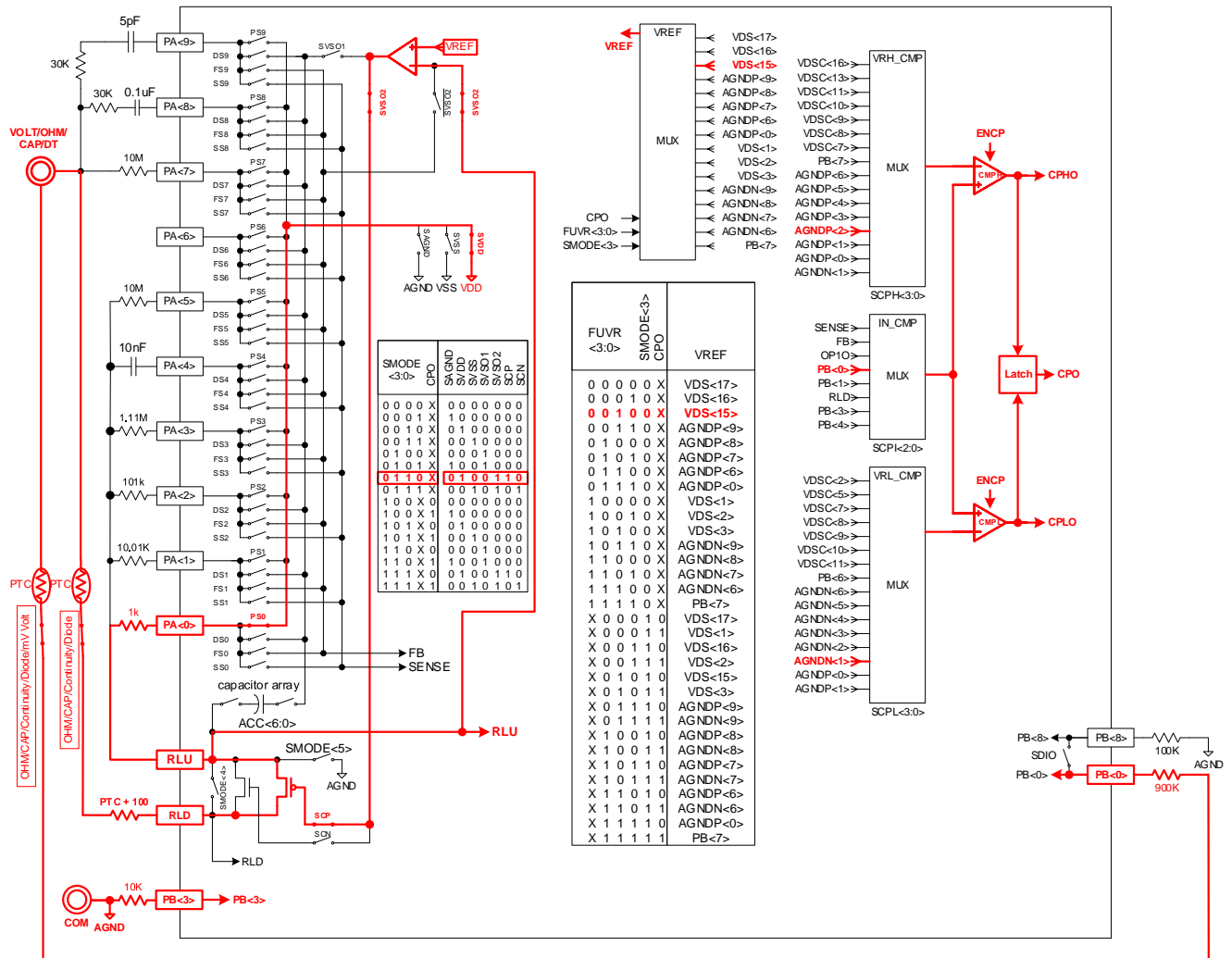


## 7.2. Diode Measurement Network Configuration



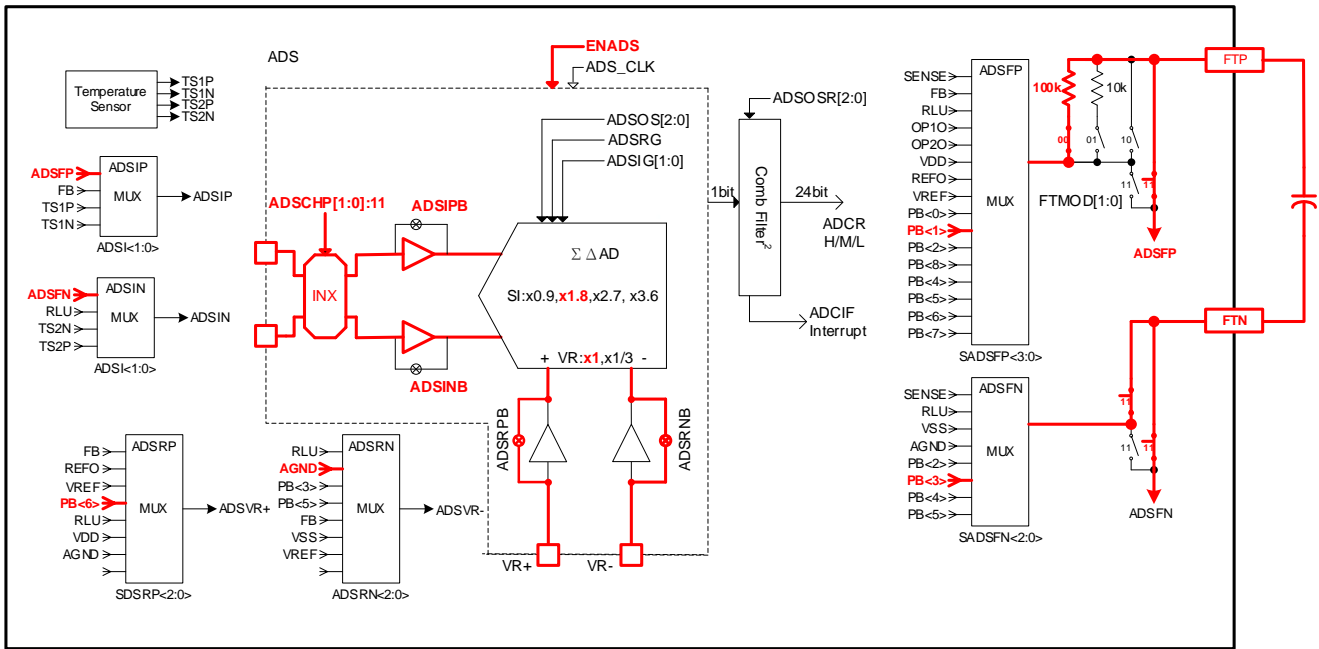
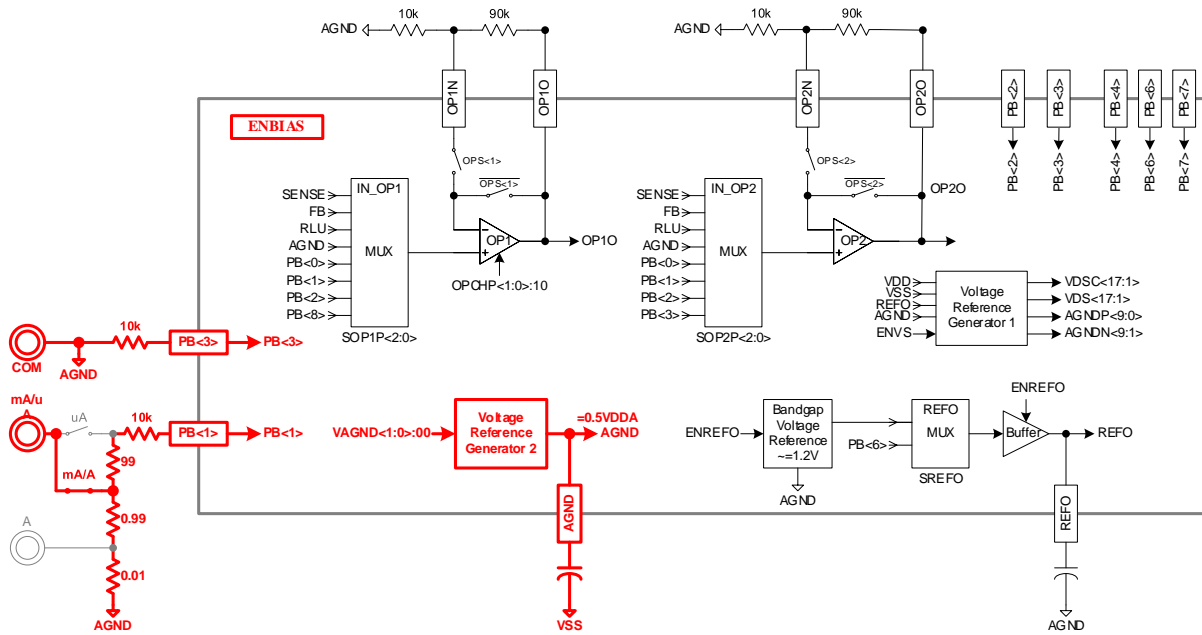
## 8. Continuity

This function can use constant current or constant voltage output measurements. This case is positive constant current output measurement.

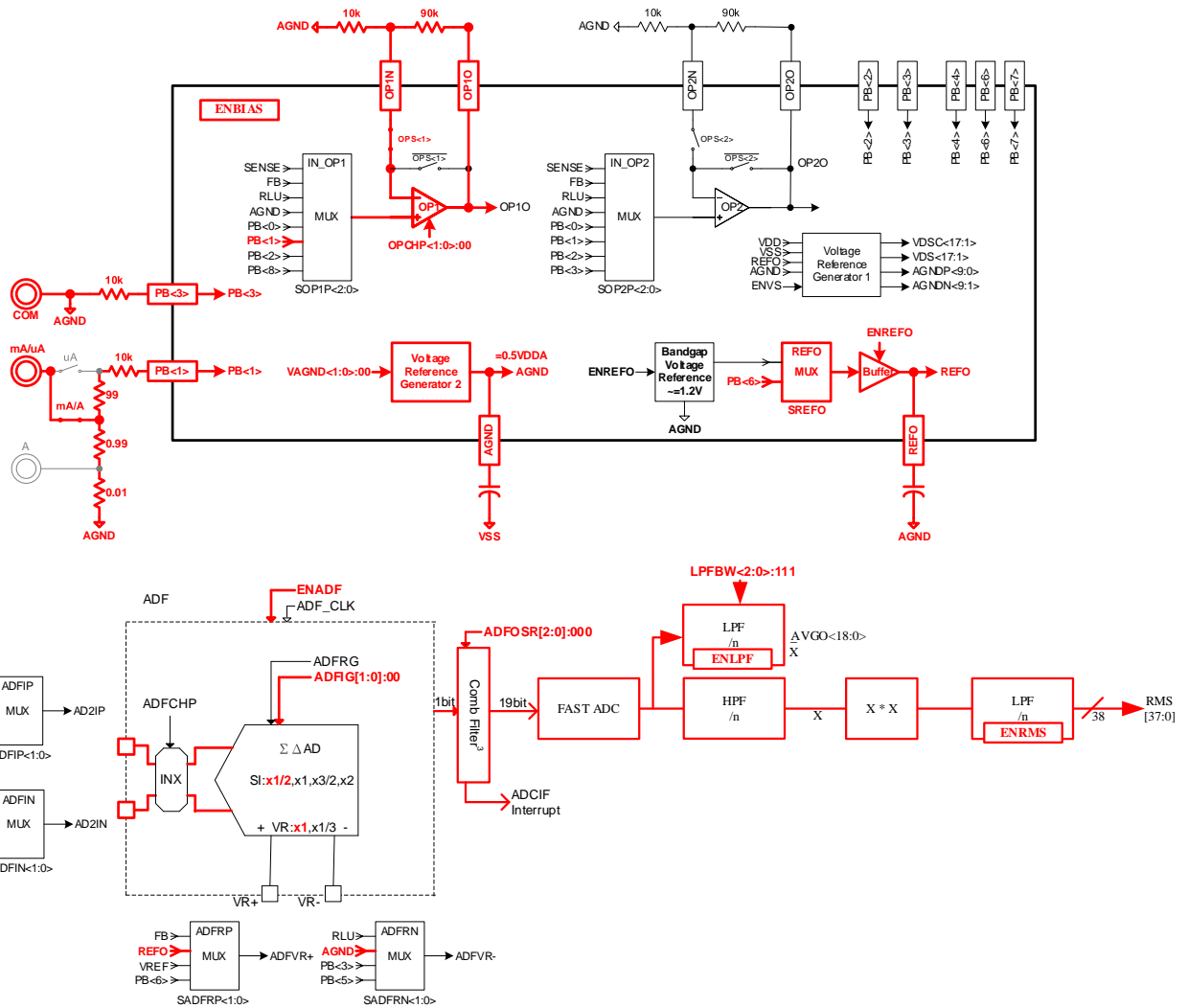




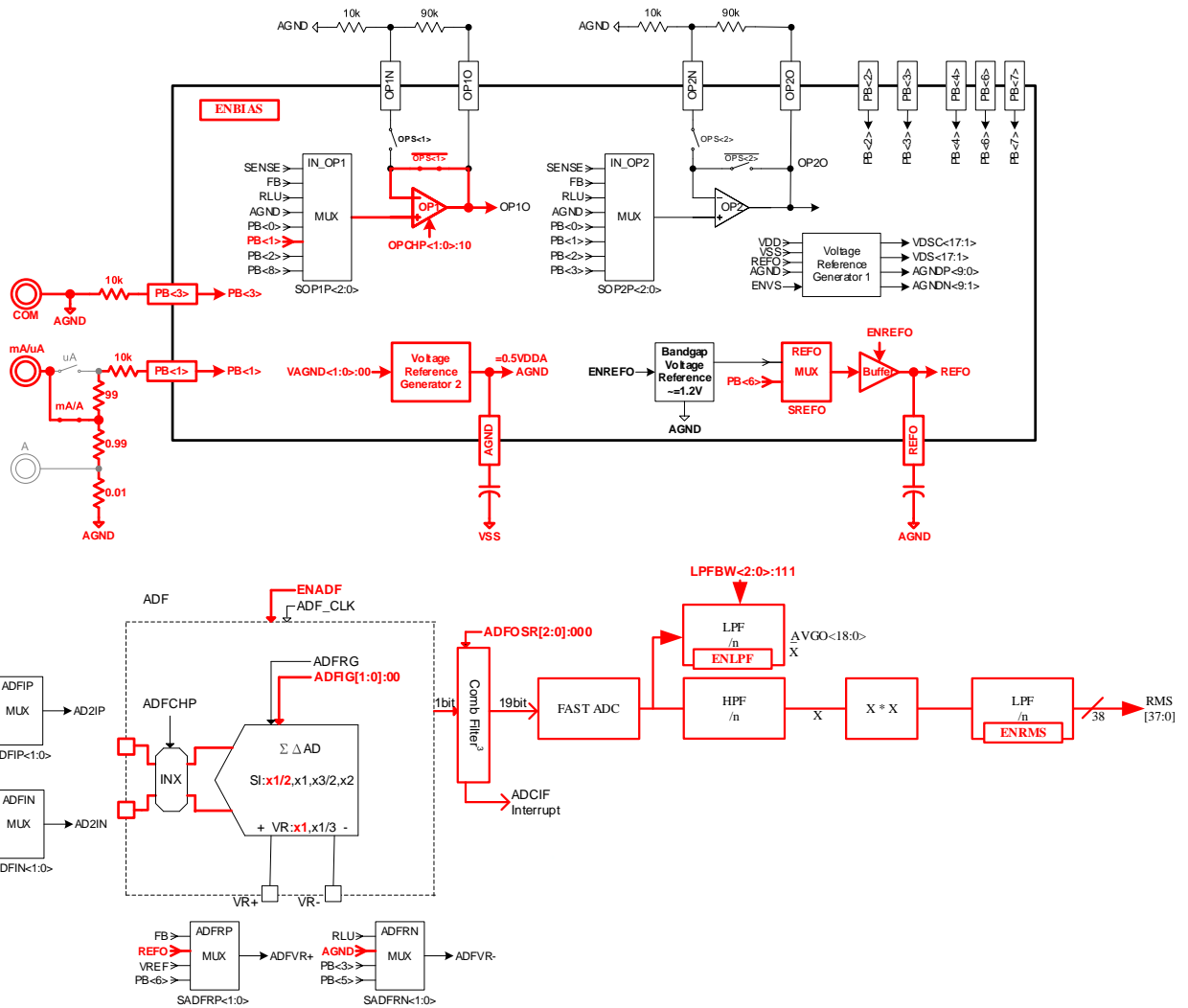
## 9.2. DC 500mA



## 9.3. AC 50mA

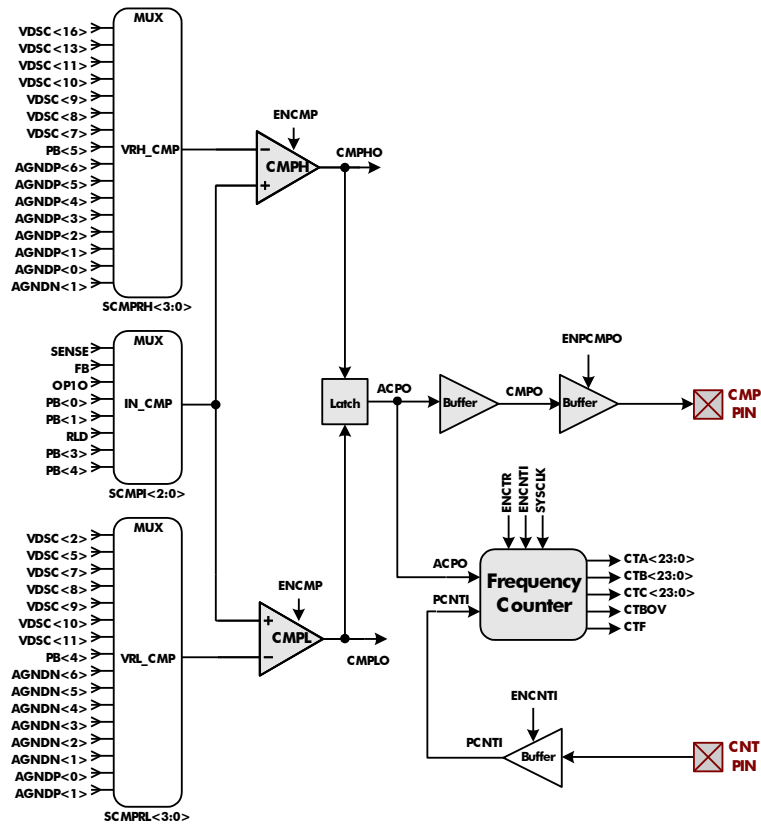


## 9.4. AC 500mA

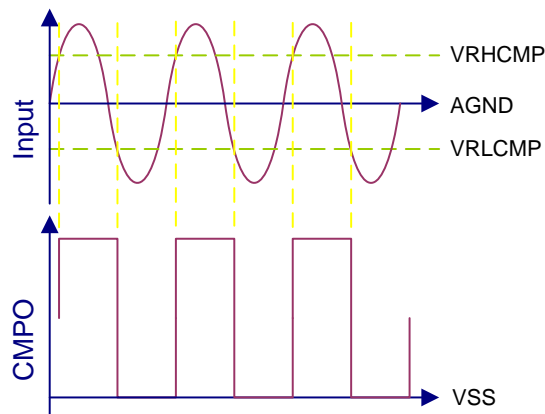


## 10. Frequency

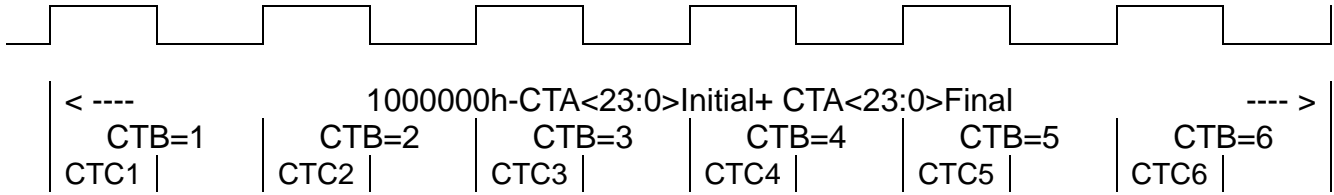
The frequency measurement can be divided into an analog input and a digital input. The analog input refers to the window comparator by PB<x> or PA<x>, and the comparator output (CMPO) is input to the Frequency Counter; the digital input is entered by the CNT to the Frequency Counter.



The analog input is only suitable for signal measurement with positive and negative half cycles. The positive trigger point of the window comparator is VRHCMP; the negative trigger point is VRLCMP. When the analog input signal reaches the positive trigger point of the window comparator, COMP is High; when the signal reaches the negative trigger point of the window comparator, COMP is Low. The comparator output (CMPO) function can be turned on during development of the product for easy debugging.



### 10.1. Frequency Counter Calculation Example Description



Calculation condition description (1kHz / 50% as an example)

FSYSCLK: System oscillator frequency, assumed to be 4MHz

CTA<23:0>Initial: Preset value before CTA count, CTA<23:8> program defaults to C000h, and CTA<7:0> is cleared to 00h

CTA<23:0>Final: The value after the CTA is counted, CTA<23:0>Initial is C00000h, and in the case of 1kHz is 000760h

CTB<23:0>: Number of cycles in time, CTA<23:0>Initial is C00000h, and in the case of 1kHz is 000419h

CTC<23:0>: The sum of the time sum of High, CTA<23:0>Initial is C00000h, and at Duty 50% is 20043Ah

Count time:

$$T = [1000000h-CTA<23:0>Initial+ CTA<23:0>Final]/FSYSCLK$$

$$= (1000000h-C00000h +000760h)/3D0900h \text{ --- } > \text{hexadecimal}$$

$$= (16777216-12582912+1888)/4000000=1.0490 \text{ --- } > \text{decimal}$$

Standby signals frequency:

$$\text{Freq} = \text{CTB}<23:0>/T$$

$$= 1049/1.0490=1000 \text{ Hz}$$

Standby signal, Duty Cycle:

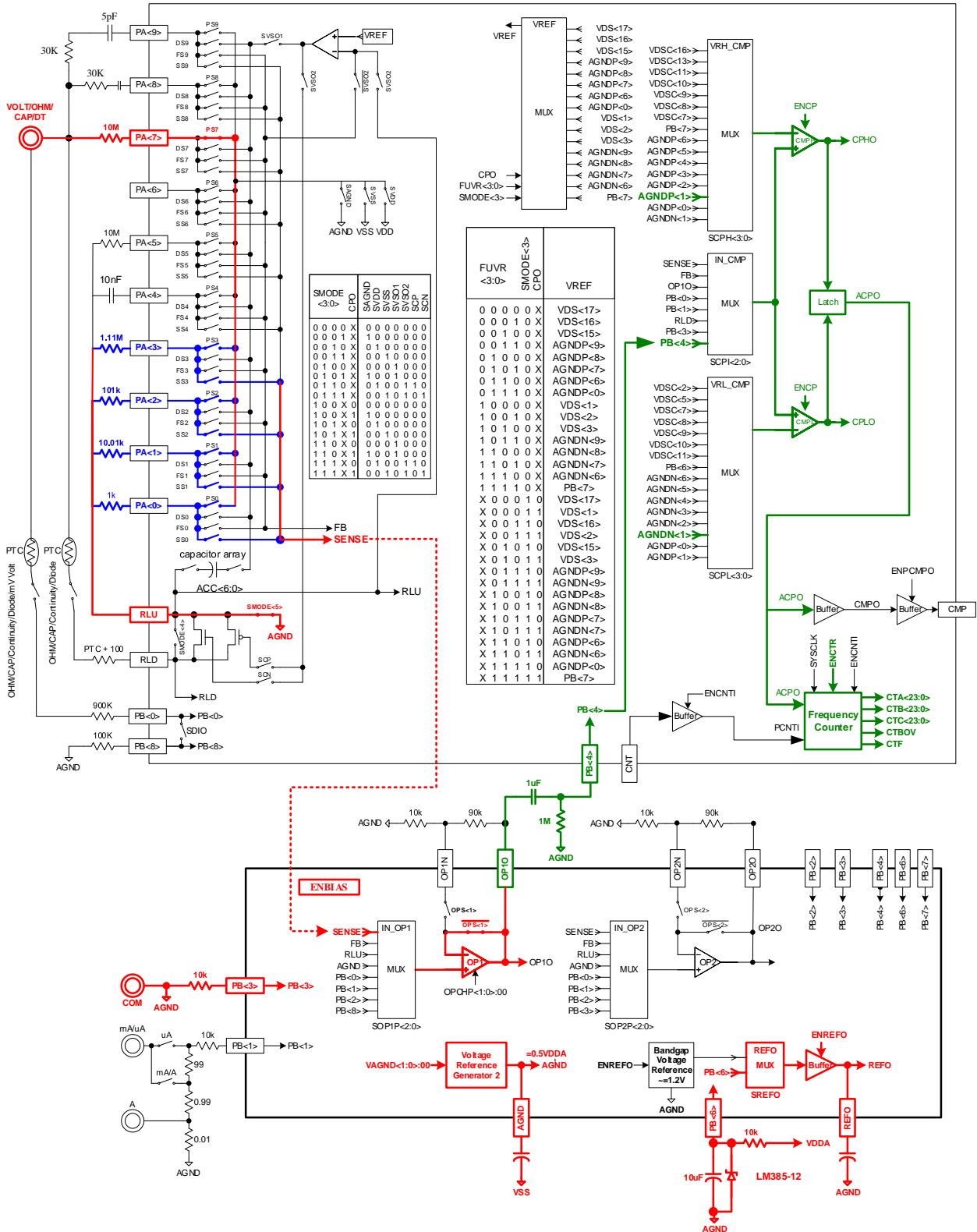
$$\text{Duty Cycle} = \text{CTC}<23:0>/[1000000h-CTA<23:0>Initial + CTA<23:0>Final]$$

$$= 20043Ah/400760h \text{ --- } > \text{hexadecimal}$$

$$= 2098234/4196192=0.5=50\% \text{ --- } > \text{decimal}$$

## 10.2. Voltage input (Analog Input)

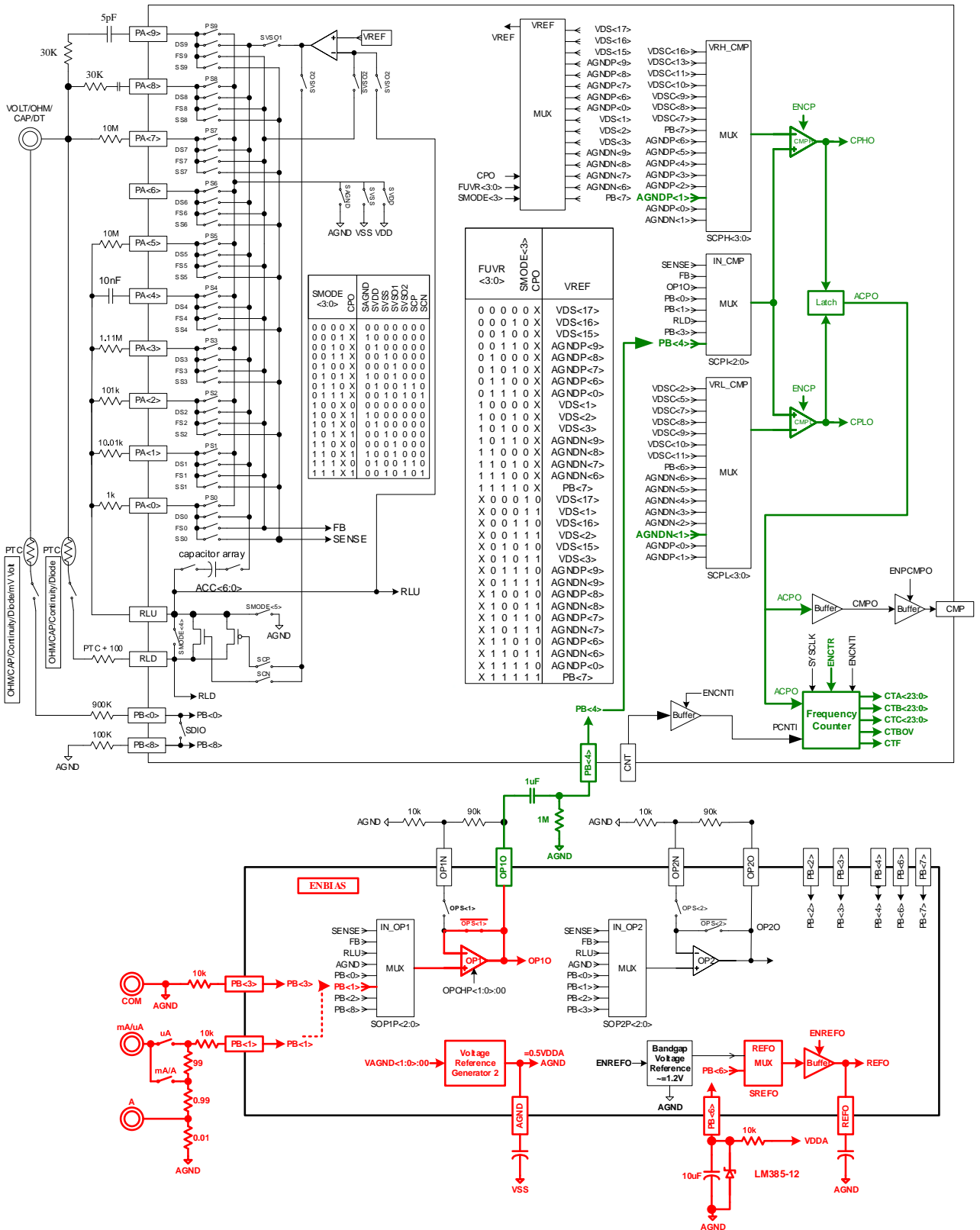
When measured frequency, the signal is inputted by PA<n> and PB<n>. If the input contains DC, must be removed by AC Coupled capacitors.



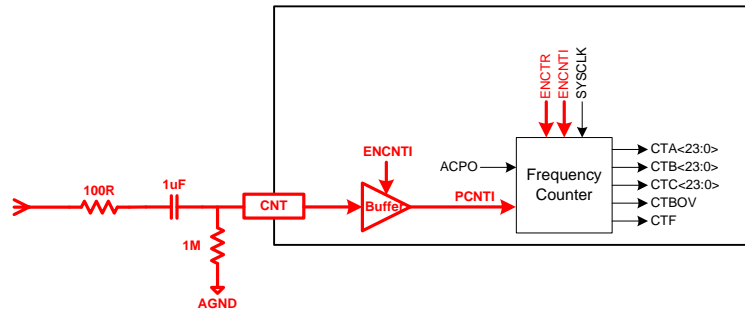
## 10.3. Current input (Analog Input)

The current and measurement frequency method is entered into the window comparator

by PB<1>, and the comparator output (CMPO) is input to the Frequency Counter.



**10.4. CNT input (Digital Input)**



## 11. Revision History

Major differences are stated thereafter:

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Version	Page	Date	Revision Summary
V01	ALL	2024/06/07	First edition Use with HY3131-AK02 to modify configuration settings