NUC970 SAR ADC Application Note

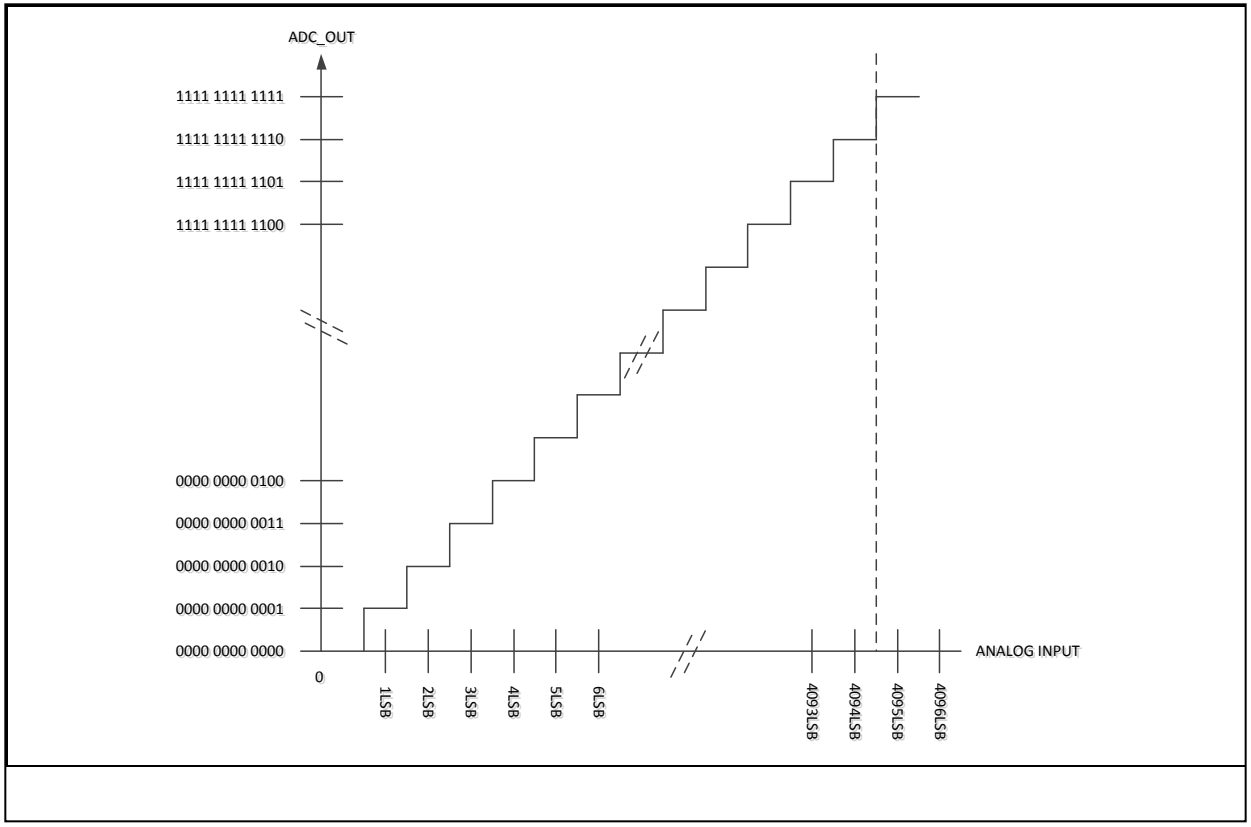
Nuvoton Technology Corp.

NUC970 SAR ADC Features

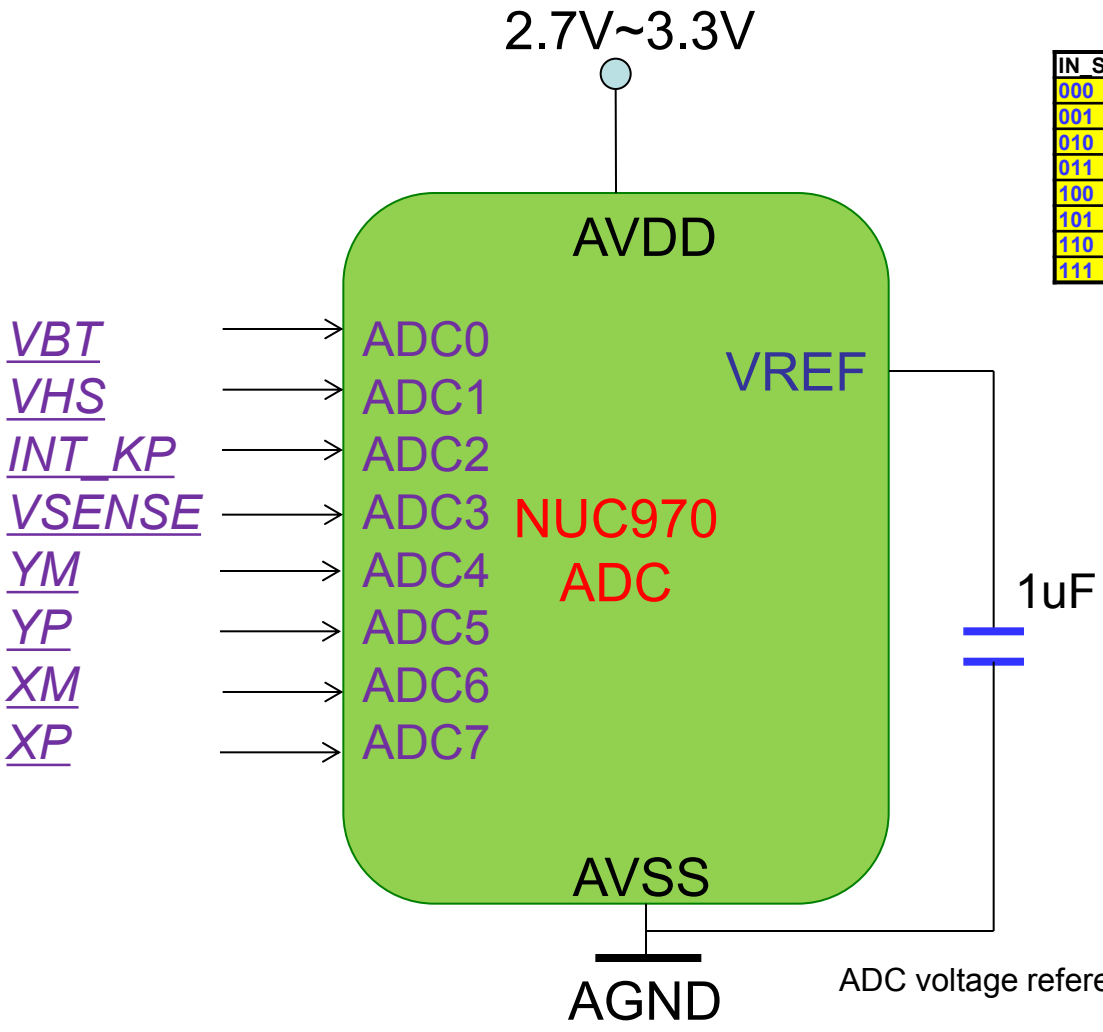
- **Resolution:** 12-bit resolution
- **DNL**: +/-1.5 LSB, **INL**: +/-3 LSB
- **Dual Data Rates:** 1MSPS/ 200KSPS (ADC1 only)
- **Power Supply (AVDD) range:** 2.7-3.6V
- **ADC0 (VBT), for Direct Battery Measurement**
- **ADC1 (VHS),** could support 1MS/S
- **ADC2 (INT_KP),** could support 200KS/S or Keypad signal input
- **ADC3 (VSENSE),** ADC analog input or for 5-wire touch detection
- **ADC4 (YM),** ADC analog input or touch negative end of Y axis
- **ADC5 (YP),** ADC analog input or touch positive end of Y axis
- **ADC6 (XM),** ADC analog input or touch negative end of X axis
- **ADC7 (XP),** ADC analog input or touch positive end of X axis
- **NUC972,** supports 4-wire or 5-Wires resistive touch screen.
- **NUC973 & NUC976,** just supported 4-Wires resistive touch screen
- **NUC977,** doesn't support touch function
- **Touch Pressure Measurement, it** just for 4-wire touch screen application

ADC Transfer Function

- The ADC output coding is offset in binary, 1LSB=VREF/4096, the transfer characteristic is shown in the following graph:



Typical Connection

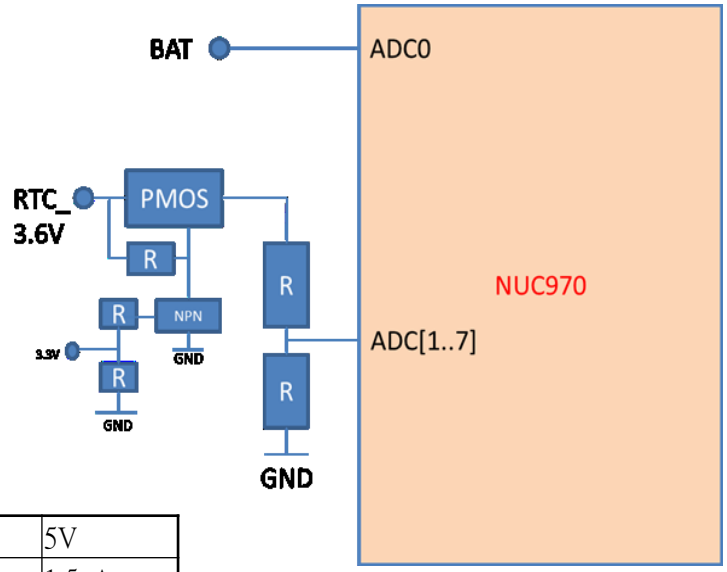


IN_SEL[2:0]	Select ADC Analog Input Signal
000	VBT
001	VHS
010	A_2
011	VSENSE
100	YM
101	YP
110	XM
111	XP

ADC voltage reference with external 1uF CAP.

ADC0 & ADC[1:7] Application for Voltage Detection

- For avoiding leakage occurred by ADC pad when AVDD not powered yet, that recommend voltage detection application should use the following connection as the figure illustrated



AVDD=0V & BAT input to ADC0

ADC0 (R_DIV=2M/2M)	3.6V	5V
leakage	0.9uA	1.5uA
voltage	1.66V	2.34V

ADC0 (R_DIV=200K/200K)	3.6V	5V
leakage	9uA	12.7uA
voltage	1.77V	2.48V

ADC0 (direct connect)	3.6V	5V
leakage	0uA	0.1uA
voltage	3.6V	5V

AVDD=0V & RTC_BAT input to ADC[1..7]

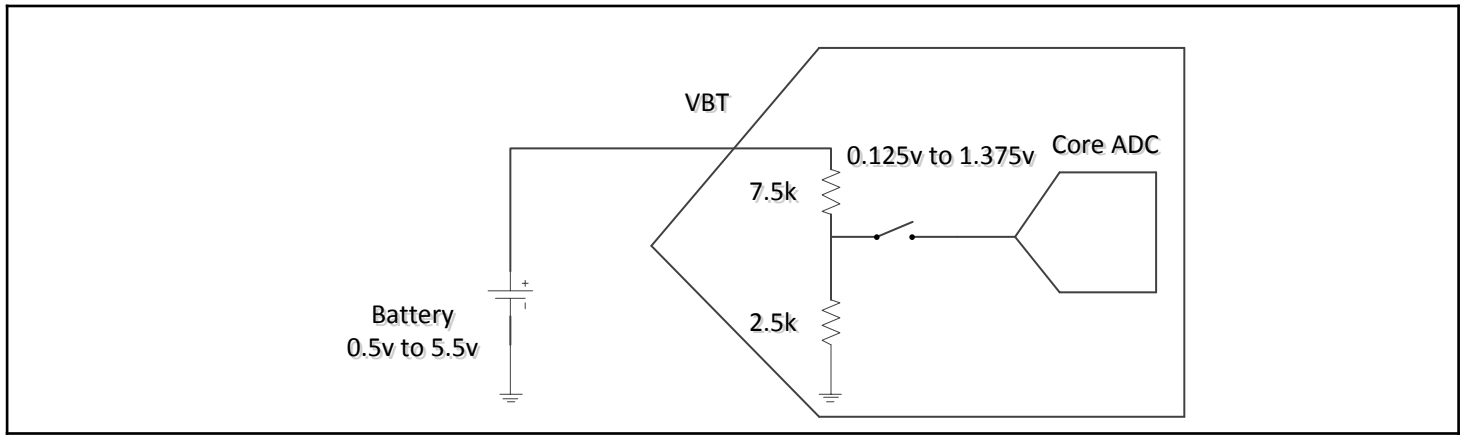
ADC[1..7] (R_DIV=2M/2M)	3.6V	5V
Leakage	1.7uA	2.4V
Voltage	302mV	332mV

ADC[1..7] (R_DIV=200K/200K)	3.6V	5V
leakage	15.4uA	22uA
Voltage	505mV	645mV

ADC[1..7] (direct connect)	3.6V	5V
leakge	117.4mA	illegal
voltage	3.6V	illegal

ADC0 (VBT) for Direct Battery Measurement

- Take VBT as input, and select internal buffer's output as the reference
  For ADC configure register VBAT_EN (ADC_CONF[8]) should be set to 1.



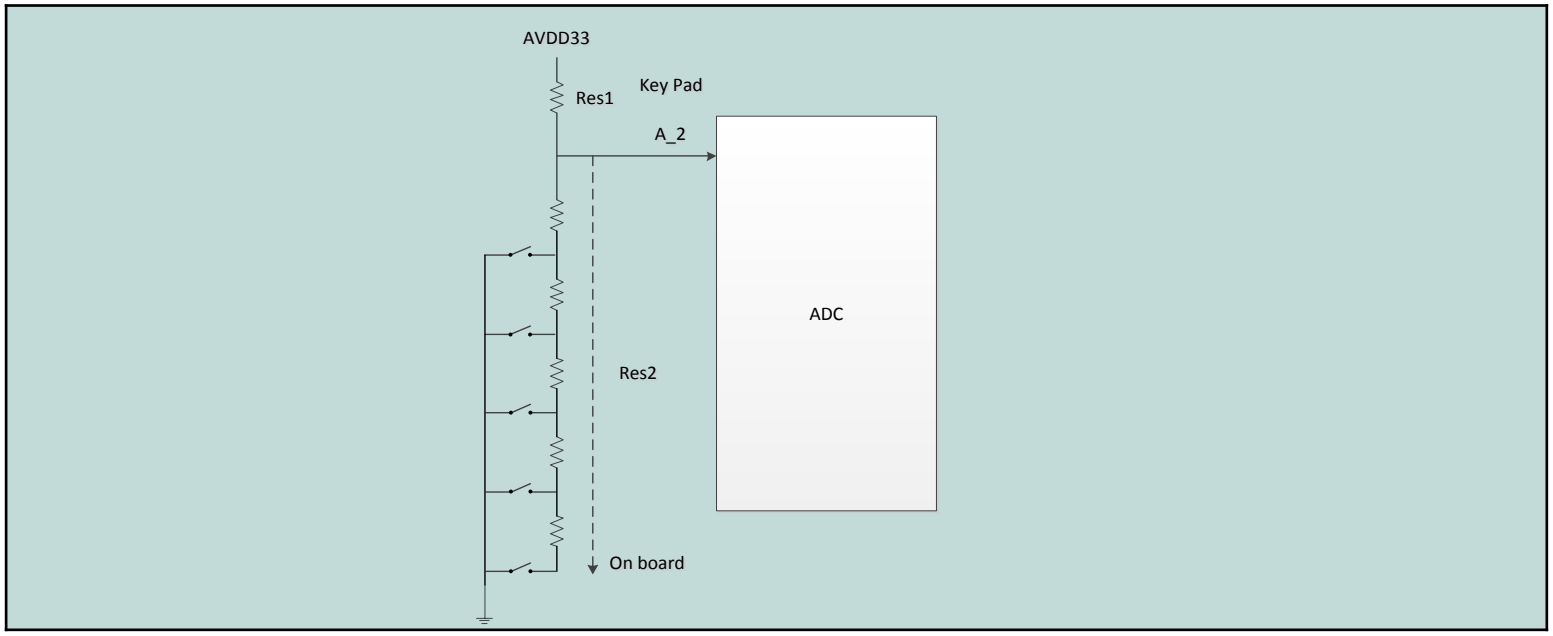
ADC Battery Voltage Detection Diagram

VBT in(v)	ADC0 output code/ V	Power Consumption (uA) /per time
0.5	196/ 0.119V	44
1	404/0.245V	90
2	820/0.5V	183
3	1236/0.754V	276
4	1648/1.006V	368
5	2062/1.258V	460
5.5	2265/1.382V	505

ADC1 (VHS)

- ADC high speed input, could support 1MS/S or 200KS/S.
- When HSPEED is set to high, it supports1MS/S
  - **ADC Configure (ADC_CONF[22]=1)**
- When HSPEED is set to low, it supports 200KS/S
  - **ADC Configure (ADC_CONF[22]=0)**

ADC2 (INT_KP)

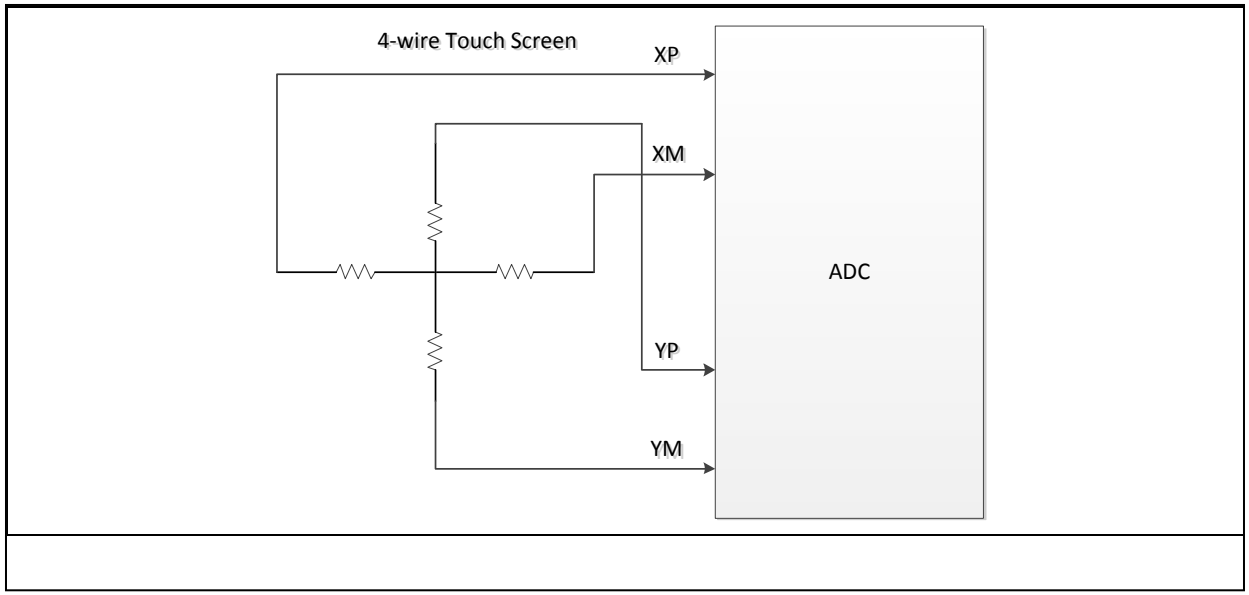


Key Pad Detection Diagram

- For ADC configure register KPC_EN (ADC_CONF[9]) should be set to 1.
  - Take ADC2 as input, and select AVDD33 and AGND33 as the reference.
  - Res1 ≤ 20K ohm and Res2 < 5.6 * Res1.
  - A 0.01uF cap is at ADC2 on board.
  - If doesn't need the interrupt, please ignore the requirement for Res1 and Res2.
  - This kind of series R scheme can not support multi-key function

Interface for 4-wire

- For ADC configure register T_EN (ADC_CONF[0]) should be set to 1.
- ADC control register WMSWCH (ADC_CTL[16]=0) (Wire Mode Switch) for 4-wire configuration.
- The following figures show the interface for 4-wire touch screen.

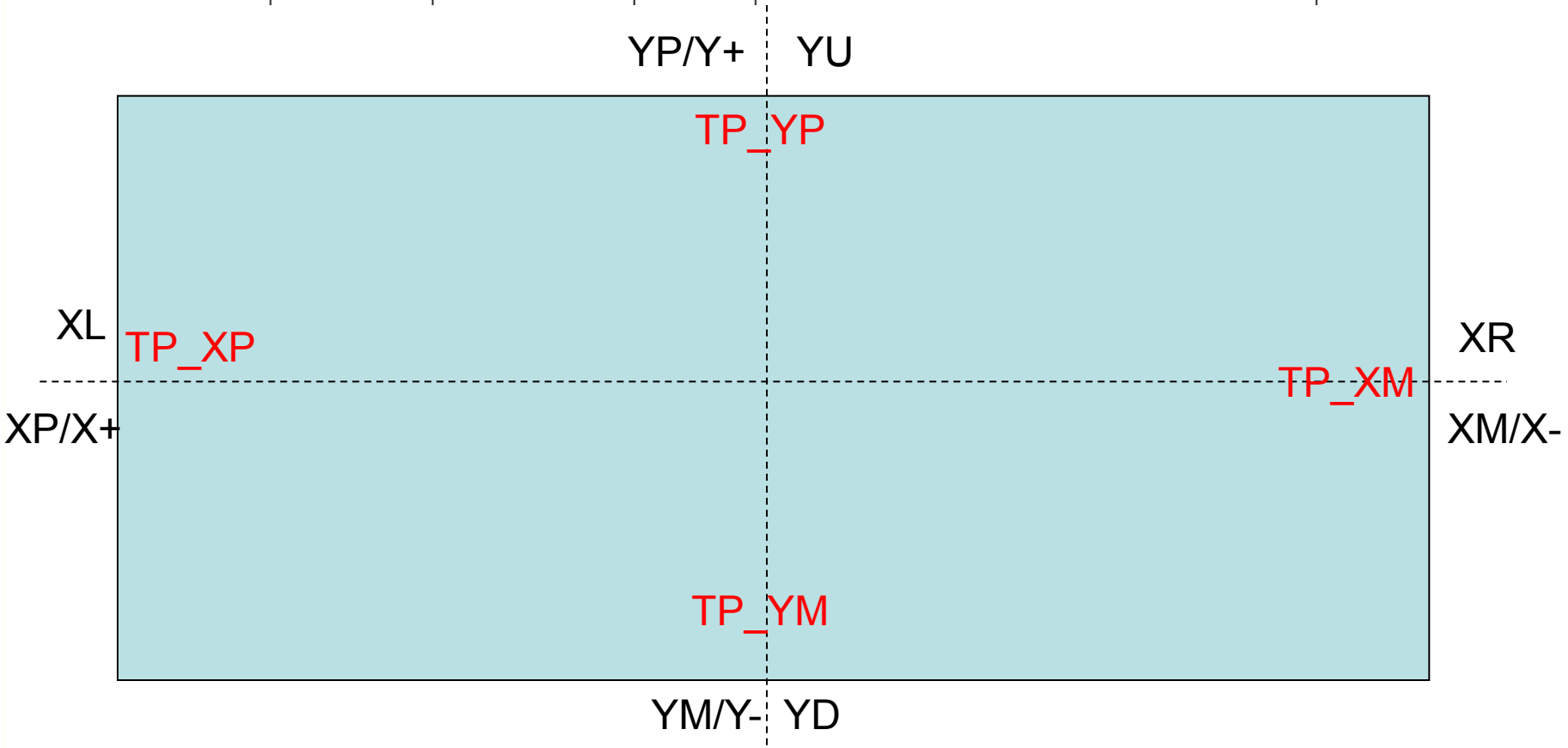


4-wire Touch Screen Connection Diagram

Note that 4 switches to bias XP, XM, YP, YM have conduction resistance under 5 ohm. And the pull up PMOS have 200K ohm typically.

4-W TP Connection

23	XL	I	Touch panel interface
24	YD	I	Touch panel interface
25	XR	I	Touch panel interface
26	YU	I	Touch panel interface



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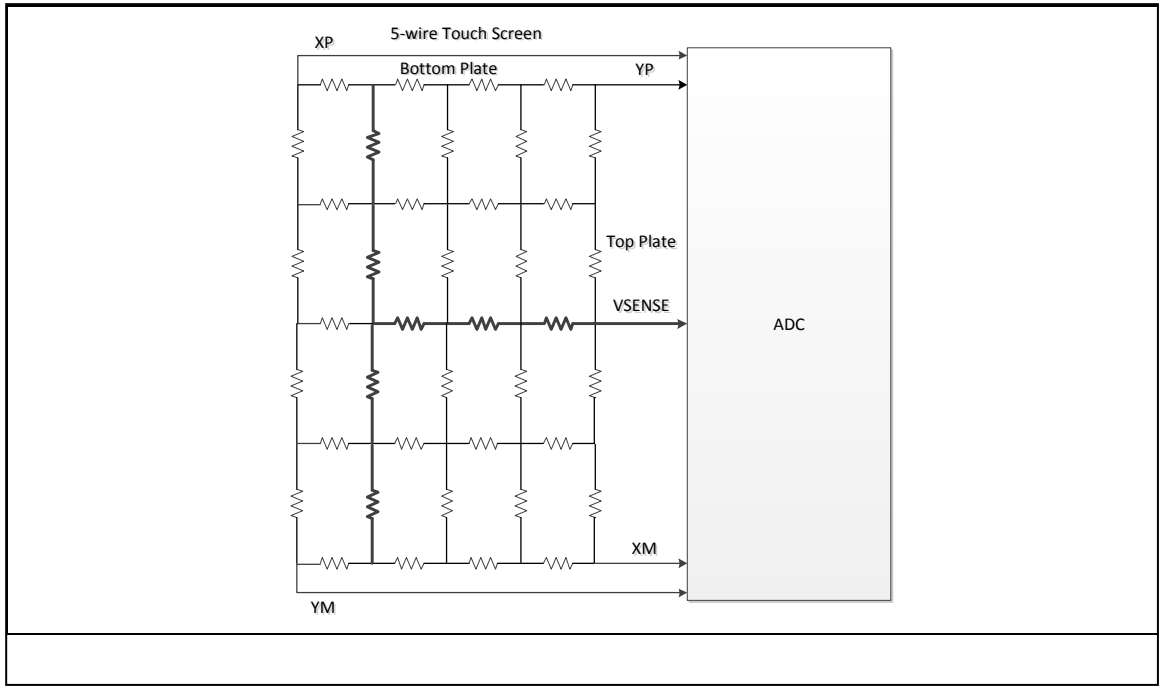
Interface for 5-wire

- For ADC configure register T_EN (ADC_CONF[0]) should be set to 1.
- ADC control register WMSWCH (ADC_CTL[16]=1) (Wire Mode Switch) for 5-wire configuration.
- The following figures show the interface for 5-wire touch screen.

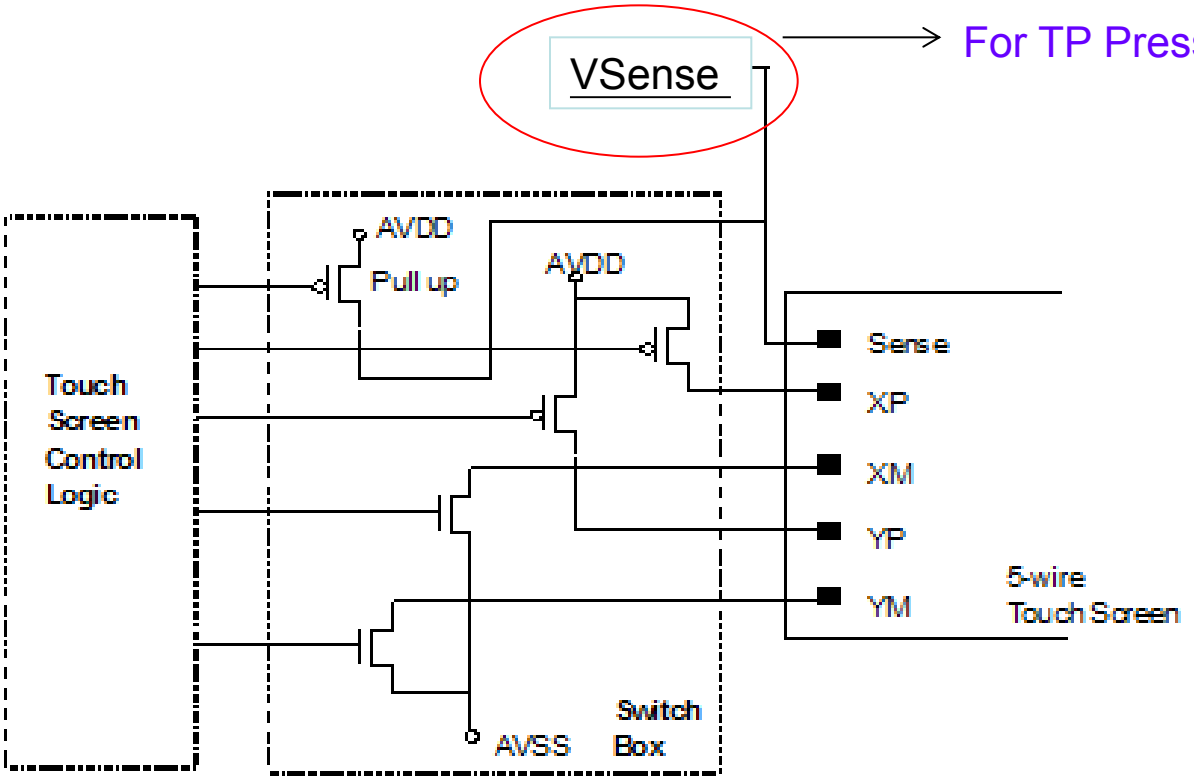


5-wire Touch Screen Connection Diagram

Note that 4 switches to bias XP, XM, YP, YM have conduction resistance under 5 ohm. And the pull up PMOS have 200K ohm typically.

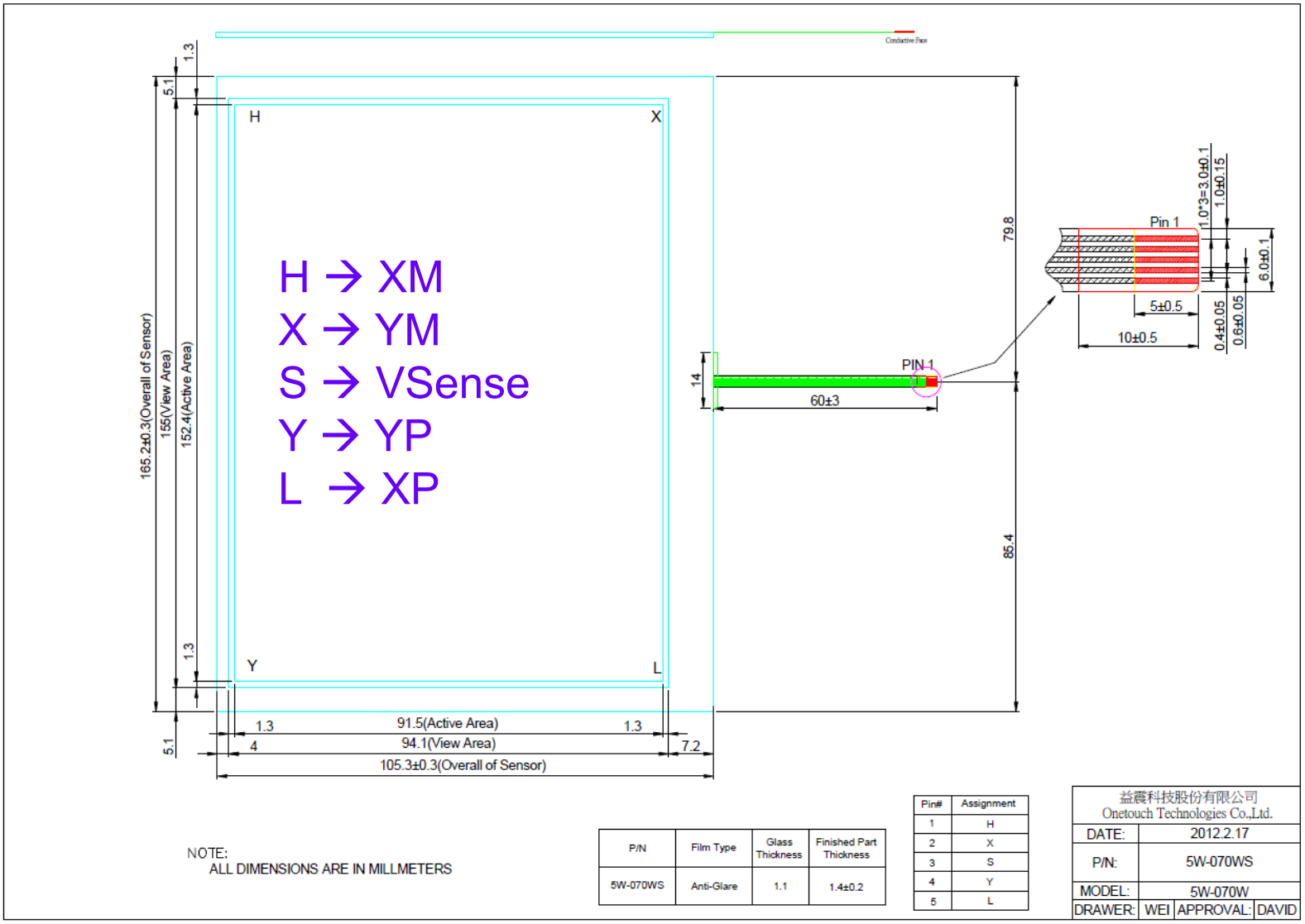
5-W Touch Connection

TP_XM, TP_YM, TP_XP, TP_YP & **VSense**



Advantage: Reliability & life time are good than 4W

5-W TP Reference Data



Analog Characteristics

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Conditions
-	Resolution	-	12	-	Bit	
DNL	Differential Nonlinearity Error	-	±1	-	LSB	V_{REF} is external AVREF pin
INL	Integral Nonlinearity Error	-	-1.2	-	LSB	V_{REF} is external AVREF pin
E_O	Offset Error	-	+3.7	-	LSB	V_{REF} is external AVREF pin
E_G	Gain Error (Transfer Gain)	-	-6.6	-	LSB	V_{REF} is external AVREF pin
E_A	Absolute Error	-	4.2	-	LSB	V_{REF} is external AVREF pin
-	Monotonic	Guaranteed				
F_{ADC}	ADC Clock Frequency	-	-	16	MHz	
T_{CAL}	Calibration Time	-	3	-	Clock	
T_S	Sample Time	-	17	-	Clock	
T_{ADC}	Conversion Time	-	20		Clock	
F_S	Sample Rate	-	-	800[1]	k SPS	
V_{AVDD}	Supply Voltage	2.7	3.3	3.6	V	
I_{DDA1}	Supply Current (Avg.)	-	1.2		mA	ADC1 channel high speed mode
I_{DDA2}	Supply Current (Avg.)	-	1.0		mA	ADC1 channel low speed mode
I_{DDA3}	Supply Current (Avg.)	-	0.4		mA	
I_{LK}	Leakage Current	-	0.1	-	uA	
V_{REF}	Reference Voltage	2	-	V_{AVDD}	V	
V_{IN}	Analog Input Voltage	0	-	V_{REF}	V	
R_{IN}	Analog Input Impedance	-	-	2	MΩ	
C_{IN}	Capacitance	-	25.6		pF	

Note. ADC1 channel supports sample rate higher than 200 kSPS. Other ADC channels support sampel rate up to 200 kSPS.