

# **NUC970 SAR ADC Application Note**



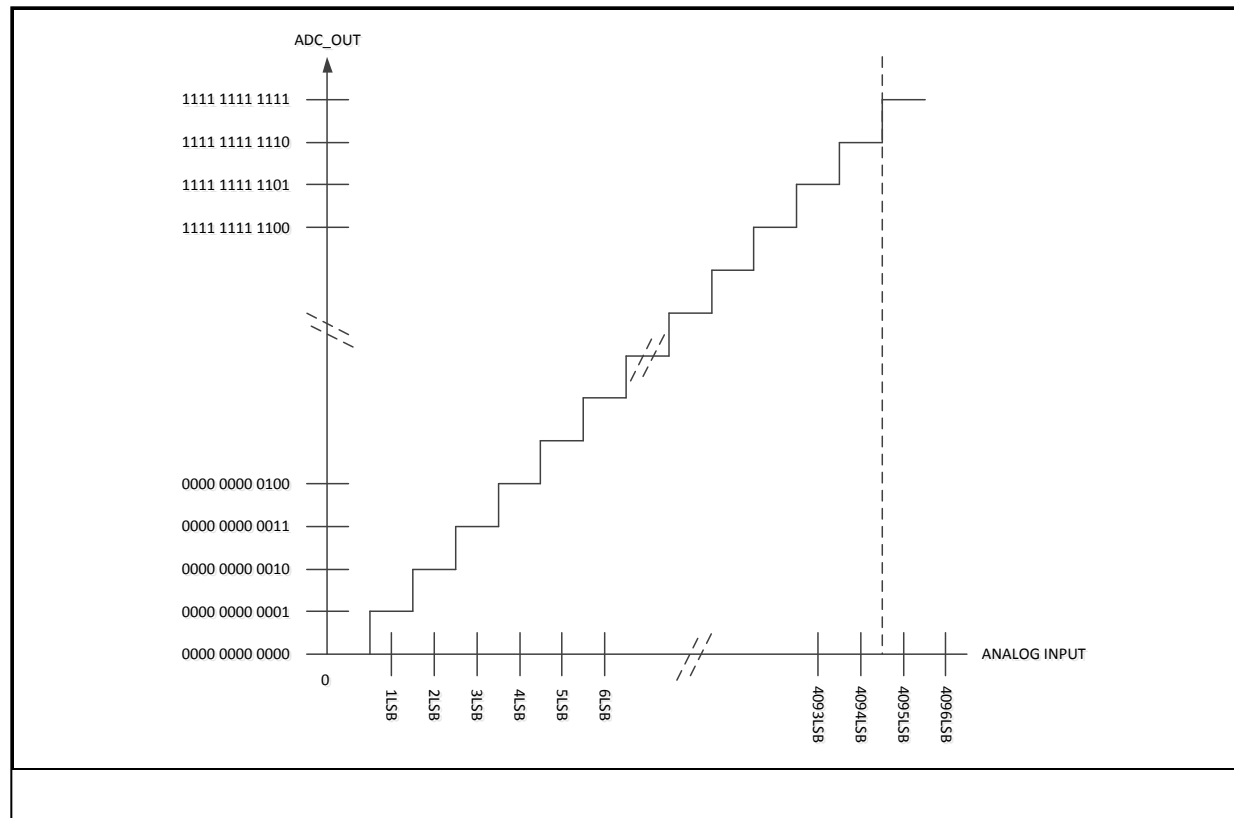
Nuvoton Technology Corp.

# NUC970 SAR ADC Features

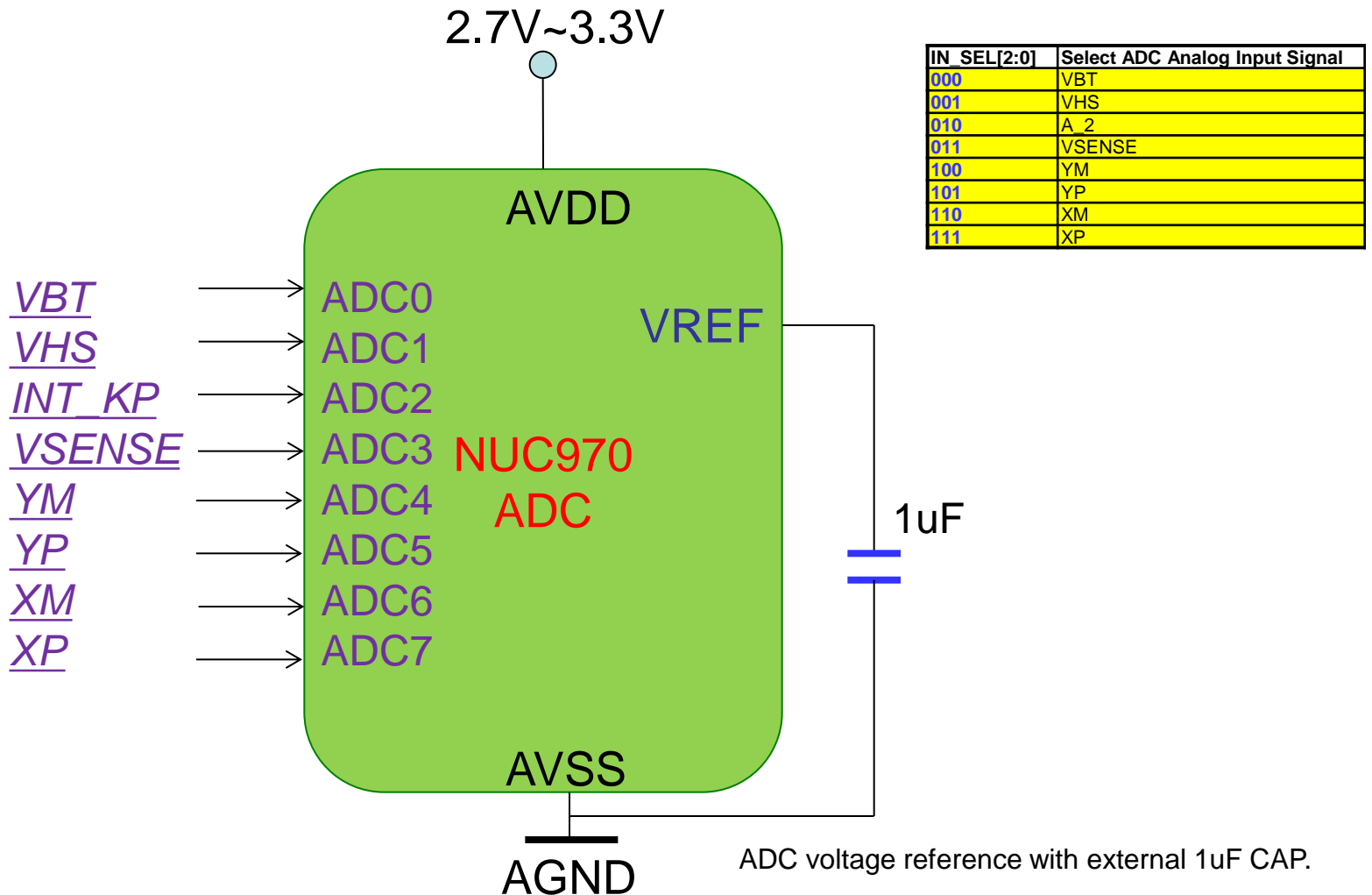
- **Resolution:** 12-bit resolution
- **DNL:** +/-1.5 LSB, **INL:** +/-3 LSB
- **Dual Data Rates:** 1MSPS/ 200KSPS (ADC1 only)
- **Power Supply (AVDD) range:** 2.7-3.6V
- **ADC0 (VBT), for Direct Battery Measurement**
- **ADC1 (VHS),** could support 1MS/S
- **ADC2 (INT\_KP),** could support 200KS/S or 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:

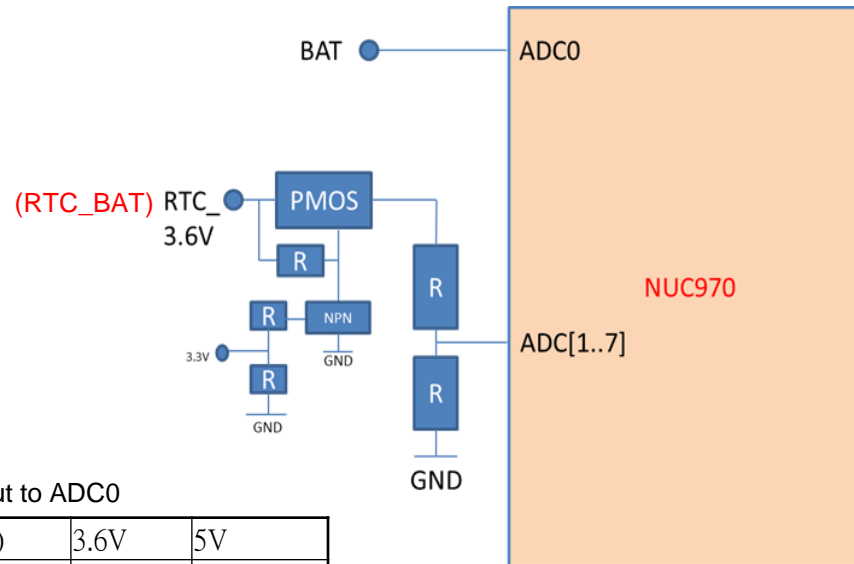


# Typical Connection



# 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

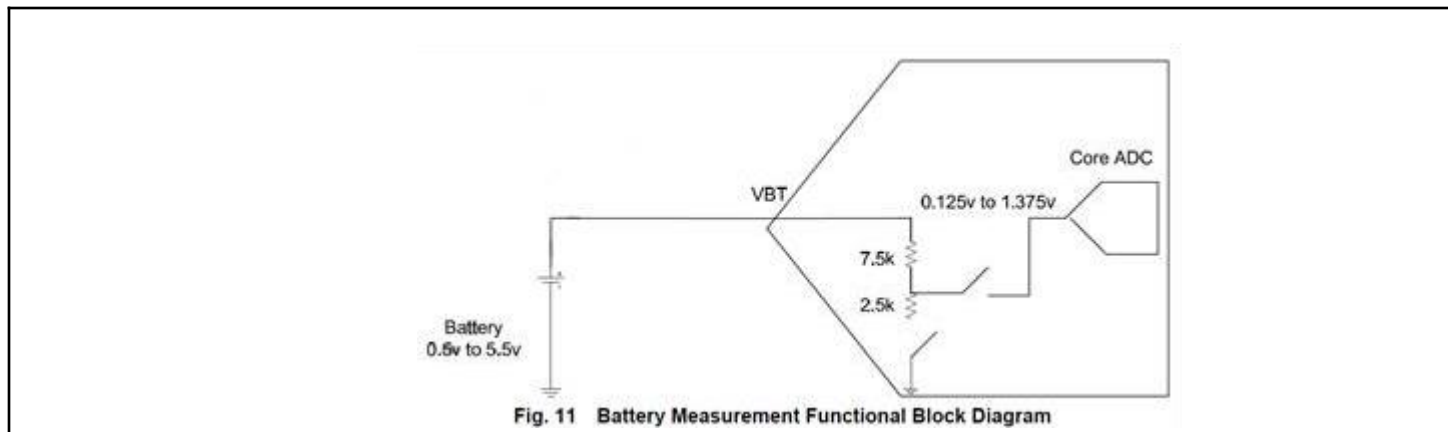
ADC0 (R_DIV=2M/2M)	3.6V	5V
leakage	0.9uA	1.5uA
voltage	1.66V	2.34V
ADC0 (R_DIV=200K/200K)	3.6V	5V
leakage	9uA	12.7uA
voltage	1.77V	2.48V
ADC0 (direct connect)	3.6V	5V
leakage	0uA	0.1uA
voltage	3.6V	5V

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.



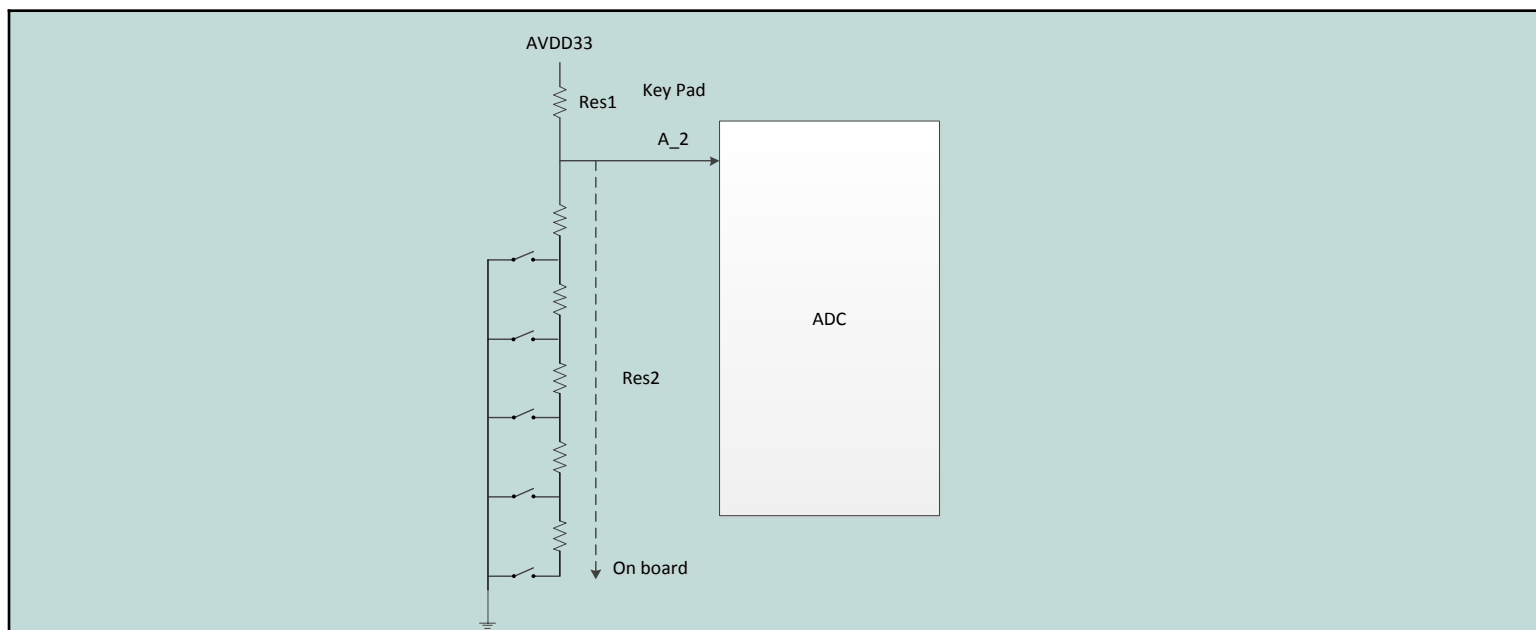
ADC Battery Voltage Detection Diagram

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 supports 1MS/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)



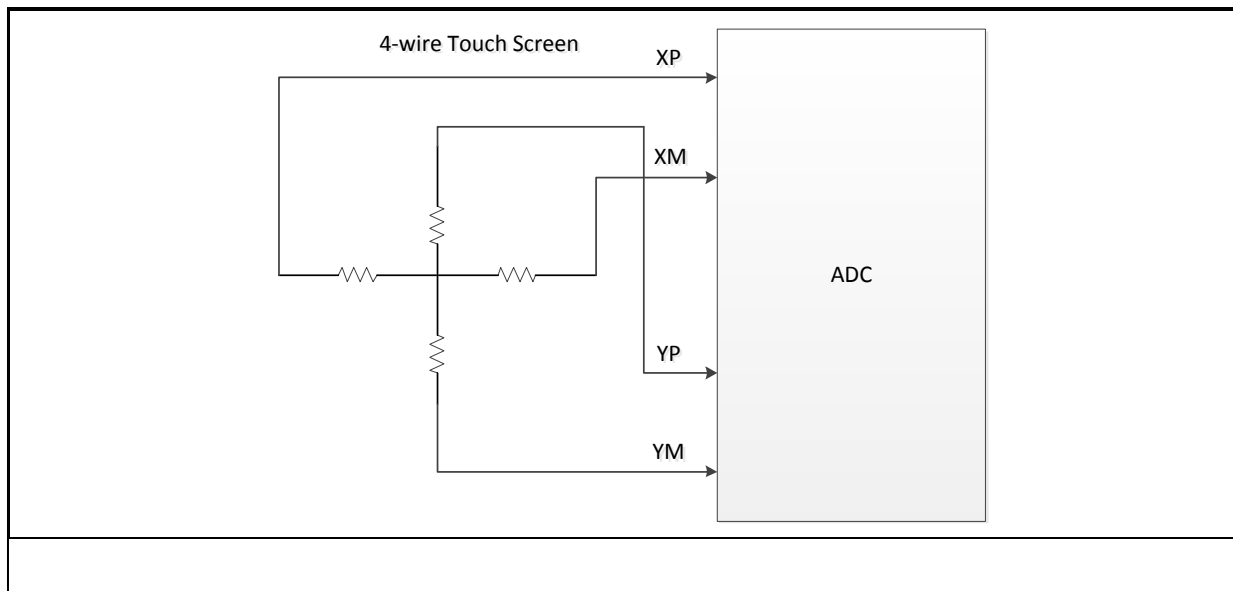
Key Pad Detection Diagram

- 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.
- $\text{Res1} \leq 20\text{K ohm}$  and  $\text{Res2} < 5.6 * \text{Res1}$ .
- 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.

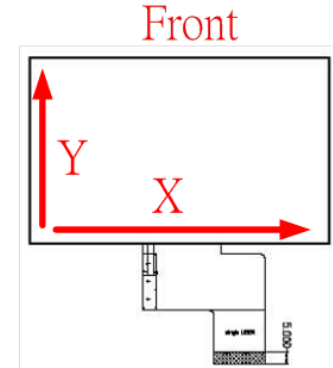


4-wire Touch Screen Connection Diagram

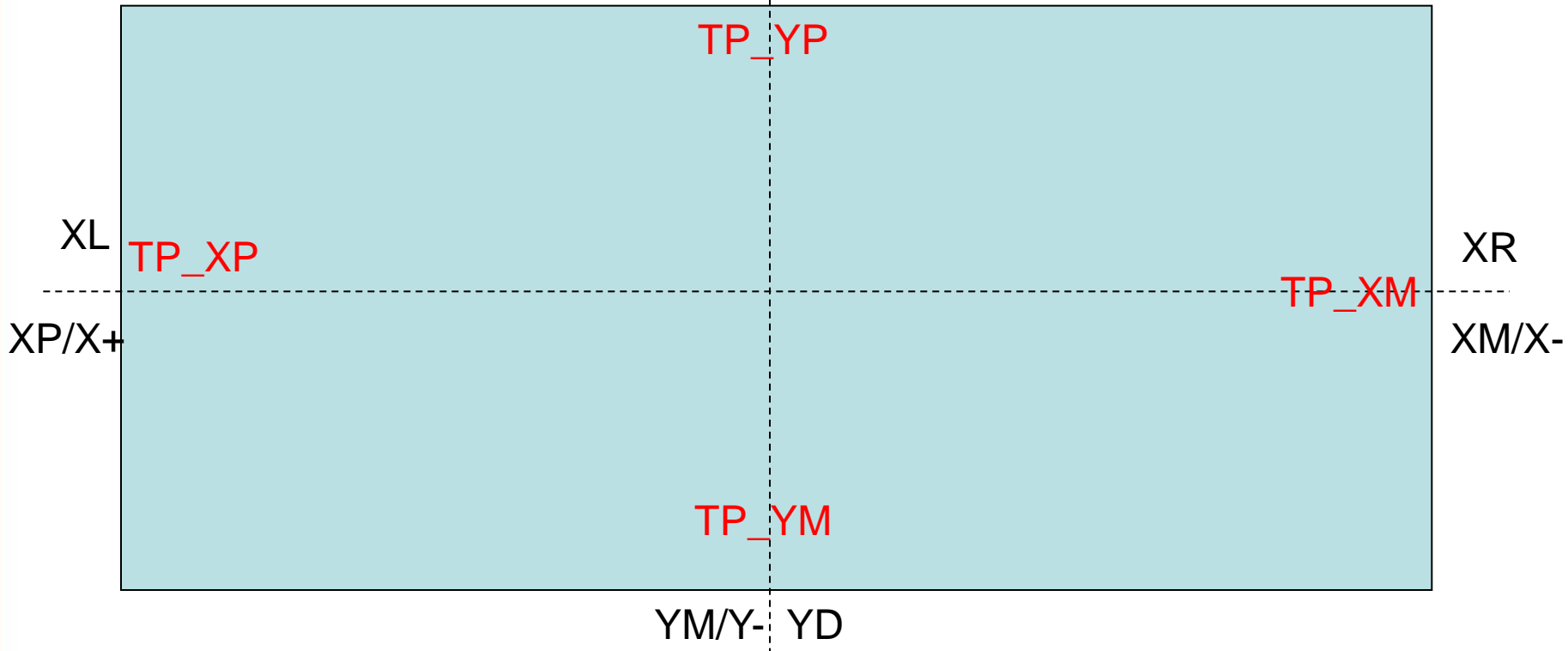
Note that 4 switches to bias XP, XM, YP, YM have conduction resistance under 5 ohm. And the pull up PMOS have 200K ohm typically.

# 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

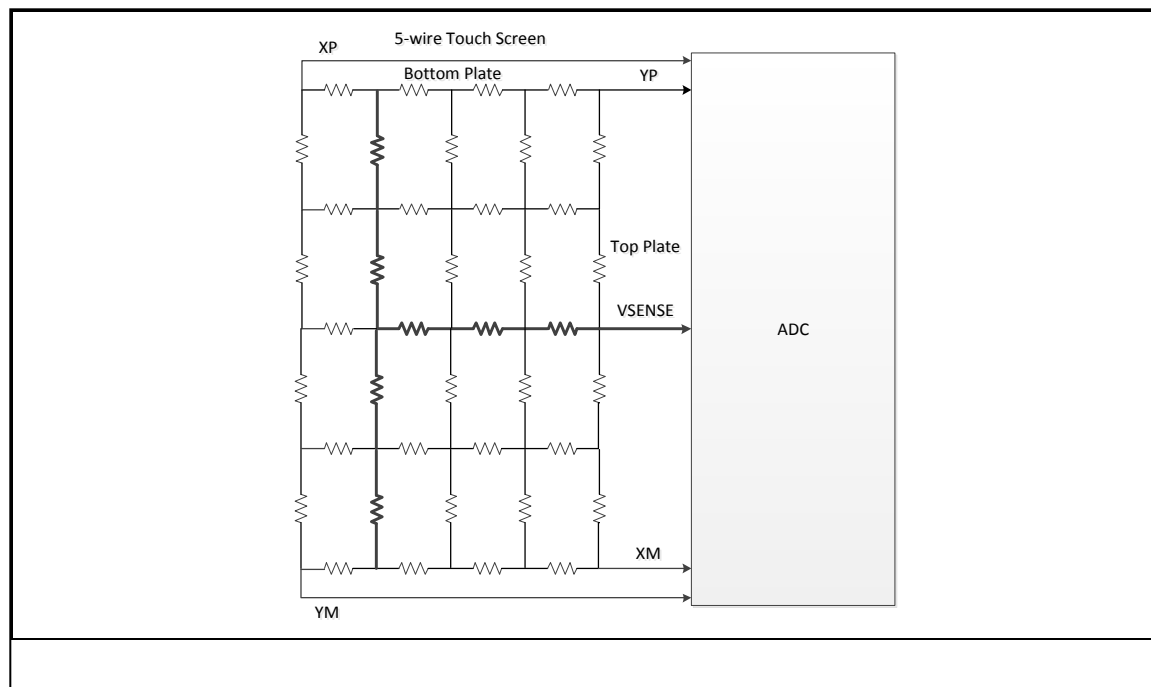


YP/Y+ YU



# 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.

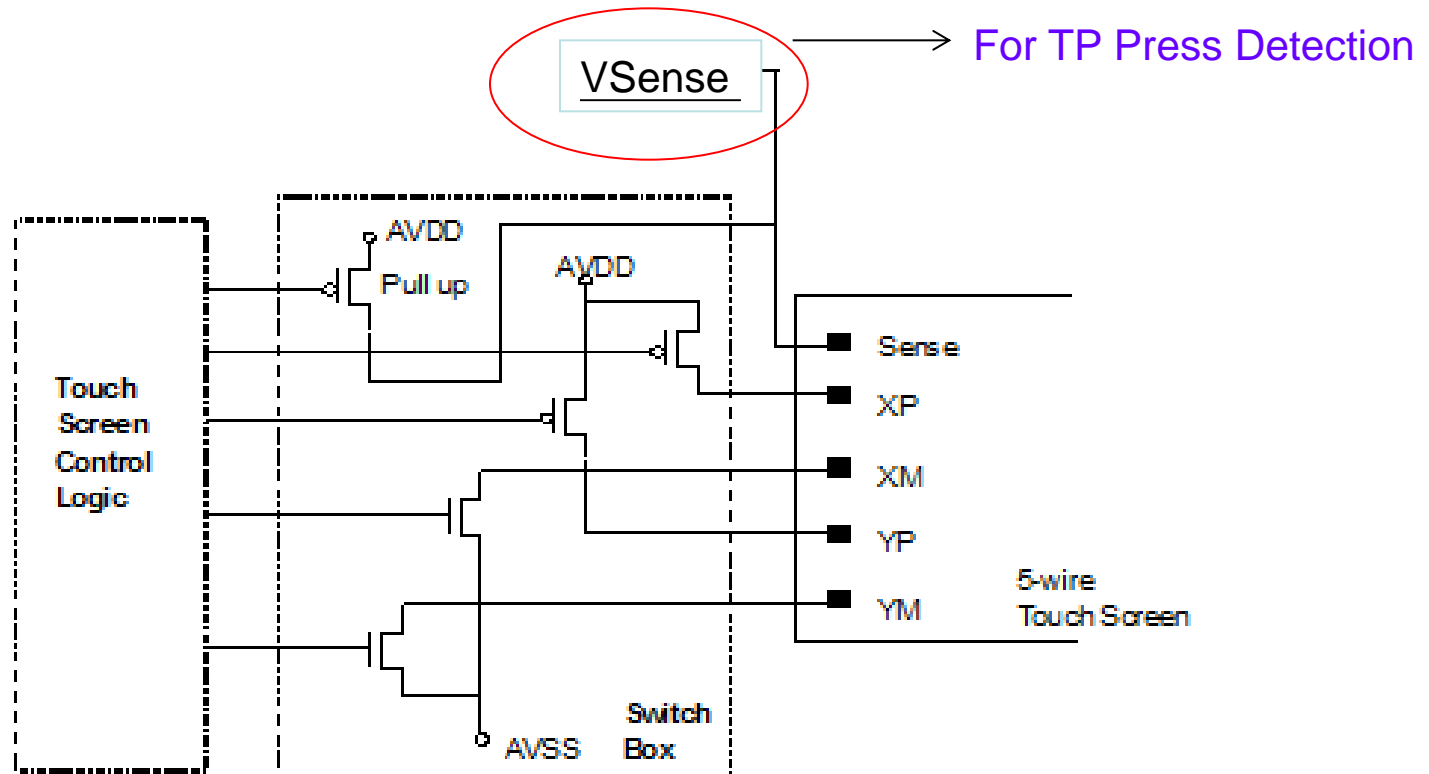


5-wire Touch Screen Connection Diagram

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.

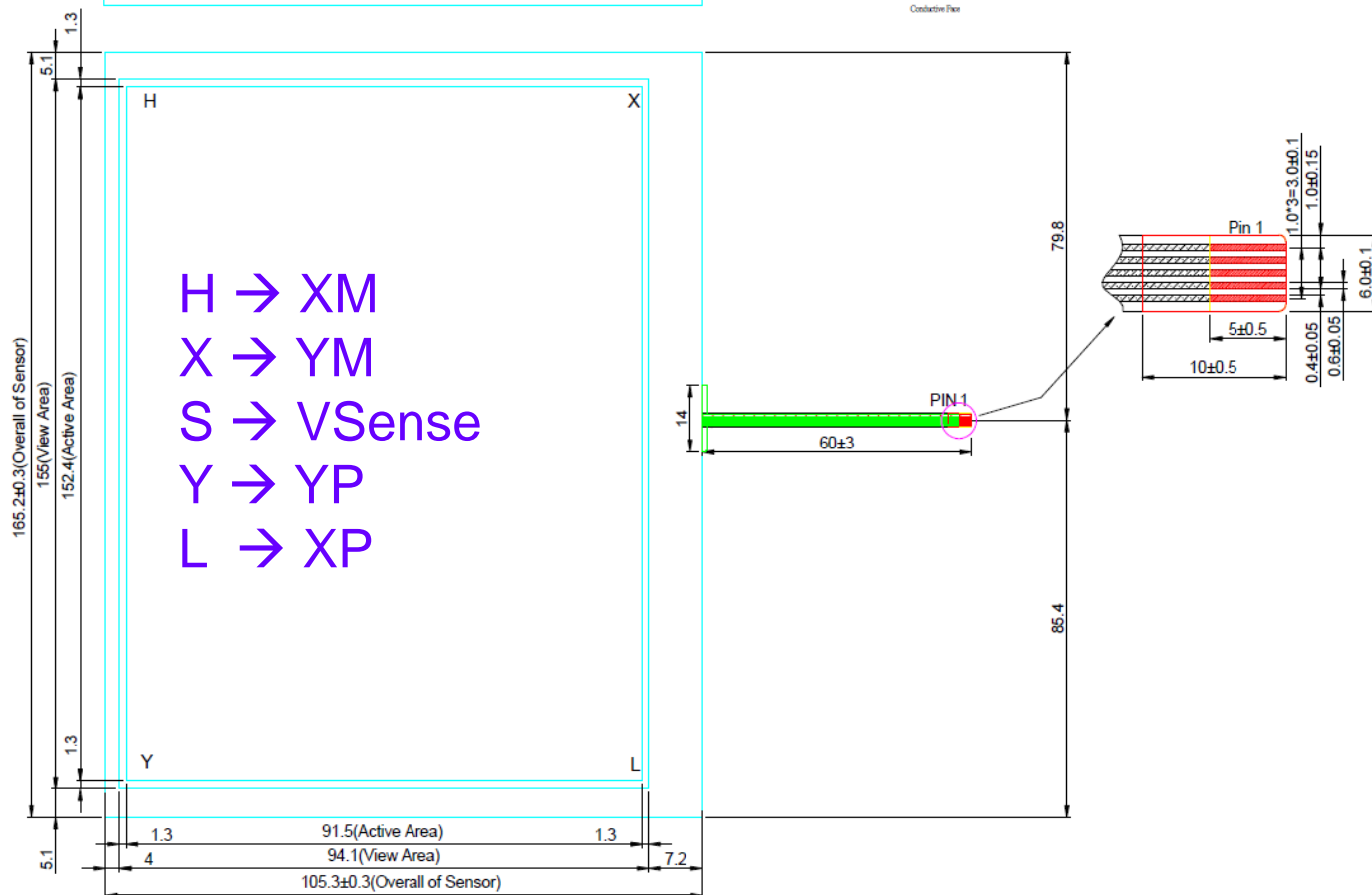
# 5-W Touch Connection

TP\_XM, TP\_YM, TP\_XP, TP\_YP & VSense



Advantage: Reliability & life time are good than 4W

H  $\rightarrow$  XM  
X  $\rightarrow$  YM  
S  $\rightarrow$  VSense  
Y  $\rightarrow$  YP  
L  $\rightarrow$  XP



P/N	Film Type	Glass Thickness	Finished Part Thickness
5W-070WS	Anti-Glare	1.1	1.4±0.2

Pin#	Assignment
1	H
2	X
3	S
4	Y
5	L

益震科技股份有限公司 Onetouch Technologies Co.,Ltd.			
DATE:	2012.2.17		
P/N:	5W-070WS		
MODEL:	5W-070W		
DRAWER:	WEI	APPROVAL:	DAVID

# Analog Characteristics

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Conditions
-	Resolution	-	12	-	Bit	
DNL	Differential Nonlinearity Error	-	$\pm 1$	-	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 <sup>[1]</sup>	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	-	$\mu A$	
$V_{REF}$	Reference Voltage	2	-	$V_{AVDD}$	V	
$V_{IN}$	Analog Input Voltage	0	-	$V_{REF}$	V	
$R_{IN}$	Analog Input Impedance	-	-	2	M $\Omega$	
$C_{IN}$	Capacitance	-	25.6		pF	

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