1 SAR A/D Controller

1.1 Overview

The A/D in JZ4740 is CMOS low-power dissipation 12bit touch screen SAR analog to digital converter. It operates with 3.3/1.8V power supply. It is developed as an embedded high resolution ADC targeting to the 0.18um CMOS process and has wide application in portable electronic devices, high-end home entertainment center, communication systems and so on.

The SAR A/D controller is dedicated to control A/D to work at three different modes: Touch Screen (measure pen position and pen down pressure), Battery (check the battery power), and SADCIN (external ADC input). Touch Screen can transfer the data to memory though the DMA or CPU. Battery and SADCIN can transfer the data to memory though CPU.

Features:

- 6 Channel
- Resolution: 12-bit
- Integral nonlinearity: ±0.5 LSB
- Differential nonlinearity: ±0.4 LSB
- Resolution/speed: up to12bit 187.5ksps
- Max Frequency: 6.0MHz
- Power-down current: 1uA
- Support touch screen measurement (Through pin XP, XN, YP, YN)
- Support voltage measurement (Through pin PBAT)
- Support external SAR-ADC input (Through pin SADCIN)
- Separate Channel Conversion Mode
- Single-end and Differential Conversion Mode
- Auto X/Y, X/Y/Z and X/Y/Z1/Z2 position measurement

1.2 Pin Description

Table 1-1 SADC Pins Description

Name	I/O	Description
XN	AI	Touch screen analog differential X- position input
YN	AI	Touch screen analog differential Y- position input
XP	AI	Touch screen analog differential X- position input
YP	AI	Touch screen analog differential Y- position input
ADIN0 (PBAT)	AI	Analog input for VBAT measurement.
ADIN1 (SADCIN)	AI	External SAR-ADC input

1.3 Register Description

In this section, we will describe the registers in SAR A/D controller. Following table lists all the registers definition. All register's 32bit address is physical address. And detailed function of each register will be described below.

Name	Description	RW	Reset Value	Address	Access Size
ADENA	ADC Enable Register	RW	0x00	0x10070000	8
ADCFG	ADC Configure Register	RW	0x0002002C	0x10070004	32
ADCTRL	ADC Control Register	RW	0x00	0x10070008	8
ADSTATE	ADC Status Register	RW	0x00	0x1007000C	8
ADSAME	ADC Same Point Time Register	RW	0x0000	0x10070010	16
ADWAIT	ADC Wait Time Register	RW	0x0000	0x10070014	16
ADTCH	ADC Touch Screen Data Register	RW	0x00000000	0x10070018	32
ADBDAT	ADC PBAT Data Register	RW	0x0000	0x1007001C	16
ADSDAT	ADC SADCIN Data Register	RW	0x0000	0x10070020	16
ADDPIN	ADC IP DATA PIN	R	0x0000	0x10070024	16

1.3.1 ADC Enable Register (ADENA)

The register ADENA is used to trigger A/D to work.

ADENA							0x10070000
Bit	7	6	5	4	3	2	1	0
	ADEN	Reserved				TCHEN	PBATEN	SADCINEN
RST	0	0	0	0	0	0	0	0

Bits	Name	Description	RW
7	ADEN[*1]	A/D Enable Control. (Only used in test mode) Check the channel function of ADC. When A/D finish sampling the data, ADEN will be cleared by hardware auto. 0: disable 1: enable	RW
6:3	Reserved	These bits always read 0, and written are ignored.	R
2	TCHEN[*2]	Touch Screen Enable Control. 0: disable 1: enable	RW
1	PBATEN[*2]	PBAT Enable Control. Sample the voltage of battery, PBATEN can be set to 1 no matter TCHEN is disable or enable, and when the voltage of battery is ready. PBATEN will be cleared by hardware auto.	RW
0	SADCINEN[*2]	SADCIN Enable Control. Sample SADCIN, SADCINEN can be set to 1 no matter TCHEN is disable or enable, and when SADCIN is ready, SADCINEN will be cleared by hardware auto.	RW

Note:

*1. When ADEN is set to 1, other bits cannot be set to 1 at the same time. This mode only used in test mode.

*2. TCHEN, PBATEN and SADCINEN can be set to 1 at the same time. The priority of the three mode is SADCIN > PBAT > TCH.

1.3.2 ADC Configure Register (ADCFG)

The register ADCFG is used to configure the A/D.

ADCFG **0x10007004**

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	SPZZ	EX_IN	Reserved											CLKOUTD NUM			DMA_EN	XYZ		SNUM			CLKDIV					BAT_MD	CMD			
RST	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0

Bits	Name	Description	RW
31	SPZZ[*1]	The $X_dY_dZ_mZ_n$ of different point measure can be different. But the $X_dY_dZ_mZ_n$ of the same point measure can be same or different. 0:The $X_dY_dZ_mZ_n$ of the same point measure is all the same. (X_dY_dZ1Z2, X_dY_dZ1Z2, X_dY_dZ1Z2, X_dY_dZ1Z2 … X_dY_dZ1Z2) 1: The $X_dY_dZ_mZ_n$ of the same point measure maybe different. (X_dY_dZ1Z2, X_dY_dZ3Z4, X_dY_dZ3Z4, X_dY_dZ1Z2 … X_dY_dZ1Z2)	RW
30	EX_IN	Choose external driver or internal driver. 0: X_sY_s or X_sY_sZ 1: X_dY_d or X_dY_dZ It is no use for $X_dY_dZ_mZ_n$. It is no use when ADCFG.XYZ = 10. It is useful when ADCFG.XYZ = 00/01.	RW
29:19	Reserved	These bits always read 0, and written are ignored.	R
18:16	DNUM	This will set which is the sampled data is the virtual value. Default: = 3'b010 <table><tr><td>DNUM</td><td>Number</td></tr><tr><td>3'b000</td><td>Reserved</td></tr><tr><td>3'b001</td><td>The virtual value is the 2nd sampled data</td></tr><tr><td>3'b010</td><td>The virtual value is the 3rd sampled data</td></tr><tr><td>3'b011</td><td>The virtual value is the 4th sampled data</td></tr><tr><td>3'b100</td><td>The virtual value is the 5th sampled data</td></tr><tr><td>3'b101</td><td>The virtual value is the 6th sampled data</td></tr><tr><td>3'b110</td><td>The virtual value is the 7th sampled data</td></tr><tr><td>3'b111</td><td>The virtual value is the 8th sampled data</td></tr></table>	RW
15	DMA_EN	When A/D is used as Touch Screen (CMD=1100), DMA_EN is used as follows: 0: The sample data is read by CPU 1: The sample data is read by DMA	RW
14:13	XYZ	When A/D is used in Touch Screen mode (CMD=1100), XYZ is used as	RW

<table>
<tr><td></td><td></td><td>follows:
<table>
<tr><td>XYZ</td><td>Measure (EX_IN = 1)</td><td>Measure (EX_IN = 0)</td></tr>
<tr><td>00</td><td>$X_d \rightarrow Y_d$</td><td>$X_s \rightarrow Y_s$</td></tr>
<tr><td>01</td><td>$X_d \rightarrow Y_d \rightarrow Z_s$</td><td>$X_s \rightarrow Y_s \rightarrow Z_s$</td></tr>
<tr><td>10</td><td>$X_d \rightarrow Y_d \rightarrow Z1_d \rightarrow Z2_d$
or
$X_d \rightarrow Y_d \rightarrow Z3_d \rightarrow Z4_d$</td><td>$X_d \rightarrow Y_d \rightarrow Z1_d \rightarrow Z2_d$
or
$X_d \rightarrow Y_d \rightarrow Z3_d \rightarrow Z4_d$</td></tr>
<tr><td>11</td><td>Reserved</td><td>Reserved</td></tr>
</table></td><td></td></tr>
<tr><td>12:10</td><td>SNUM</td><td>The number of repeated sampling one point. When A/D is used as Touch Screen (CMD=1100), SNUM is used as follows:
<table>
<tr><td>SNUM</td><td>Number</td></tr>
<tr><td>000</td><td>1</td></tr>
<tr><td>001</td><td>2</td></tr>
<tr><td>010</td><td>3</td></tr>
<tr><td>011</td><td>4</td></tr>
<tr><td>100</td><td>5</td></tr>
<tr><td>101</td><td>6</td></tr>
<tr><td>110</td><td>8</td></tr>
<tr><td>111</td><td>9</td></tr>
</table></td><td>RW</td></tr>
<tr><td>9:5</td><td>CLKDIV</td><td>A/D converter frequency.
A/D works at the frequency between 500KHz and 6MHz.
If CLKDIV =N, Then the frequency divide number = 12MHz/N+1.
0< N < 24</td><td>RW</td></tr>
<tr><td>4</td><td>BAT_MD</td><td>When AD is used as PBAT measure the following channel mode can be chose to measure the battery power.
0: PBAT (full battery voltage>=2.5V)
1: PBAT (full battery voltage<2.5V)</td><td>RW</td></tr>
</table>

<table>
<tr><td>3:0</td><td>CMD</td><td>CMD is used to choose the current sample command when adc_en_r is set to 1 (single channel test mode).
<table>
<tr><td>CMD</td><td>Function</td><td>Reference mode</td></tr>
<tr><td>0000</td><td>Measure X Position (X-plate is driven by external DC power)</td><td>Single-end</td></tr>
<tr><td>0001</td><td>Measure Y Position (Y-plate is driven by external DC power)</td><td>Single-end</td></tr>
<tr><td>0010</td><td>Measure X Position</td><td>Differential</td></tr>
<tr><td>0011</td><td>Measure Y Position</td><td>Differential</td></tr>
<tr><td>0100</td><td>Measure Z1 Position</td><td>Differential</td></tr>
<tr><td>0101</td><td>Measure Z2 Position</td><td>Differential</td></tr>
<tr><td>0110</td><td>Measure Z3 Position</td><td>Differential</td></tr>
<tr><td>0111</td><td>Measure Z4 Position</td><td>Differential</td></tr>
<tr><td>1000</td><td>Measure Touch Pressure Z</td><td>Single-end</td></tr>
<tr><td>1001</td><td>Measure PBAT (>=2.5V)</td><td>Single-end</td></tr>
<tr><td>1010</td><td>Measure PBAT (<2.5V)</td><td>Single-end</td></tr>
<tr><td>1011</td><td>Measure SADCIN</td><td>Single-end</td></tr>
<tr><td>1100</td><td colspan="2">INT_PEN enable, this mode is the default value.</td></tr>
<tr><td>1101~1111</td><td colspan="2">Reserved</td></tr>
</table>
</td><td>RW</td></tr>
</table>

Note[*1]:

X_s, Y_s, Z_s means the reference mode of X, Y, Z is single-end mode.

X_d, Y_d, $Z1_d$, $Z2_d$, $Z3_d$, Z4d means the reference mode of X, Y, Z1, Z2, Z3, Z4 is differential mode.

When you measure Xs you need to make sure that X-plate is driven by external DC power.

When you measure Ys you need to make sure that Y-plate is driven by external DC power.

1.3.3 ADC Control Register (ADCTRL)

The register ADCTRL is used to control A/D to work.

ADCTR 0x10070008

Bit	7	6	5	4	3	2	1	0
	Reserved			PENDM	PENUM	DTCHM	DRDYM	SRDYM
RST	0	0	0	0	0	0	0	0

Bits	Name	Description	RW
7:5	Reserved	These bits always read 0, and written are ignored.	R
4	PENDM	Pen down interrupt mask. 0= enabled 1= masked	RW

3	PENUM	Pen up interrupt mask. 0= enabled 1= masked	RW
2	DTCHM	Touch Screen Data Ready interrupt mask. 0= enabled 1= masked	RW
1	DRDYM	Data ready interrupt mask. (ADCEN = 1) PBAT data ready interrupt mask. 0= enabled 1= masked	RW
0	SRDYM	SADCIN Data Ready interrupt mask. 0= enabled 1= masked	RW

1.3.4 ADC Status Register (ADSTATE)

The register ADCSTATE is used to keep the status of A/D.

ADSTS **0x1007000C**

Bit	7	6	5	4	3	2	1	0
	Reserved			PEND	PENU	DTCH	DRDY	SRDY
RST	0	0	0	0	0	0	0	0

Bits	Name	Description	RW
7:5	Reserved	These bits always read 0, and written are ignored.	R
4	PEND	Pen down interrupt flag. Write 1 to this bit, the bit will clear this bit. 1: active 0: not active	RW
3	PENU	Pen up interrupt flag. Write 1 to this bit, the bit will clear this bit. 1: active 0: not active	RW
2	DTCH	Touch screen data ready interrupt flag. Write 1 to this bit, the bit will clear this bit. 1: active 0: not active	RW
1	DRDY	Data ready interrupt flag when ADCEN = 1. PBAT data ready interrupt flag. Write 1 to this bit, the bit will clear this bit. 1: active 0: not active	RW

0	SRDY	SADCIN Data ready interrupt flag. Write 1 to this bit, the bit will clear this bit. 1: active 0: not active	RW

1.3.5 ADC Same Point Time Register (ADSAME)

The register ADSAME is used to store the interval time between repeated sampling the same point. The clock frequency of the counter is 12M/128.

ADSAME **0x10070010**

Bit	31-16	15-0
		SCNT
RST		0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

1.3.6 ADC Wait Pen Down Time Register (ADWAIT)

The register ADWAIT is used to store the interval time of wait pen down. And the register can be used as the interval time among the different point. The clock frequency of the counter is 12M/128.

ADDIFF **0x10070014**

Bit	31-16	15-0
		WCNT
RST		0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

1.3.7 ADC Touch Screen Data Register (ADTCH)

The read-only ADTCH is corresponded to 2x32 bit FIFO, it keep the sample data for touch screen. 0~11 bits are data, 15 bit is data type. 16~27 bits are data, 31 bit is data type. When write to the register, DATA will be clear to 0.

ADTCH **0x10070018**

Bit	31	30-28	27-16	15	14-12	11-0
	TYPE1	Reserved	TDATA1	TYPE0	Reserved	TDATA0
RST	0	0 0 0	0 0 0 0 0 0 0 0 0 0 0 0	0	0 0 0	0 0 0 0 0 0 0 0 0 0 0 0

Bits	Name	Description	RW
31	TYPE1	Type of the Touch Screen Data1. When A/D is used as Touch Screen, ADCFG.XYZ=10 TYPE1=1: $X_d \rightarrow Y_d \rightarrow Z1 \rightarrow Z2$ TYPE1=0: $X_d \rightarrow Y_d \rightarrow Z3 \rightarrow Z4$ When A/D is used as Touch Screen, ADCFG.XYZ=00 or XYZ=01, TYPE1=0.	RW
30:28	Reserved	These bits always read 0, and written are ignored.	R
27:16	TDATA1	The concert data of touch screen A/D.	RW
15	TYPE0	Type of the Touch Screen Data2. When A/D is used as Touch Screen, ADCFG.XYZ=10 TYPE0=1: $X_d \rightarrow Y_d \rightarrow Z1 \rightarrow Z2$ TYPE0=0: $X_d \rightarrow Y_d \rightarrow Z3 \rightarrow Z4$ When A/D is used as Touch Screen, ADCFG.XYZ=00 or XYZ=01, TYPE0=0.	RW
14:12	Reserved	These bits always read 0, and written are ignored.	R
11:0	TDATA0	The concert data of touch screen A/D.	RW

Note:

(1) When A/D is used as Touch Screen, EX_IN=0 and ADCFG.XYZ=00.
The format of touch screen data is as follows:

Type1	Reserved	Data1	Type0	Reserved	Data0
0	000	Y_s	0	000	X_s

(2) When A/D is used as Touch Screen, EX_IN=1 and ADCFG.XYZ=00.
The format of touch screen data is as follows:

Type1	Reserved	Data1	Type0	Reserved	Data0
0	000	Y_d	0	000	X_d

(3) When A/D is used as Touch Screen, EX_IN=0 and ADCFG.XYZ=01.
The format of touch screen data is as follows:

Type1	Reserved	Data1	Type0	Reserved	Data0
0	000	Y_s	0	000	X_s
0	000	000000000000	0	000	Z_s

Users need to read twice to get the whole data. The first time reading gets the data Y_s and X_s. The second time reading gets the data Z_s. The relation between “touch pressure” and “Z_s” are inverse ratio.

(4) When A/D is used as Touch Screen, EX_IN=1 and ADCFG.XYZ=01
The format of touch screen data is as follows:

Type1	Reserved	Data1	Type0	Reserved	Data0
0	000	Y_d	0	000	X_d
0	000	000000000000	0	000	Z_s

Users need to read twice to get the whole data. The first time reading gets the data Y_d and X_d. The second time reading gets the data Z_s. The relation between "touch pressure" and "Z_s" are inverse ratio.

(5) When A/D is used as Touch Screen, ADCFG.XYZ=11,TYPE=1
The format of touch screen data is as follows:

Type1	Reserved	Data1	Type0	Reserved	Data0
1	000	Y_d	1	000	X_d
1	000	$Z2_d$	1	000	$Z1_d$

Users need to read twice to get the whole data. The first time reading gets the data Y_d and X_d. The second time reading gets the data $Z2_d$ and $Z1_d$.

The touch pressure measurement formula is as follows: (You can use formula 1 or formula 2.)

$$R_{\text{TOUCH}} = R_{\text{X-Plate}} \bullet \frac{\text{X-Position}}{4096}\left(\frac{Z_2}{Z_1} - 1\right) \qquad (1)^{*1}$$

$$R_{\text{TOUCH}} = \frac{R_{\text{X-Plate}} \bullet \text{X-Position}}{4096}\left(\frac{4096}{Z_1} - 1\right) - R_{\text{Y-Plate}} \bullet \left(1 - \frac{\text{Y-Position}}{4096}\right) \qquad (2)^{*1}$$

(6) When A/D is used as Touch Screen, ADCFG.XYZ=11,TYPE=0
The format of touch screen data is as follows:

Type1	Reserved	Data1	Type0	Reserved	Data0
0	000	Y_d	0	000	X_d
0	000	$Z4_d$	0	000	$Z3_d$

Users need to read twice to get the whole data. The first time reading gets the data Y_d and X_d. The second time reading gets the data $Z4_d$ and $Z3_d$.

The touch pressure measurement formula is as follows: (You can use formula 3 or formula 4.)

$$R_{\text{TOUCH}} = R_{\text{Y-Plate}} \bullet \frac{\text{Y-Position}}{4096}\left(\frac{Z_4}{Z_3} - 1\right) \qquad (3)^{*1}$$

$$R_{TOUCH} = \frac{R_{Y\text{-}Plate} \bullet Y\text{-}Position}{4096}\left(\frac{4096}{Z_3} - 1\right) - R_{X\text{-}Plate} \bullet \left(1 - \frac{X\text{-}Position}{4096}\right) \qquad (4)^{*1}$$

Note*1:

To determine pen or finger touch, the pressure of the touch needs to be determined. Generally, it is not necessary to have very high performance for this test; therefore, the 8-bit resolution mode is recommended (however, calculations will be shown here are in 12-bit resolution mode).

$R_{X\text{-}plate}$: Total X-axis resistor value (about 200Ω~ 600Ω)
$R_{Y\text{-}plate}$: Total Y-axis resistor value (about 200Ω~ 600Ω)
X-Position: X-axis voltage sample value
Y-Position: Y-axis voltage sample value
Z1, Z2: Z1, Z2 voltage sample value
Z3, Z4: Z3, Z4 voltage sample value

1.3.8 ADC PBAT Data Register (ADBDAT)

The read-only ADBDAT is a 16-bit register, it keep the sample data of both “PBAT mode” and “Single channel check” mode. 0~11 bits are data.

ADBDAT **0x1007001C**

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Reserved				BDATA											
RST	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	Name	Description	RW
15:12	Reserved	These bits always read 0, and written are ignored.	R
11:0	BDATA	Data of A/D convert when ADCEN = 1. Data of PBAT A/D convert. When write to the register, DATA will be clear to 0.	RW

When ADCCFG.BAT_MD = 0 (full battery voltage>=2.5V), the measured voltage V_{BAT} is as follows:

$$V_{BAT} = \frac{BDATA}{4096} \bullet 7.5V$$

When ADCCFG.BAT_MD = 1 (full battery voltage<2.5V), the measured voltage V_{BAT} is as follows:

$$V_{BAT} = \frac{BDATA}{4096} \bullet 2.5V$$

It is recommended to connect a capacitance of about 0.1uF near to pin ADIN0 to have a more stable battery measurement and better ESD protection.

1.3.9 ADC SADCIN Data Register (ADSDAT)

The read-only ADSDAT is a 16-bit register, it keep the sample data. 0~11 bits are data.

ADDAT **0x10070020**

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Reserved				SDATA											
RST	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	Name	Description	RW
15:12	Reserved	These bits always read 0, and written are ignored.	R
11:0	SDATA	Data of SADCIN A/D convert. When write to the register, DATA will be clear to 0.	RW

1.3.10 ADC IP DATA PIN (ADDPIN)

The read-only ADDPIN is a 16-bit fake register. The transfer data is come from SADC IP output data directly. This is used to check IP data.

ADDPIN **0x10070024**

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Reserved				DATA											
RST	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	Name	Description	RW
15:12	Reserved	These bits always read 0, and written are ignored.	R
11:0	DATA	Data of transfer.	R

1.4 SAR A/D Controller Guide

The following describes steps of using SAR-ADC.

1.4.1 Single Operation (only used as a test mode to check the channel function)

(1) Set ADTCTL to 0x1f to mask all the interrupt of SADC.
(2) Set ADCFG.CMD to choose one CMD;(0000~1011)
(3) Set ADCFG.CLKDIV to set A/D clock frequency;
(4) Set ADTCTL.PDEN to 0;
(5) Set ADENA.ADEN to 1 to start A/D;
(6) When ADSTATE.DRDY to 1, you can read the sample data from ADBDAT and ADENA.ADEN will be set to 0 auto.

1.4.2 A simple Touch Screen Operation

(Pen Down → Sample some data of several points → Pen Up)

(1) Set ADTCTL to 0x1f to mask all the interrupt of SADC.
(2) Set DMA_EN to choose whether to use DMA to read the sample data out or to use CPU to read the sample data out;
(3) Set ADCFG.SPZZ, ADCFG.EX_IN and ADCFG.XYZ to choose sample mode
 1: $X_s \rightarrow Y_s$ (Single-end X→Single-end Y).
 2: $X_d \rightarrow Y_d$ (Differential X→Differential Y).
 3: $X_s \rightarrow Y_s \rightarrow Z_s$ (Single-end X→Single-end Y→Single-end Z)
 4: $X_d \rightarrow Y_d \rightarrow Z_s$ (Differential X→Differential Y→Single-end Z)
 5: $X_d \rightarrow Y_d \rightarrow Z1_d \rightarrow Z2_d$ or $X_d \rightarrow Y_d \rightarrow Z3_d \rightarrow Z4_d$ (Reference register ADCFG.SPZZ)
 (Differential X→Differential Y→Differential Z1→Differential Z2 or
 Differential X→Differential Y→Differential Z3→Differential Z4,)
(4) Set ADCFG.CLKDIV to set A/D clock frequency;
(5) Set ADWAIT to decide the wait time of pen down and the interval time between sampling different points. This time delay is necessary because when pen is put down or pen position change, there should be some time to wait the pen down signal to become stable.
(6) Set ADSAME to decide the interval time between repeated sampling the same point. User can repeat sampling one point to get the most accurate data.
(7) Set ADTCTL.PENDM to 0 to enable the pen down interrupt of touch panel;
(8) Set ADENA.TCHEN to 1 to start touch panel;
(9) When pen down interrupt is happened, you should set ADTCTL.PENDM to 1 and clear ADSTATE.PEND to close pen down interrupt. Then you should clear ADSTATE.PENDU and set ADTCTL.PENUM to 0 to enable pen up interrupt.
(10) When pen down interrupt is happened, the SAR ADC is sampling data. When ADSTATE.DTCH to 1, user must read the sample data from ADTCH. The SAR ADC will not sample the next point until the whole data of the one point are read (no matter by CPU or DMA). If ADCFG.XYZ is mode one and mode two, user only needs to read once to get the whole data. In other modes, user needs to read twice to get the whole data.
(11) Repeat 10 till pen up interrupt happened.
(12) When pen up interrupt is happened, you should set ADTCTL.PENUM to 1 and clear ADSTATE.PENU. Then you should clear ADSTATE.PENDD and set ADTCTL.PENPM to 0 to enable pen down interrupt.
(13) Wait pen down interrupt and repeat from 9.

(14) When you want to shut down the touch screen, user can set the ADENA.TCHEN to 0. If the last point is not sampled completely, user can abandon it.

1.4.3 PBAT Sample Operation

(1) Set ADCFG.CLKDIV to set A/D clock frequency;
(2) Set ADCFG.CH_MD to choose PBAT test mode channel.
(3) Set ADENA.PBATEN to 1 to enable the channel.
(4) When ADSTATE.DRDY = 1, you can read the sample data from ADPBAT. And the PBATEN will be set to 0 auto.

1.4.4 SADCIN Sample Operation

(1) Set ADCFG.CLKDIV to set A/D clock frequency;
(2) Set ADENA.SADCINEN to 1 to enable the channel.
(3) When ADSTATE. SRDY = 1, you can read the sample data from ADSDAT. And the SADCINEN will be set to 0 auto.

Note:

Touch Screen mode can be interrupt by the PBAT and SADCIN mode. And the priority is SADCIN > PBAT > TOUCH. If SADCINEN or PBATEN is set to 1 before or at the same time with TCHEN, SAR ADC will first work in SADCIN mode then in PBAT mode at last in touch screen mode. If SADCINEN and PBATEN are set to 1 after the TCHEN, the SAR ADC will work in touch screen mode first and finish sampling the same point completely then turn to the SADCIN or PBAT mode. And return to touch screen mode.