APPLICATION NOTE

ABSTRACT
This application note provides set-up recommendations on power-on reset, power saving modes, interrupt signalling and various audio and touchscreeen ADC features. It also includes a pseudo code, showing how to set up the touchscreen controller.

AN10154
Notes on using the UCB1400

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1.0 Power-on reset

After power-up, a reset should be applied to UCB1400 as soon as possible to bring the chip to the default state. This is achieved by performing a complete cold reset sequence (i.e., with both SDATA_OUT and SYNC held at logic LOW, hold the $\overline{\text{RESET}}$ pin to logic LOW for at least 1 µs and then transition to a logic HIGH).

2.0 Power saving modes

The UCB1400 allows individual blocks to be shut down when not used to reduce power consumption. Table 1 lists the settings of some commonly used modes.

Table 1. Power saving modes settings

MODE	HPEN	PR0	PR1	PR3	PR4	PR5	SLP1	SLP0	BIAS	AE	SL	SR
Full audio (Line L&R in) only	1	0	0	0	0	0	1	1	0	0	4	4
Full audio (Mono MIC in) only	1	0	0	0	0	0	1	1	0	0	0	0
Audio ADC (Line L&R in) only	0	0	1	0	0	0	1	1	0	0	4	4
Audio ADC (Mono MIC in) only	0	0	1	0	0	0	1	1	0	0	0	0
Audio DAC & HP only	1	1	0	0	0	0	1	1	0	0	X	X
Touchscreen bias & 10-bit ADC only	0	1	1	1	0	0	1	1	1	1	X	X
10-bit ADC only	0	1	1	1	0	0	1	1	0	1	X	X
AC-link only	0	1	1	1	0	0	1	1	0	0	X	X
Idle	0	1	1	1	1	0	1	1	0	0	X	X
Standby	0	1	1	1	0	1	1	1	0	0	X	X

Note that apart from the PR bits defined by the AC-link standard, UCB1400 is equipped with the audio Smart Low-Power mode bits, controlled by the SLP[1:0] bits in register 0x6C. Under normal operation, it is recommended to set both SLP0 and SLP1 to 1. This will ensure that UCB1400 consumes the least amount of current whatever audio sample rates or ADC input (Line-in or MIC) the user chooses. For instance, if the user chooses mono MIC instead of stereo Line-in, power consumption will be reduced because the Line-in amplifiers will be shut down.

The standby mode should be used when the system is idling for an extended period of time. This mode has the lowest power consumption and still has the capability of touch or GPIO event detection via interrupt. A typical scenario will involve UCB1400 in standby mode generating an interrupt in response to a tap on the touch screen. The interrupt routine then instructs the AC-link controller to wake up UCB1400 via a warm reset, set UCB1400 to touchscreen bias and 10-bit ADC only mode to capture the touch coordinates before returning to standby mode if appropriate.

3.0 Interrupt signaling

The UCB1400 supports interrupt signaling via the IRQOUT pin, which can be connected to, e.g., a GPIO pin of the host processor for interrupt detection.

Additionally, if the GIEN bit of the Feature Control/Status Register 1 (0x6A) is set, UCB1400 can also support interrupt signaling via the AC-link alone by sending the interrupt information through:

- GPIO_INT bit of input slot 12 when BIT_CLK is on.
- LOW-to-HIGH transition of the SDATA_IN pin when BIT_CLK is off.

The user needs to choose the appropriate mechanism based on the capability of the AC-link controller.

4.0 Audio DAC features

4.1 HPEN bit

UCB1400 defaults to headphone driver off after a cold reset. The user needs to turn on the HPEN bit in the Feature Control/Status Register 1 (0x6A) explicitly to enable the headphone driver. To minimize any ‘click’ sound when the audio DAC and headphone driver are subsequently powered up or down, the following sequence is recommended:

- Audio DAC and headphone driver power-down: First set HPEN = 0. Then set PR1 = 1.
- Audio DAC and headphone driver power-up: First set PR1 = 0. Then set HPEN = 1.

4.2 VREFDRV pin

The UCB1400 implements the VREFDRV pin that acts as a virtual ground to the headphone driver output LINE_OUT_L and LINE_OUT_R. This allows direct connection to a stereo headphone without the use of external DC blocking capacitors.

4.3 Headphone short circuit detection

The headphone driver is equipped with a short circuit protection on each of the LINE_OUT_L, LINE_OUT_R and VREFDRV output. When HPEN = 1, the short circuit protection circuit will signal a short circuit by setting the corresponding bit (CLPL, CLPR or CLPG) in the Extra Interrupt register (0x70). In addition, an interrupt is generated whenever the CLPP or CLPN bit is set in the Positive and/or Negative INT Enable Registers. In that case, the CPLS bit will be set in the INT Clear/Status register (index 0x62). The user can subsequently examine the Extra Interrupt register (0x70) to determine the source of the short circuit. When HPEN = 0, the CLPL, CLPR and CLPG bits should not be used as they do not contain valid short circuit detection information.

4.4 Bass/Treble/Deemphasis

The UCB1400 supports bass and treble boost via the use of the Feature Control/Status Register 1 (0x6A). If M[1:0] is set to FLAT (‘00’), both bass and treble boost will be disabled. If M[1:0] is set to MINIMUM (‘01’ or ‘10’) or MAXIMUM (‘11’), both bass and treble boost will be activated with the actual boost determined by the BB (for bass) and TR (for treble) settings. The difference between the MINIMUM and MAXIMUM modes is that additional bass boost is possible with the MAXIMUM mode, as shown in Table 2.

Table 2. Difference between MINIMUM and MAXIMUM modes

Bass Boost			
BB	**M = FLAT (dB)**	**M = MINIMUM (dB)**	**M = MAXIMUM (dB)**
0–9	0	2*BB	2*BB
10–12	0	18	2*BB
13–15	0	18	24
Treble Boost			
TR	**M = FLAT (dB)**	**M = MINIMUM (dB)**	**M = MAXIMUM (dB)**
0–3	0	2*TR	2*TR

4.5 Deemphasis

For playback of, e.g., CD encoded with emphasis, the DE bit in the Feature Control/Status Register 1 (0x6A) can be set to ‘1’ to provide the necessary deemphasis.

5.0 Audio ADC features

5.1 DC and HIPS filter

Under normal operation, both these filters should be enabled in the Feature Control/Status Register 1 (0x6A) by setting the corresponding bits to '1'. This will ensure the audio ADC data to be free of DC components.

5.2 MICGND

The MICGND pin of UCB1400 can be used as a ground switch to activate or deactivate the phantom power of electret microphones, as shown in Figure 1. MICGND is connected to ground if microphone is selected, i.e., SL = 0 in the Record Select register (index 0x1A). Otherwise, MICGND is left open causing the current into the microphone to be cut off. To reduce the extra noise introduced by MICGND, it may be required to add a capacitor (22–100 μF) between MICGND and ground to obtain high signal-to-noise ratio.

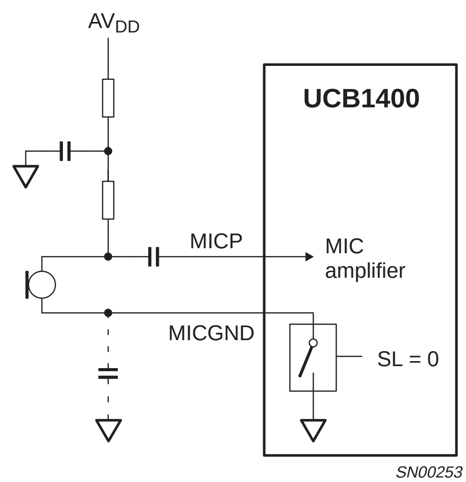

Figure 1. MICGND usage.

6.0 Touchscreen connection

UCB1400 is designed to interface directly with any 4-wire resistive touchscreen. The connections are as follows:

- TSPX: to positive (+) terminal the X plate
- TSMX: to negative (–) terminal the X plate
- TSPY: to positive (+) terminal the Y plate
- TSMY: to negative (–) terminal the Y plate

If desired, a capacitor can be put between ground and each of TSPX, TSMX, TSPY and TSMY to reduce noise. However, using such capacitors will increase the set-up time for each touchscreen measurement.

A pseudo code showing how to control the touchscreen with UCB1400 is attached at the end of this application note.

7.0 10-bit ADC noise reduction

UCB1400 provides several options to reduce the effect of system noise on the 10-bit ADC performance.

7.1 Internal bandgap reference filtering

The 10-bit ADC reference circuit includes a bandgap circuit with a nominal output voltage of about 1.2 V. The connection from the bandgap reference output to the ADC reference input is via a series resistor of about 50 kΩ.

If the VREFB bit in register 0x66 is set to 1, the voltage after this resistor is connected to the VREFBYP pin, which allows an external capacitor (about 100 nF) to be connected to filter residual noise from the bandgap reference before being used by the 10-bit ADC. The pin also allows a direct measurement of the bandgap voltage, but no current must be drawn. If the VREFB bit in register 0x66 is set to 0, the VREFBYP pin is unused.

Our bench evaluation suggests bandgap filtering provides a marginal overall improvement in the 10-bit ADC performance. If the additional space of the capacitor is not an issue, we recommend the user to include this capacitor footprint in the PCB as a manufacturing option. Subsequent evaluation can then be performed to determine if such a capacitor needs to be assembled or not.

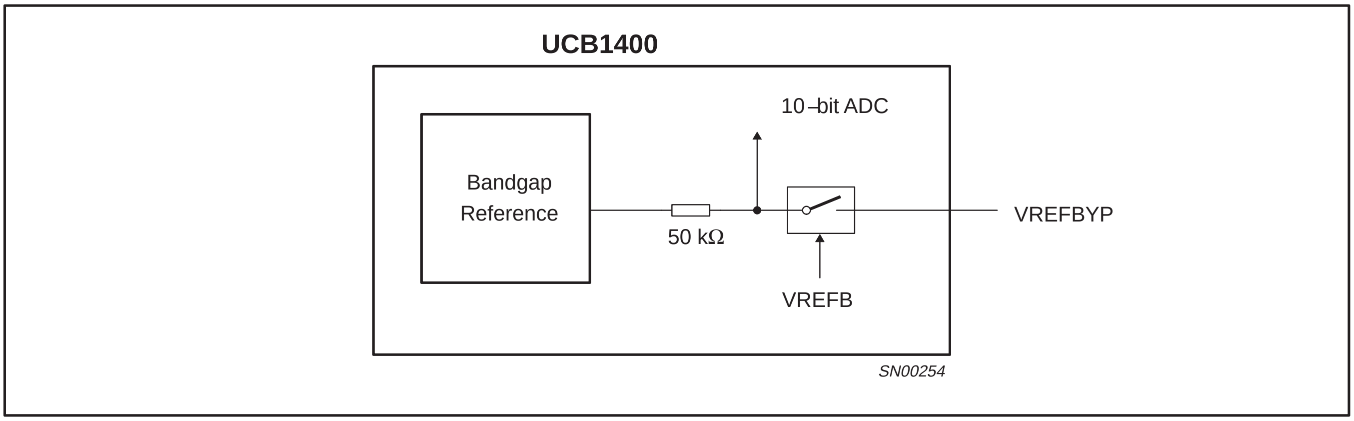

Figure 2. Bandgap reference and VREFBYP.

7.2 10-bit ADC Filter Mode (AVE = 1 and ASE = 0)

If the AVE bit in the Feature/Control Status Register 2 (0x6C) is set to ‘1’, additional digital filtering is applied to the ADC data, making it more immune to high frequency fluctuations in a noisy environment. This mode can be used for all 10-bit ADC measurement, except that it cannot be used in combination with the ADCSYNC mode (see Section 7.3). This means that the ASE bit of the ADC Control Register (index 0x66) has to be set to ‘0’.

Our bench evaluation suggests this mode is very useful in reducing the effect of system noise. We recommend the use of this mode under normal operation.

7.3 ADCSYNC Mode (AVE = 0 and ASE = 1)

Mechanical characteristics of the LCD and a normal four-wire touchscreen panel imply that quite a lot of noise is generated on the touchscreen plates when data is being shifted into the LCD panel (refer to Figure 3). That means, that during data transfer from the controller to the LCD panel, reading touch samples will produce unreliable results.

To maximize the reliability of the touch values UCB1400 gets from the touchscreen panel, UCB1400 may synchronize the access to the touchscreen plates with the quiet moments of the LCD panel through the use of the ADCSYNC pin, as shown in Figure 3.

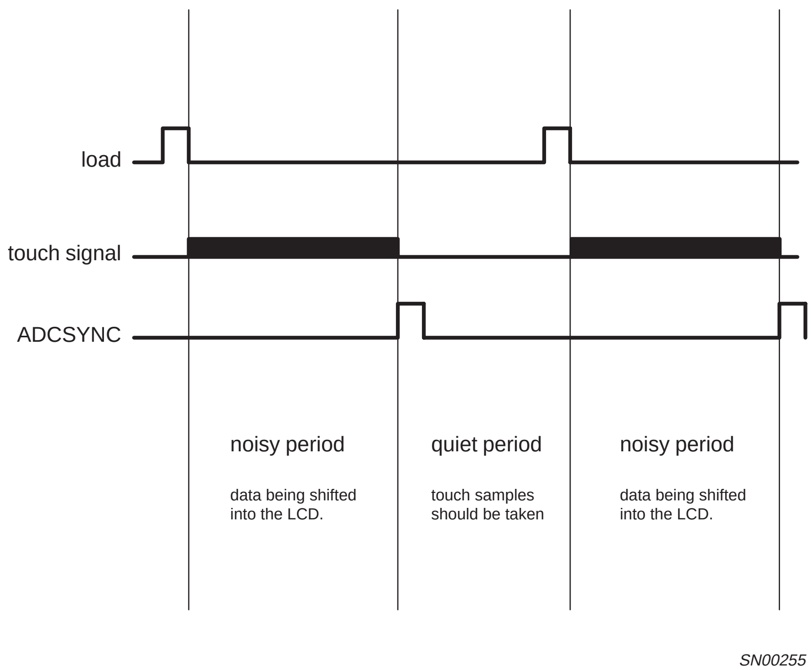

Figure 3. Using ADCSYNC to synchronize touchscreen sampling.

If the ASE bit of the ADC Control Register (index 0x66) is set to 1, the UCB1400 will delay the start of the ADC conversion until after the rising edge of the ADCSYNC signal. Here are the requirements of the ADCSYNC signal:

- The rising edge should occur after the noisy period when data re being shifted into the LCD.
- The pulse width needs to be longer than the BITCLK period (about 82 ns) for reliable detection by UCB1400.

8.0 Pseudo Code for TouchScreen Control

```
class UCB1400HW {
public:
        static void SetTMXP(BOOL s)          { SetReg(0x5E,s,13); }  // bit 13
        static void SetTPXP(BOOL s)          { SetReg(0x5E,s,12); }  // bit 12
        static void SetTMXN(BOOL s)          { SetReg(0x60,s,13); }  // bit 13
        static void SetTPXN(BOOL s)          { SetReg(0x60,s,12); }  // bit 12
        static void ClrTMXS()                { SetReg(0x62,1,13); }  // bit 13
        static void ClrTPXS()                { SetReg(0x62,1,12); }  // bit 12
        static void SetTouchModeInt()        { SetReg(0x64,0x00C3); }
        static void SetTouchModePosX()       { SetReg(0x64,0x0A12); } // TSPX=Biased, TSMX=Ground
        static void SetTouchModePosY()       { SetReg(0x64,0x0A48); } // TSPY=Biased, TSMY=Ground
        static void SetTouchModePres()       { SetReg(0x64,0x09C3); } // TSPX/MX=Biased, TSPY/MY=Ground
        static void ConvertPosX()            { SetReg(0x66,0x8088); } // Read X position from TSPY
        static void ConvertPosY()            { SetReg(0x66,0x8080); } // Read Y position from TSPX
        static void ConvertPres()            { SetReg(0x66,0x8080); } // does not matter which input
        static BOOL CheckPenDown()           { return (GetReg(0x64,13,12)==0); }  // bits 13..12
        static WORD GetAD()                  { WORD d;
                                                   while (((d=GetReg(0x68))&0x8000)==0);
                                                   return d&0x03FF; }
};

void UCB1400HW::InitUCB1400()
{
        dc–>AC97_cold_reset(); Sleep(500);
        SetTouchModeInt(); ClrTPXS(); SetTPXN(TRUE);
}

void UCB1400HW::GetTouchSample()
{
        int i;

        // UCB1400 is in interrupt mode at this point
        if (CheckPenDown())
        {
                SetTouchModePosX();
                for (i=0; i < MAX_SAMPLE; i++)
                {
                        ConvertPosX(); x[i]=GetAD();
                }
                SetTouchModePosY();
                for (i=0; i < MAX_SAMPLE; i++)
                {
                        ConvertPosY(); y[i]=GetAD();
                }
```

```
                SetTouchModePres();
                for (i=0; i < MAX_SAMPLE; i++)
                {
                        ConvertPres(); p[i]=GetAD();
                }
                SetTouchModeInt();
        }
}
```

9.0 Revision history

Revision	Date	Description
_2	200207024	Second version. Supersedes AN10154–01 (9397 750 09966) dated 2002 Jun 24. Modifications: • Section 7.2: Title and first paragraph modified. • Section 7.3: Title modified.
–01	200206024	Initial version.

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