MC33978 power consumption calculation
Featuring the MC33978 - 22 channel switch detection interface IC

1 Introduction

The MC33978 is a 22 channel switch detection interface designed to monitor multiple system switches and communicate its open/close status via SPI communication protocol. The MC33978 targets various applications such as body controls, smart junction box, and power train controllers in auto applications, machine tool controls, PLC controllers, among other industrial applications. NXP analog ICs are manufactured using the SMARTMOS process, a combinational BiCMOS manufacturing flow which integrates precision analog, power functions, and dense CMOS logic together on a single cost-effective die.

As part of the newer requirements of the automotive industry, power consumption has become a critical factor for modules running off auto battery voltage uninterruptedly.

The purpose of this document is to present a systematic way to estimate the power consumption of the MC33978 device for multiple switch status monitoring in any given application. It provides a comprehensive explanation on how total power consumption can be improved by implementing Low-power mode and making use of the configurations provided in this operating mode.

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2 Switch monitoring power requirements

Implementing wetting current technics to ensure proper contact and reduce oxidation effects on the switch's metal plates is the main factor contributing to overall power dissipation of switch monitoring systems. However, battery powered conditions during long periods of time, required very low-power consumptions while still being able to detect and act upon switch status changes at any time.

To address such applications, NXP's MC33978 integrates flexible operating modes to improve the overall power consumption during normal operation, and providing a superior power consumption and thermal performance during sleep (low-power consumption) conditions.

Figure 1 shows a typical application diagram for the MC33978

![Figure 1. Block diagram](image)

MC33978 features 22 input channels from which 14 are dedicated Switch-to-Ground (SG) current source, and eight are programmable inputs (SP) which can be programmed as a Switch-to-Ground (SG) current source or Switch-to-Battery (SB) current sink. Throughout this application note, input channels are referred to as SG or SB, to point out their differences during operation.

For simplicity, all power calculations use nominal values as specified on the MC33978 datasheet. Specific values not called out on the datasheet are typical values obtained through simulation and/or bench evaluation of the device.

3 MC33978 power distribution

The MC33978 employs two supplies as inputs into the device for various use.

- The VBATP pin is the main power supply for the chip from which the internal supplies are generated as well as the power supply for the SG circuit current source.

- The VDDQ pin is used for the I/O buffer supply to talk to the MCU or other logic level devices, including the AMUX output clamp voltage.

The power consumption from these two supplies can be divided in quiescent and load currents, which change depending on the operating mode. The total power dissipation comprises the sum of quiescent current and all load currents per switch detection channel, according to its configuration.
3.1 Normal operation power calculation

During normal operation, the quiescent current is given by the configuration of the SG/SP channels. Table 1 shows general configurations with their corresponding quiescent current during normal mode.

Table 1. Typical quiescent current in normal mode

<table>
<thead>
<tr>
<th>Setup</th>
<th>Condition</th>
<th>Quiescent current</th>
</tr>
</thead>
</table>
| Power on Reset (base current)      | \( V_{BATTERY} = 12 \) V  
All switches open  
SP channels configured as SB (default)  
ALL channel tristated                                      | ~2.5 mA          |
| Tristate Disable                   | \( V_{BATTERY} = 12 \) V  
All switches open  
SP channels configured as SB (default)  
All switches tristate disable                         | ~7.25 mA         |
| Tristate Disable with All channels as SG | \( V_{BATTERY} = 12 \) V  
All switches open  
SP channels configured as SG.  
All switches tristate disable                         | ~6.1 mA          |

To obtain a proper calculation of the quiescent current for a given scenario, use the base current (~2.5 mA) and:

- Add ~165 \( \mu \)A per each SG channel enabled (untristated)
- Add ~300 \( \mu \)A per each channel configured as SB enabled (untristated)

Example 1: SG0-SG7 enabled, SP0-SP1 set as SB and enabled (untristated).

\[
I_{QBATP} = 2.5 mA + (8 \times 165 \mu A) + (2 \times 300 \mu A) = 4.42 mA
\]

To SPI

The load current in Normal mode applies only when the switch is closed. The total power calculation should account for the maximum number of channels which could be closed at the same time, and the wetting current configured per channel. For SG channels, the current is source by the internal SG circuit through the closed switch. Channels programmed as SB sink the current from the battery voltage through the internal current sink circuit as shown in Figure 2.

**Figure 2. SG and SB configurations**
Worst case power dissipation occurs when the continuous wetting current is enabled. In such case, the total load current is the sum of the wetting current of all enable channels.

When the continuous wetting current option is disabled in any of the input channels, upon a switch closure, the wetting current level is ON for 20 ms and brought down to the sustain current level (2.0 mA) for the rest of the time. Since it is not expected to have all switches closing at the same time, the maximum power calculation does not require the use of the wetting current level. Instead, the sustain current (2.0 mA) should be used as the load current for these input channels.

**Figure 3. Switch to ground load current waveform**

Example 2: Load current for SG0-SG7 with continuous wetting current enabled at 20 mA. SP0-SP1 set as SB, with continuous wetting current disabled and $I_{WET} = 20$ mA.

\[
\begin{align*}
I_{SG} &= 8 \times 20\text{mA} = 160\text{mA} \\
I_{SB} &= 2 \times 2\text{mA} = 4\text{mA} \\
I_{LOAD} &= I_{SG} + I_{SG} = 164\text{mA}
\end{align*}
\]

\text{{Eqn. 2 \quad Eqn. 3 \quad Eqn. 4}}

The total power dissipation during normal mode is calculated by adding up the total quiescent current ($IQ_{BATP}$) plus the total load current calculated and multiply by the $V_{BATP}$ voltage. Note that $V_{BATP}$ is the battery voltage minus $\sim$1.0 V voltage drop caused by the reverse polarity protection diode, for practical purposes, voltage is assumed to be applied directly at $V_{BATP}$.

Example 3: Total power dissipation for Examples 1 and 2.

\[
\begin{align*}
I_{TOTAL} &= IQ_{BATP} + I_{LOAD} = 4.42\text{mA} + 164\text{mA} = 168.42\text{mA} \\
P_{TOTAL} &= I_{TOTAL} \times (V_{BATP}) = 168.42\text{mA} \times 12\text{V} = 2.0210\text{W}
\end{align*}
\]

\text{{Eqn. 5 \quad Eqn. 6}}

The MC33978 supports a $T_{JMAX} = 150^\circ\text{C}$ maximum operating temperature. Therefore package dissipation must be taken into consideration when designing the application, in order to ensure proper operation of device in worst case conditions required by the application.
3.2 LPM power calculations

There are many configurations directly affecting the current consumption of the MC33978 in Low-power mode (LPM). The following configurations are listed.

- Polling rate
- Slow polling
- Wake-up enable (Tristate / Untristate)
- Polling current level
- Comparator only

This section explains how each one of these features impact the current consumption during low-power operation, to be able to calculate the total current consumption in this mode.

3.2.1 Polling rate and slow polling

During LPM, the MC33978 turns off all internal supplies while it starts a polling cycle at the given polling rate, as shown in Figure 4. Such cycle is intended to bring the device to a “virtual active” mode for a small period of time (t\text{ACTIVEPOLL}) in which it checks the status of all enabled channels. If the status of all channels is the same as in the previous cycle, it takes no action and shuts the internal circuitry down and waits for the next cycle to check for any status change. If any of the input channels experience a change of status, this is detected in the following polling cycle, and the MC33978 returns to Normal mode and sets the INT_B pin and interrupt flag to announce a status change event has occurred to the MCU.

![Figure 4. Polling cycle](image)

During the OFF time, the device consumes an $I_{\text{BASE}} = 20 \mu A$ base current. However during the polling pulse, the device becomes virtually active and consumes an $I_{\text{POLL}} = 330 \mu A$ polling current for the duration of the polling pulse ($t_{\text{ACTIVEPOLL}} = 58 \mu s$). In the Low-power mode, the total quiescent current per channel is given by the average current during a complete polling period.

As the polling period is decreased, the polling pulse is more frequent and the OFF time is shorter, therefore, the average quiescent current is increased, as depicted in Figure 5.
The MC33978 has a master polling rate from 3.0 ms to 128 ms \( (t_{POLL}) \), which controls the base polling frequency for all input channels. A slow polling rate operation is selectable for each individual channel. By setting the corresponding bit on the slow polling register, the polling frequency will be four times slower, reducing the current used by that specific channel, thereby reducing overall power consumption. Note that reducing the polling rate, increments the latency time for switch detection, and therefore a proper analysis must be made to find the best balance between power consumption and switch detection latency for each specific application.

### 3.2.2 Wake-up enable

The MC33978 can disable each one of the channels from waking up during Low-power mode by writing a 0 (zero) in the wake-up enable bits. By disabling the wake-up function, the corresponding SG/SB circuit is not powered and is removed from the polling cycle, and thus not contributing to the total polling current.

If all channels are wake-up disabled, the polling circuit is turned off and the quiescent current of the device is the base current \( (I_{POLLINGQ} = 20 \, \mu A) \) during LPM. Be aware that no switch detection is possible during LPM, when all Wake-up channels are turned off.

During **Tristate** mode, the quiescent current due to an SG channel, is slightly different than the quiescent current of an SB channel. To simplify the current calculation provided by each wake-up enabled channel, use the following steps:

1. Calculate the overhead polling current
   
   a) The SG overhead current \( (I_{QSG}) \) is calculated as follows:

   \[
   I_{QSG} = I_{POLLINGQ} + \left( 3.5 \times I_{POLL} \times \frac{t_{ACTIVEPOLL}}{t_{POLL}} \right) \]

   \[\text{Eqn. 7}\]

   b) The SB overhead current \( (I_{QSB}) \) is calculated as follows:

   \[
   I_{QSB} = I_{POLLINGQ} + \left( 2.0 \times I_{POLL} \times \frac{t_{ACTIVEPOLL}}{t_{POLL}} \right) \]

   \[\text{Eqn. 8}\]

2. If at least one SG channel is Wake-up enabled, calculate the total quiescent current \( (I_{QLPM}) \) using the \( I_{QSG} \) overhead current as follows:

   \[
   I_{QLPM} = I_{QSG} + \left( I_{POLL} \times \frac{t_{ACTIVEPOLL}}{t_{POLL}} \times \frac{SG_{CH}}{22} + \frac{(1 + 0.021SB_{CH})}{8} \right) \]

   \[\text{Eqn. 9}\]

   - Where the \( SG_{CH} \) and \( SB_{CH} \) are the number of SG and SB channels enabled respectively.
3. If no SG channels are set to Wake-up enable, the total quiescent current ($I_{QLPM}$) would account only for the SB overhead current as well as the quiescent current per SB channel enabled, as is shown the following:

$$I_{QLPM} = I_{Q_{SB}} + \left(I_{POLL} \times \left(\frac{t_{ACTIVEPOLL}}{t_{POLL}}\right) \times \left(\frac{0.106SB_{CH}}{8}\right)\right)$$  \hspace{1cm} \text{Eqn. 10}

– Where SB_{CH} are the number of SB channels enabled.

Note that Equation 9 and Equation 10 consider only the quiescent current, due to enable channels in tristate condition and with no switch closed. These equations may be used to obtain the total LPM quiescent current, as long as there is one or more channels set to tristate.

In the scenario where all enabled channels are set to the untristate condition, the overhead current is the same for both SG and SB channels and is calculated as follows:

1. SG/SB Overhead current ($I_{QSX}$)

$$I_{QSX} = I_{POLLINGIQ} + \left(2.0 \times I_{POLL} \times \left(\frac{t_{ACTIVEPOLL}}{t_{POLL}}\right)\right)$$  \hspace{1cm} \text{Eqn. 11}

2. If at least one SG channel is Wake-up enabled, calculate the total quiescent current ($I_{QLPM}$) using the $I_{QSX}$ overhead current as follows:

$$I_{QLPM} = I_{QSX} + I_{POLL} \times \left(\frac{t_{ACTIVEPOLL}}{t_{POLL}}\right) \times \left(\frac{SG_{CH} + SB_{CH}}{22}\right)$$  \hspace{1cm} \text{Eqn. 12}

– Where the $SG_{CH}$ and $SB_{CH}$ are the number of SG and SB channels enabled respectively.

3. If no SG channels are set to Wake-up enable, the total quiescent current ($I_{IQ}$) would account only for the quiescent current per each SB channel enabled, as is shown below:

$$I_{QLPM} = I_{QSX} + I_{POLL} \times \left(\frac{t_{ACTIVEPOLL}}{t_{POLL}}\right) \times \left(\frac{SB_{CH}}{8}\right)$$  \hspace{1cm} \text{Eqn. 13}

– Where $SB_{CH}$ are the number of SB channels enabled

### 3.2.3 Low-power mode current level

The MC33978 wakes up from Low-power mode when it detects a change in the status of anyone of the switches. However for the switches that are normally closed or are meant to remain closed during Low-power mode, a close circuit active current must be accounted for during each one of the polling pulses. This current is consider a load current during the LPM operation.

The SG Channels use a default of 1.0 mA current level during the polling pulse, while the SB channels use a 2.2 mA current by default. Both, SG and SB channels can be programmed to use the wetting current level during the polling pulse by setting the polling current bits in the respective polling current configuration register. Likewise, the SB channels may be programmed to use the default (1200 μs) or a fast (58 μs) polling pulse width.

Use the following equations to calculate the overall load current during LPM, where $SG_{CLOSE}$ and $SB_{CLOSE}$ are the number of SG and SB channels in close condition respectively.

$$I_{LOAD[LPM]} = \frac{1mA \times SG_{CLOSE} \times t_{ACTIVEPOLLSG}}{t_{POLL}} + \frac{2.2mA \times SB_{CLOSE} \times t_{ACTIVEPOLLSB}}{t_{POLL}}$$  \hspace{1cm} \text{Eqn. 14}

The total Low-power mode current is given by the sum of the $I_{QLPM}$ + $I_{LOAD[LPM]}$. If an input channels is configue to use the programmed wetting current as the active current during the Low-power mode, replace the 1.0 mA/2.0 mA default current with the wetting current to calculate the load current for each channel programmed to operate with the wetting current in the Low-power mode.
### 3.2.4 Comparator only current calculation

The comparator only register allows the input comparators to be active during LPM with no polling current. In this case, the inputs can receive a digital signal on the order of the LPM clock cycle and wake-up on a change of state. In this operating mode, the switch detection threshold used is $V_{\text{ICTH_{2P5}}} = 2.5\, \text{V}$ and each channel configured in comparator only mode, adds up 2.5 $\mu$A to the Low-power mode quiescent current.

### 3.2.5 LPM power calculation example.

Using the steps outlined previously, the following is an example of the Low-power mode power calculation for the following application.

- $\text{VBATP} = 11\, \text{V}$
- Polling rate = 32 ms
- 10 x SG, LPM current = 1.0 mA, Wake-up Enable (Switch Normally open)
- 4 x SB, LPM current = $I_{\text{WET}} = 6.0\, \text{mA}$, Wake-up Enable (Switch Normally open)
- 2 x SG, Comparator Only mode.

Step 1. Calculate LPM Quiescent current (using Equation 11 and Equation 12 - all channels are untristated)

$$I_{QX} = I_{\text{BASE}} + \left(2.0 \times I_{\text{POL}} \times \frac{t_{\text{ACTIVEPOL}}}{{t_{\text{POL}}}}\right) = 20\, \mu\text{A} + \left(2.0 \times 330 \mu\text{A} \times \frac{58 \mu\text{s}}{32000 \mu\text{s}}\right) = 21.196\, \mu\text{A}$$

*Eqn. 15*

$$I_{QLPM} = I_{QX} + I_{\text{POL}} \times \frac{t_{\text{ACTIVEPOL}}}{t_{\text{POL}}} \times \left(\frac{SG_{\text{CH}}}{22} + \frac{SB_{\text{CH}}}{8}\right) = 21.1496\, \mu\text{A} + \left(330 \mu\text{A} \times \frac{58}{32000} \times \left(\frac{10}{22} + \frac{4}{8}\right)\right) = 21.720\, \mu\text{A}$$

*Eqn. 16*

Step 2. Add the quiescent current due to the channels configured as Comparator only

$$I_Q = I_{QLPM} + (2 \times 2.5\, \mu\text{A}) = 21.720\, \mu\text{A} + 5\, \mu\text{A} = 26.720\, \mu\text{A}$$

*Eqn. 17*

Step 3. Since all channels are normally opened, there is no load current to account for in this example.

Step 4. The total power dissipated in Low-power mode is given by:

$$P_{\text{TOTAL(LPM)}} = (I_{\text{LOAD}} + I_Q) \times (V_{\text{BATTERY}} - 1\, \text{V}) = (26.72\, \mu\text{A}) \times (12\, \text{V} - 1\, \text{V}) = 29.4\, \mu\text{W}$$

*Eqn. 18*
4 MC33978 real life power performance

This section is intended to show the real performance of the MC33978 compared to the calculated power consumption in one specific scenario. Furthermore, the MC33978 Current and Power Calculator tool is introduced as an easy way to estimate the overall system power used by the MC33978.

4.1 MC33978 current and power calculator

The MC33978 current and power calculator was created to simplify the process for estimating the total current and power used by the MC33978 device. The first section of the tool provides the current and power calculation from the specific configuration.

```
<table>
<thead>
<tr>
<th>Switch detect inputs</th>
<th>Continuous Wake</th>
<th>Wake Up enable</th>
<th>Comparator Only</th>
<th>LPBI Threshold</th>
<th>LPM current</th>
<th>Wetting current level</th>
<th>Slow Polling</th>
<th>Wake Desensitize</th>
<th>Interrupt En</th>
<th>Tristate</th>
<th>SP as SBI/SG</th>
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</tbody>
</table>

Figure 6. MC33978 current and power calculator

In the configuration section, each one of the channels can be programmed independently with all the available features of the MC33978.

Figure 7. Configuration section

As part of the configuration section, the device provides a summary of the operating polling rate and load current contribution from each one of the channels as well as the option to simulate the load current with a close or open switch condition.
Finally the main tab also provides the ability to reset, save, and load configurations for quick evaluation of various scenarios, along with the option to evaluate the device performance under the worst or typical conditions.

Figure 8. Polling and load current summary

As a secondary feature, the MC33978 current and power calculator provides a list with the calculated SPI words matching the configuration in the main tab.

Figure 9. Table functions
4.2 MC33978 performance

A specific scenario was defined and setup using the KIT33978EPEVB to demonstrate the accuracy of the MC33978 current and power calculator. Figure 11 shows the system configuration, as well as the connection diagram, to ensure proper measuring without taking any losses due to parasitics or pull-up connections not required for the MC33978 device.

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**Figure 10. Calculated SPI words configuration**

**Figure 11. KIT33978EPEVB schematic**
The MC33978 is to be programmed using the SPIGEN interface with the following configuration:

1. VBATTERY = 13 V, VBATP = 12 V
2. Polling Rate = 3.0 ms
3. SG0 - SG5 (6 channels)
   a) Wake-up Enable
   b) UNTRISTATE
   c) 6.0 mA Wetting current
   d) Continuous wetting current EN
   e) Normal polling level
4. SG6 - SG7 (2 Channel)
   a) Wake-up Enable
   b) UNTRISTATE
   c) 2.0 mA Wetting current
   d) Pulse wetting current
   e) Comp Only in LPM
5. SP0 - SP3 as SG (4 channels)
   a) Wake-up enable
   b) UNTRISTATE
   c) 16 mA Wetting current
   d) Pulse Wetting current
   e) Normal polling level
6. SP4-SP7 as SB (4 channels)
   a) Wake-up enable
   b) UNTRISTATE
   c) 16 mA Wetting current
   d) Pulse wetting current
   e) Normal polling level
7. SG8 - SG13 (6 channels)
   a) Wake-up Disabled
To program the previous configuration, the following SPI commands were set upon Power On Reset.

**Table 2. SPI Configuration**

<table>
<thead>
<tr>
<th>Register name</th>
<th>Operation</th>
<th>Register address</th>
<th>Data sent</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
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<td>Switch Status</td>
<td>Read</td>
<td>3E</td>
<td>0000FF</td>
<td>• Read Switch Status register</td>
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<td>Fault Status</td>
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<td>42</td>
<td>0000FF</td>
<td>• Read Fault status register</td>
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<td>LPM Configuration</td>
<td>Write</td>
<td>1F</td>
<td>000000</td>
<td>• Polling Rate = 3.0 ms</td>
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<td>• Interrupt Timer = OFF</td>
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<td>Device Configuration</td>
<td>Write</td>
<td>03</td>
<td>0008F0</td>
<td>• SBPOLL pulse = 1.2 ms</td>
</tr>
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<td></td>
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<td>• VBATOP = Enabled</td>
</tr>
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<td>• WAKE_B VDDQ check = no check</td>
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<td></td>
<td></td>
<td>• INT_B out = Level</td>
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<tr>
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<td>• ACONFIG = SPI control</td>
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<td></td>
<td></td>
<td>• SP7 - SP4 = SB channels</td>
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<td></td>
<td></td>
<td></td>
<td>• SP3 - SP0 = SG channel</td>
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<tr>
<td>Wetting Current Level SG Register 1</td>
<td>Write</td>
<td>0B</td>
<td>009249</td>
<td>• SG0 = 6.0 mA</td>
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<tr>
<td></td>
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<td></td>
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<td>• SG1 = 6.0 mA</td>
</tr>
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<td></td>
<td></td>
<td>• SG2 = 6.0 mA</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>• SG3 = 6.0 mA</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>• SG4 = 6.0 mA</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>• SG5 = 6.0 mA</td>
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<td></td>
<td></td>
<td></td>
<td>• SG6 = 2.0 mA</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>• SG7 = 2.0 mA</td>
</tr>
<tr>
<td>Wetting Current Level SP Register</td>
<td>Write</td>
<td>09</td>
<td>DB6DB6</td>
<td>• SP0 = 16 mA</td>
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<td></td>
<td></td>
<td>• SP1 = 16 mA</td>
</tr>
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<td></td>
<td></td>
<td>• SP2 = 16 mA</td>
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<td></td>
<td>• SP3 = 16 mA</td>
</tr>
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<td></td>
<td></td>
<td>• SP4 = 16 mA</td>
</tr>
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<td></td>
<td></td>
<td>• SP5 = 16 mA</td>
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<td>• SP6 = 16 mA</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>• SP7 = 16 mA</td>
</tr>
<tr>
<td>Wake up Enable SG</td>
<td>Write</td>
<td>23</td>
<td>0000FF</td>
<td>• SG0 - SG7 Enabled</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• SG8 - SG13 Disabled</td>
</tr>
<tr>
<td>Wake up Enable SP</td>
<td>Write</td>
<td>21</td>
<td>0000FF</td>
<td>• SP0 - SP7 Enabled</td>
</tr>
<tr>
<td>Comparator Only SG</td>
<td>Write</td>
<td>27</td>
<td>0000C0</td>
<td>• SG6 - SG7 Comp only Enabled</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>• All others disabled</td>
</tr>
<tr>
<td>Continuous Wetting current SG</td>
<td>Write</td>
<td>19</td>
<td>00003F</td>
<td>• SG0 - SG5 Cont. wetting current</td>
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<td></td>
<td></td>
<td></td>
<td>• SG6 - SG13 Pulse Wetting current</td>
</tr>
<tr>
<td>Continuous Wetting current SP</td>
<td>Write</td>
<td>17</td>
<td>000000</td>
<td>• SP0 - SP7 Pulse Wetting current</td>
</tr>
<tr>
<td>Tristate SG</td>
<td>Write</td>
<td>07</td>
<td>003F00</td>
<td>• SG0 - SG7 = Untristated</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>• SG8 - SG13 = Tristated</td>
</tr>
<tr>
<td>Tristate SP</td>
<td>Write</td>
<td>05</td>
<td>000000</td>
<td>• SP0 - SP7 = Untristated</td>
</tr>
</tbody>
</table>
Figure 12. MC33978 configuration with SPIGEN
Figure 13. MC33978 configuration with SPIGEN Prt.2
4.3 Comparing calculated vs. real data

Figure 14 through Figure 19 show the calculated and real data obtain from the configuration set in the previous section.

4.3.1 For the open switch condition

---

**MC33978 Current and Power Calculator**

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>Battery</strong></td>
<td>13.0 V</td>
</tr>
<tr>
<td><strong>VBATP (Bat - 1v)</strong></td>
<td>12.0 V</td>
</tr>
<tr>
<td><strong>VBATP normal mode</strong></td>
<td>5.7 mA</td>
</tr>
<tr>
<td><strong>Normal Mode total current</strong></td>
<td>5.7 mA</td>
</tr>
<tr>
<td><strong>Normal mode Power</strong></td>
<td>68.2 mW</td>
</tr>
</tbody>
</table>

---

![Figure 14. Calculated current consumption (all switches open)](image)

![Figure 15. Normal mode total current (all switches open)](image)

![Figure 16. Total low-power mode current (all switches open)](image)
4.3.2 Close switch condition

**MC33978 Current and Power Calculator**

<table>
<thead>
<tr>
<th>Battery</th>
<th>13.0 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>VBATP (Bat - 1v)</td>
<td>12.0 V</td>
</tr>
<tr>
<td>VBATP normal mode</td>
<td>5.7 mA</td>
</tr>
<tr>
<td>Normal Mode total current</td>
<td>61.7 mA</td>
</tr>
<tr>
<td>Normal mode Power</td>
<td>740.2 mW</td>
</tr>
</tbody>
</table>

Figure 17. Calculated current consumption (all switches closed)

![Current consumption display](image1)

Figure 18. Normal mode total current (all switches closed)

![Current consumption display](image2)

Figure 19. Total low-power mode current (all switches open)
5 Conclusion

The MC33978 provide a flexible solution for switch monitoring applications with a high energy efficiency compared to other solutions. Although the current and power estimation process may be somehow confusing and elaborated, NXP provides a simple and accurate way to simplify this process for the customer, including the important concepts behind the power utilization of the MC33978. Consequently, the customer can easily apply the formulas presented in this application note, saving time and effort when using the MC33978 current and power calculator to developing their application.
6 References

Following are URLs where you can obtain information on related NXP products and application solutions:

<table>
<thead>
<tr>
<th>Document Number and Description</th>
<th>URL</th>
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<table>
<thead>
<tr>
<th>Support Pages</th>
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<td>Power Management Home Page</td>
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<tr>
<td>Analog Home Page</td>
<td><a href="http://www.nxp.com/analog">http://www.nxp.com/analog</a></td>
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</table>
7 Revision history

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<th>Revision</th>
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<tr>
<td>1.0</td>
<td>3/2015</td>
<td>• Initial release</td>
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<tr>
<td></td>
<td>7/2016</td>
<td>• Updated to NXP document form and style</td>
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