

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 multiples 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

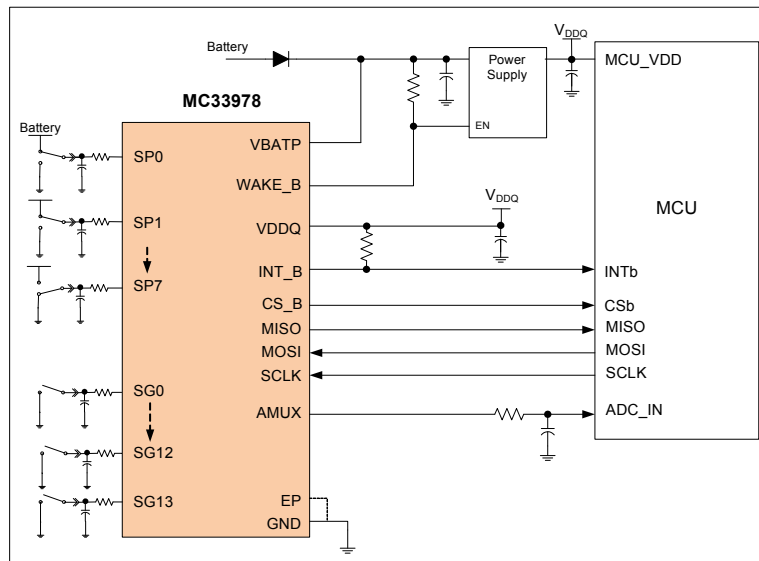


Figure 1. Block diagram

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

Setup	Condition	Quiescent current
Power on Reset (base current)	$V_{BATTERY} = 12\text{ V}$ All switches open SP channels configured as SB (default) ALL channel tristated	~2.5 mA
Tristate Disable	$V_{BATTERY} = 12\text{ V}$ All switches open SP channels configured as SB (default) All switches tristate disable	~7.25 mA
Tristate Disable with All channels as SG	$V_{BATTERY} = 12\text{ V}$ 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 μA per each SG channel enabled (untristated)
- Add ~300 μA per each channel configured as SB enabled (untristated)

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

$$I_{Q_{BATP}} = 2.5\text{mA} + (8 \times 165\mu\text{A}) + (2 \times 300\mu\text{A}) = 4.42\text{mA}$$

Eqn. 1

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](#).

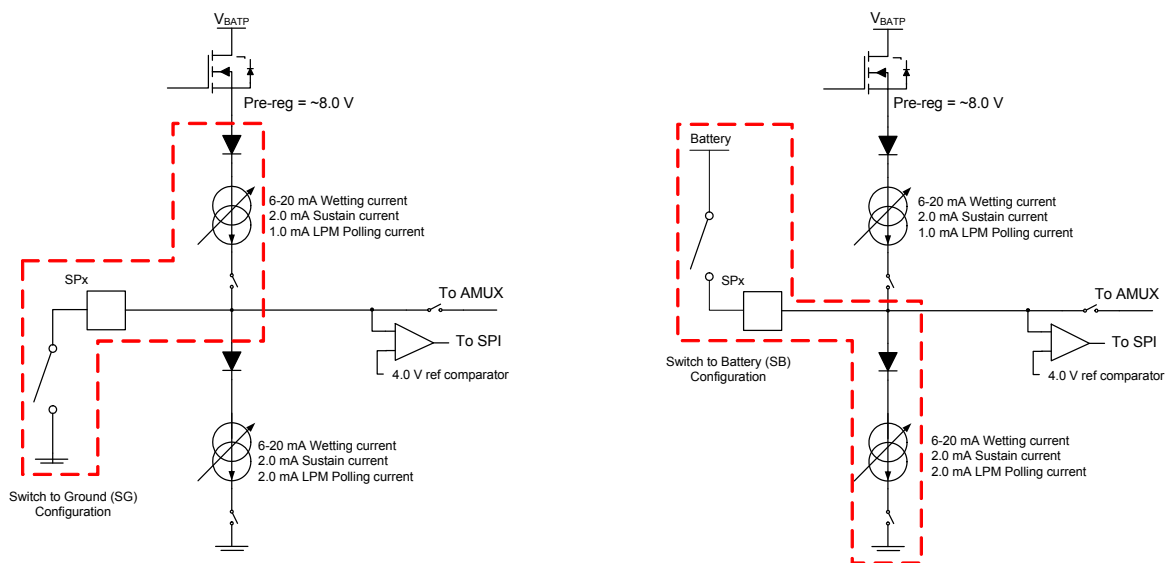


Figure 2. SG and SB configurations

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.

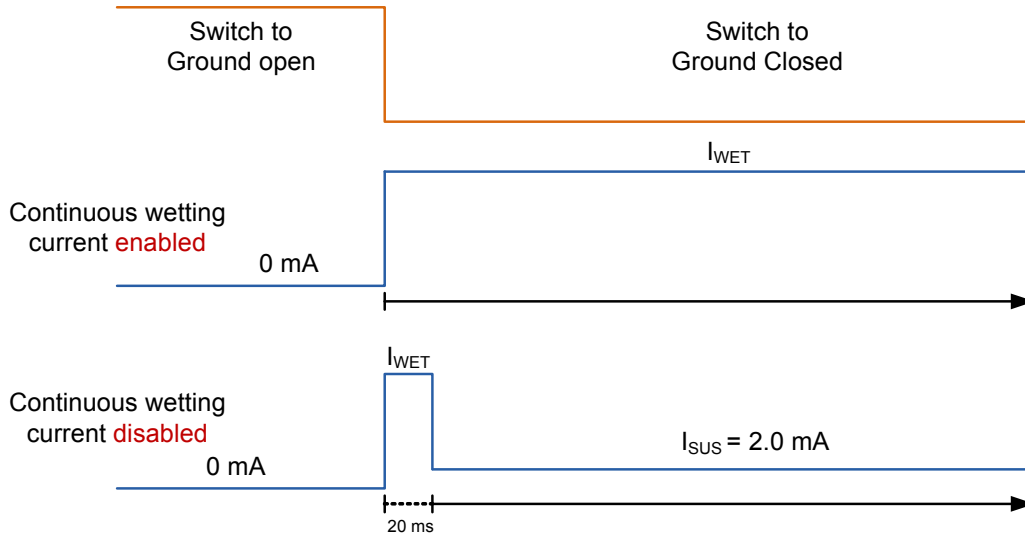


Figure 3. Switch to ground load current waveform

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 $I_{WETT} = 20\text{ mA}$.

$$I_{SG} = 8 \times 20\text{mA} = 160\text{mA} \tag{Eqn. 2}$$

$$I_{SB} = 2 \times 2\text{mA} = 4\text{mA} \tag{Eqn. 3}$$

$$I_{LOAD} = I_{SG} + I_{SB} = 164\text{mA} \tag{Eqn. 4}$$

The total power dissipation during normal mode is calculated by adding up the total quiescent current (I_{QBATP}) plus the total load current calculated and multiply by the V_{BATP} voltage. Note that V_{BATP} is the battery voltage minus ~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.

$$I_{TOTAL} = I_{QBATP} + I_{LOAD} = 4.42\text{mA} + 164\text{mA} = 168.42\text{mA} \tag{Eqn. 5}$$

$$P_{TOTAL} = I_{TOTAL} \times (V_{BATP}) = 168.42\text{mA} \times 12\text{V} = 2.0210\text{W} \tag{Eqn. 6}$$

The MC33978 supports a $T_{JMAX} = 150\text{ }^\circ\text{C}$ 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

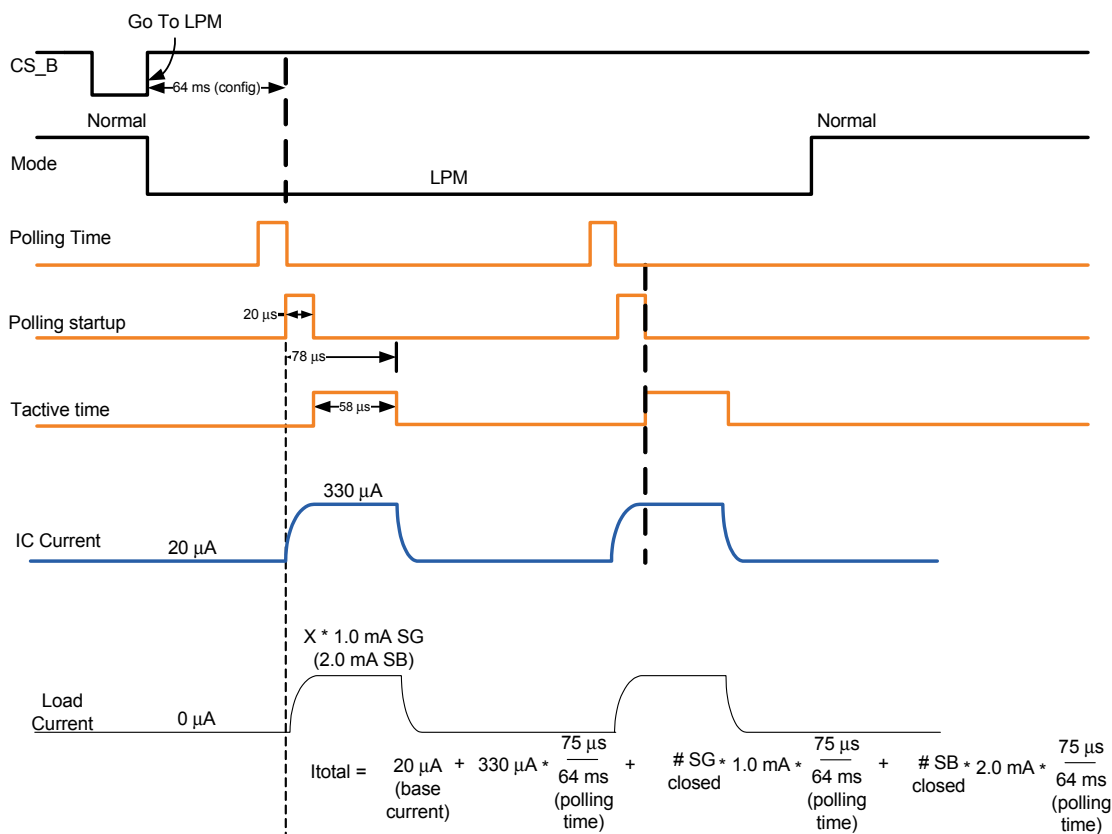
There are many configurations directly affecting the current consumption of the MC33978 in Low-power mode (LPM). The following configurations are listed.

- 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 ($t_{ACTIVEPOLL}$) 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.



During the OFF time, the device consumes an $I_{BASE} = 20 \mu\text{A}$ base current. However during the polling pulse, the device becomes virtually active and consumes an $I_{POLL} = 330 \mu\text{A}$ polling current for the duration of the polling pulse ($t_{ACTIVEPOLL} = 58 \mu\text{s}$). 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

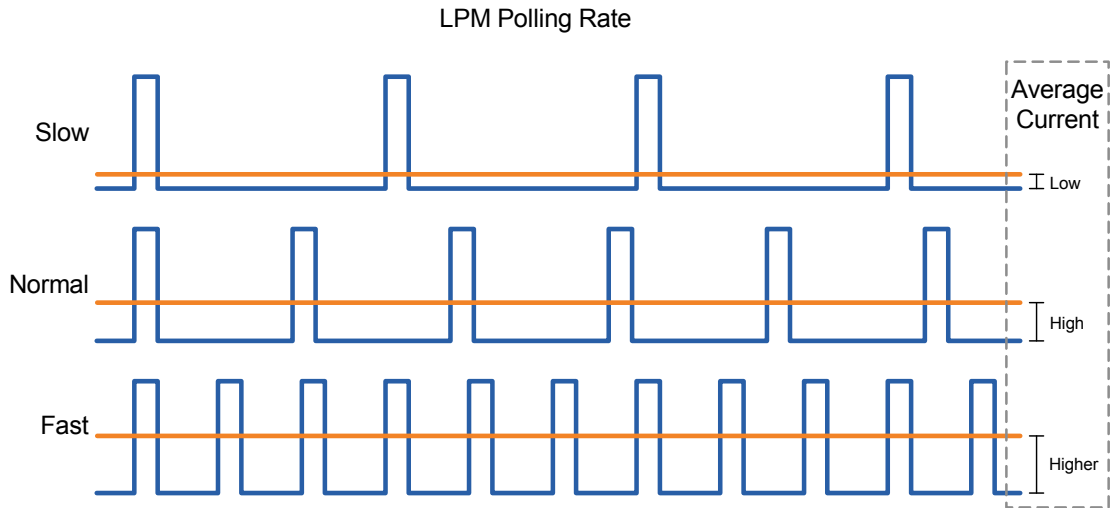


Figure 5. Polling current

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 ($I_{POLLINGIQ} = 20 \mu\text{A}$) during LPM. Be aware that no switch detection is possible during LPM, when all Wake-up channels are turned off. The Total quiescent current varies depending on the output state (tristated or untristated), as well as the type of channels (SG or SB).

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 ($I_{Q_{SG}}$) is calculated as follows:

$$I_{Q_{SG}} = I_{POLLINGIQ} + \left(3.5 \times I_{POLL} \times \left(\frac{t_{ACTIVEPOLL}}{t_{POLL}} \right) \right) \quad \text{Eqn. 7}$$

- b) The SB overhead current ($I_{Q_{SB}}$) is calculated as follows:

$$I_{Q_{SB}} = I_{POLLINGIQ} + \left(2.0 \times I_{POLL} \times \left(\frac{t_{ACTIVEPOLL}}{t_{POLL}} \right) \right) \quad \text{Eqn. 8}$$

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

$$I_{Q_{LPM}} = I_{Q_{SG}} + \left(I_{POLL} \times \left(\frac{t_{ACTIVEPOLL}}{t_{POLL}} \right) \times \left(\frac{SG_{CH}}{22} + \frac{(1 + 0.021 SB_{CH})}{8} \right) \right) \quad \text{Eqn. 9}$$

- 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 ($I_{Q_{LPM}}$) would account only for the SB overhead current as well as the quiescent current per SB channel enabled, as is shown the following:

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

- 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 ($I_{Q_{SX}}$)

$$I_{Q_{SX}} = I_{POLLINGIQ} + \left(2.0 \times I_{POLL} \times \left(\frac{t_{ACTIVEPOLL}}{t_{POLL}} \right) \right) \quad \text{Eqn. 11}$$

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

$$I_{Q_{LPM}} = I_{Q_{SX}} + I_{POLL} \times \left(\frac{t_{ACTIVEPOLL}}{t_{POLL}} \right) \times \left(\frac{SG_{CH}}{22} + \frac{SB_{CH}}{8} \right) \quad \text{Eqn. 12}$$

- 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_{Q}) would account only for the quiescent current per each SB channel enabled, as is shown below:

$$I_{Q_{LPM}} = I_{Q_{SX}} + I_{POLL} \times \left(\frac{t_{ACTIVEPOLL}}{t_{POLL}} \right) \times \left(\frac{SB_{CH}}{8} \right) \quad \text{Eqn. 13}$$

- 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 μ s) or a fast (58 μ s) 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.

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

The total Low-power mode current is given by the sum of the $I_{Q_{LPM}} + I_{LOAD[LPM]}$. If an input channels is configure 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 $V_{ICTH2P5} = 2.5 \text{ V}$ and each channel configured in comparator only mode, adds up $2.5 \mu\text{A}$ 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.

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

$$I_{QSX} = I_{BASE} + \left(2.0 \times I_{POLL} \times \left(\frac{t_{ACTIVEPOLL}}{t_{POLL}} \right) \right) = 20\mu\text{A} + \left(2.0 \times 330\mu\text{A} \times \frac{58\mu\text{s}}{32000\mu\text{s}} \right) = 21.196\mu\text{A} \quad \text{Eqn. 15}$$

$$I_{QLPM} = I_{QSX} + I_{POLL} \times \left(\frac{t_{ACTIVEPOLL}}{t_{POLL}} \right) \times \left(\frac{SG_{CH}}{22} + \frac{SB_{CH}}{8} \right) = 21.1496\mu\text{A} + \left(330\mu\text{A} \times \frac{58}{32000} \times \left(\frac{10}{22} + \frac{4}{8} \right) \right) = 21.720\mu\text{A} \quad \text{Eqn. 16}$$

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

$$I_Q = I_{QLPM} + (2 \times 2.5\mu\text{A}) = 21.720\mu\text{A} + 5\mu\text{A} = 26.720\mu\text{A} \quad \text{Eqn. 17}$$

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:

$$P_{TOTAL(LPM)} = (I_{LOAD} + I_Q) \times (V_{BATTERY} - 1\text{V}) = (26.72\mu\text{A}) \times (12\text{V} - 1\text{V}) = 29.4\mu\text{W} \quad \text{Eqn. 18}$$

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.

MC33978 Current and Power Calculator

Battery	13.0 V	Polling Time	3.0 ms	Polling times	
VBATP (Bat - 1v)	12.0 V	IVBATP LPM	39.4 μ A	Polling Pulse SG	58.0 μ s
IVBATP normal mode	5.7 mA	Total Load current	5.2 μ A	Polling Pulse SB	1200.0 μ s
Normal Mode total current	5.7 mA	Total LPM current	44.6 μ A		
Normal mode Power	68.2 mW				

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.

Switch detect inputs	Continuous Wet	Wake Up enable	Comparator Only	LPM Threshold	LPM current	Wetting current level	Slow Polling	Wake Debounce	Interrupt En	Tristate	SP as SB/SG
SG0	Yes	Yes	No	Normal	Default	6.0 mA	No	No	Yes	Untristate	
SG1	Yes	Yes	No	Normal	Default	6.0 mA	No	No	Yes	Untristate	
SG2	Yes	Yes	No	Normal	Default	6.0 mA	No	No	Yes	Untristate	
SG3	Yes	Yes	No	Normal	Default	6.0 mA	No	No	Yes	Untristate	
SG4	Yes	Yes	No	Normal	Default	6.0 mA	No	No	Yes	Untristate	
SG5	Yes	Yes	No	Normal	Default	6.0 mA	No	No	Yes	Untristate	
SG6	No	Yes	Yes	Normal	Default	2.0 mA	No	No	Yes	Untristate	
SG7	No	Yes	Yes	Normal	Default	2.0 mA	No	No	Yes	Untristate	
SG8	No	No	No	Normal	Default	10.0 mA	No	No	Yes	Tristate	
SG9	No	No	No	Normal	Default	10.0 mA	No	No	Yes	Tristate	
SG10	No	No	No	Normal	Default	10.0 mA	No	No	Yes	Tristate	
SG11	No	No	No	Normal	Default	10.0 mA	No	No	Yes	Tristate	
SG12	No	No	No	Normal	Default	10.0 mA	No	No	Yes	Tristate	
SG13	No	No	No	Normal	Default	10.0 mA	No	No	Yes	Tristate	
SP0	No	Yes	No	Normal	Default	16.0 mA	No	No	Yes	Untristate	SG
SP1	No	Yes	No	Normal	Default	16.0 mA	No	No	Yes	Untristate	SG
SP2	No	Yes	No	Normal	Default	16.0 mA	No	No	Yes	Untristate	SG
SP3	No	Yes	No	Normal	Default	16.0 mA	No	No	Yes	Untristate	SG
SP4	No	Yes	No	Normal	Default	16.0 mA	No	No	Yes	Untristate	SB
SP5	No	Yes	No	Normal	Default	16.0 mA	No	No	Yes	Untristate	SB
SP6	No	Yes	No	Normal	Default	16.0 mA	No	No	Yes	Untristate	SB
SP7	No	Yes	No	Normal	Default	16.0 mA	No	No	Yes	Untristate	SB
Global setups	No	No	No	Normal	Default	10.0 mA	No	No	Yes	Tristate	SG
	Set	Set	Set	Set	Set	Set	Set	Set	Set	Set	Set

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.

SPI Words	Read word	Write word	
SPI check	0x00000000		
Device Configuration	0x020000F0	0x030000F0	Device config setup
Tri-State Enable SP	0x04000000	0x05000000	VBATP OV disable
Tri-State Enable SG	0x06003F00	0x07003F00	WAKE_B VDDQ check
WettingCurrentLevel SP	0x08DB6DB6	0x09DB6DB6	INT_B Output
WettingCurrentLevel0 SG	0x0A009249	0x0B009249	AMUX Config
WettingCurrentLevel1 SG	0x0C01B6DB	0x0D01B6DB	SP Config (on main page)
Continuous Wetting current Enable SP	0x16000000	0x17000000	
Continuous Wetting Current Enable SG	0x1800003F	0x1900003F	
InterruptEnable SP	0x1A0000FF	0x1B0000FF	
InterruptEnable SG	0x1C003FFF	0x1D003FFF	
Low Power Mode configuration	0x1E000020	0x1F000020	Interrupt timer
WakeUpEnable SP	0x200000FF	0x210000FF	
WakeUpEnable SG	0x220000FF	0x230000FF	
LPM Comparator Only SP	0x24000000	0x25000000	
LPM Comparator Only SG	0x260000C0	0x270000C0	
LPM Threshold SP	0x280000FF	0x290000FF	
LPM Threshold SG	0x2A003FFF	0x2B003FFF	
LPM Polling Current config SP	0x2C000000	0x2D000000	
LPM Polling current config SG	0x2E000000	0x2F000000	
LPM Slow Polling SP	0x30000000	0x31000000	
LPM Slow Polling SG	0x32000000	0x33000000	
WakeUpDebounce SP	0x34000000	0x35000000	
WakeUpDebounce SG	0x36000000	0x37000000	
Enter Low Power Mode		0x39000000	
AMUX Channel Select SPI	0x3A000001	0x3B000001	AMUX select
Read Switch Status	0x3E000000		AMUX Setting
Fault Status	0x42000000		
Interrupt Pulse Request		0x47000000	
Reset (logic regs goto default state)		0x49000000	

Figure 10. Calculated SPI words configuration

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.

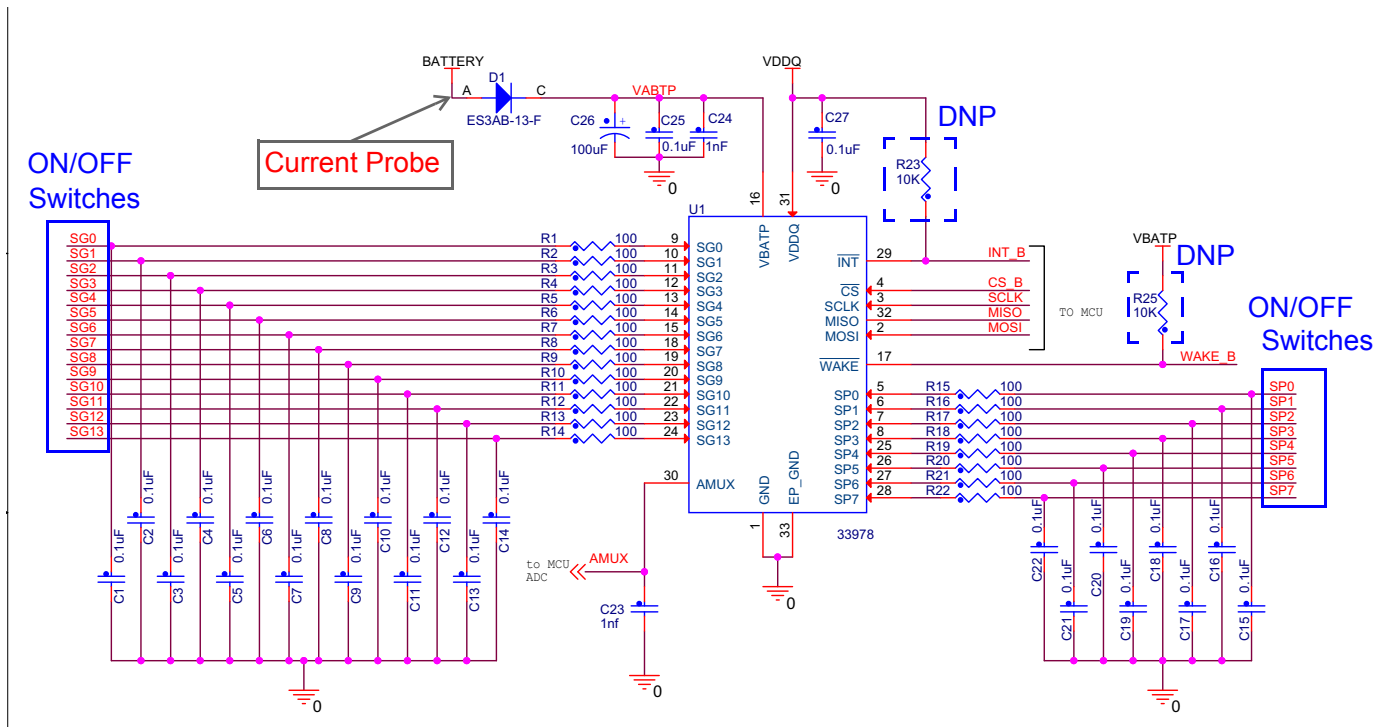


Figure 11. KIT33978EPEVB schematic

MC33978 real life power performance

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

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

Low Power Mode Configuration

Write

Int 3	Int 2	Int 1	Int 0	poll 3	poll 2	poll 1	poll 0
-------	-------	-------	-------	--------	--------	--------	--------

Polling Time (ms)

Device Configuration Register

Write

SBPOLL TIME	VBATP OV Disable	WAKE_B VDDQ Check	INT_B Out	A CONFIG 1	A CONFIG 0	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0
-------------	------------------	-------------------	-----------	------------	------------	-----	-----	-----	-----	-----	-----	-----	-----

Wetting Current Level 0 Register SG
Default = 16mA (110 highlighted)

Read

SG5 Bit 0	SG4 Bit 2	SG4 Bit 1	SG4 Bit 0	SG3 Bit 2	SG3 Bit 1	SG3 Bit 0	SG2 Bit 2	SG2 Bit 1	SG2 Bit 0	SG1 Bit 2	SG1 Bit 1	SG1 Bit 0	SG0 Bit 2	SG0 Bit 1	SG0 Bit 0
-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------

SG7 Current SG6 Current SG5 Current SG4 Current SG3 Current SG2 Current SG1 Current SG0 Current

Wetting Current Level SP
Default = 16mA (110 highlighted)

Read

SP5 Bit 0	SP4 Bit 2	SP4 Bit 1	SP4 Bit 0	SP3 Bit 2	SP3 Bit 1	SP3 Bit 0	SP2 Bit 2	SP2 Bit 1	SP2 Bit 0	SP1 Bit 2	SP1 Bit 1	SP1 Bit 0	SP0 Bit 2	SP0 Bit 1	SP0 Bit 0
-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------

SP7 Current SP6 Current SP5 Current SP4 Current SP3 Current SP2 Current SP1 Current SP0 Current

SG Continuous Wetting Current Enable Register (Clear to disable, highlighted blue to enable)

Read Default = Pulsed (clear)

SG13	SG12	SG11	SG10	SG9	SG8	SG7	SG6	SG5	SG4	SG3	SG2	SG1	SG0
------	------	------	------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Figure 12. MC33978 configuration with SPIGEN

SP Continuous Wetting Current Enable Register (Clear to disable, highlighted blue to enable)

Read Write Default = Pulsed (clear) Enable All Bits Clear Bits

> Seq

SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0
-----	-----	-----	-----	-----	-----	-----	-----

SG Wake Up Register (Clear to not allow SG to wake IC, highlighted blue to enable wake up)

Default = Enabled (highlighted)

Read Write Enable All Bits Clear Bits

> Seq

SG13	SG12	SG11	SG10	SG9	SG8	SG7	SG6	SG5	SG4	SG3	SG2	SG1	SG0
------	------	------	------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

SP Wake Up Register (Clear to not allow SG to wake IC, highlighted blue to enable wake up)

Default = Enabled (highlighted)

Read Write Enable All Bits Clear Bits

> Seq

SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0
-----	-----	-----	-----	-----	-----	-----	-----

SG LPM Comparator Only Register (Clear to disable, highlighted blue to enable)

Read Write Default = Disabled (clear) Enable All Bits Clear Bits

> Seq

SG13	SG12	SG11	SG10	SG9	SG8	SG7	SG6	SG5	SG4	SG3	SG2	SG1	SG0
------	------	------	------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

SG Tristate Register (Clear to untristate, highlighted blue to tristate)

Default = tristated (highlighted)

Read Write Enable All Bits Clear Bits

> Seq

SG13	SG12	SG11	SG10	SG9	SG8	SG7	SG6	SG5	SG4	SG3	SG2	SG1	SG0
------	------	------	------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

SP Tristate Register (Clear to untristate, highlight blue to tristate)

Read Write Default = Tristate (highlighted) Enable All Bits Clear Bits

> Seq

SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0
-----	-----	-----	-----	-----	-----	-----	-----

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

Battery	13.0 V	Polling Time	3.0 ms
VBATP (Bat - 1v)	12.0 V	IVBATP LPM	39.4 μ A
IVBATP normal mode	5.7 mA	Total Load current	5.2 μ A
Normal Mode total current	5.7 mA	Total LPM current	44.6 μ A
Normal mode Power	68.2 mW		

Figure 14. Calculated current consumption (all switches open)

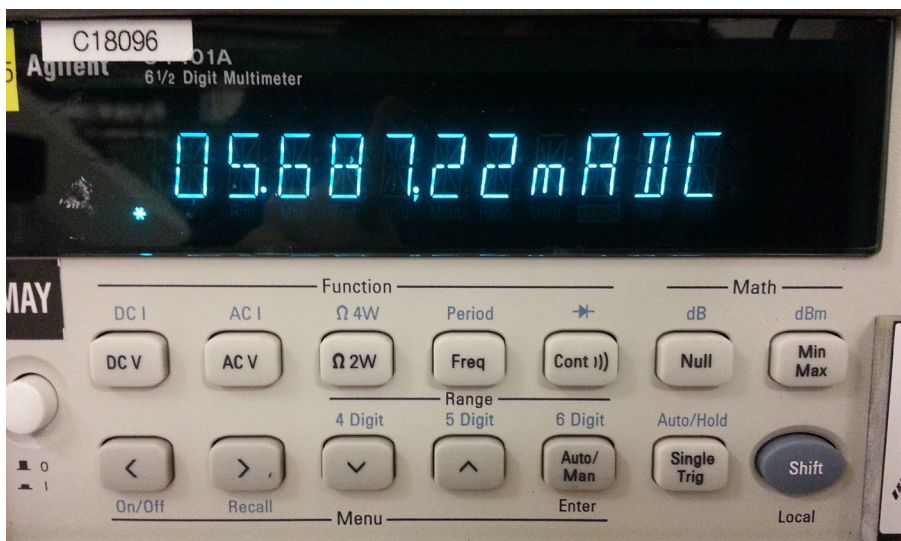


Figure 15. Normal mode total current (all switches open)

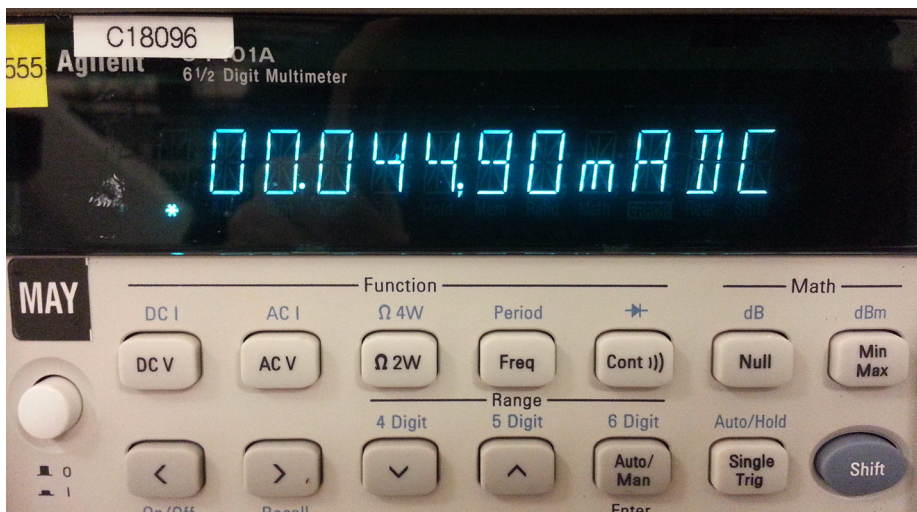


Figure 16. Total low-power mode current (all switches open)

4.3.2 Close switch condition

MC33978 Current and Power Calculator

Battery	13.0 V	Polling Time	3.0ms
VBATP (Bat - 1v)	12.0 V	IVBATP LPM	39.4 μ A
IVBATP normal mode	5.7 mA	Total Load current	3398.4 μ A
Normal Mode total current	61.7 mA	Total LPM current	3437.8 μ A
Normal mode Power	740.2 mW		

Figure 17. Calculated current consumption (all switches closed)

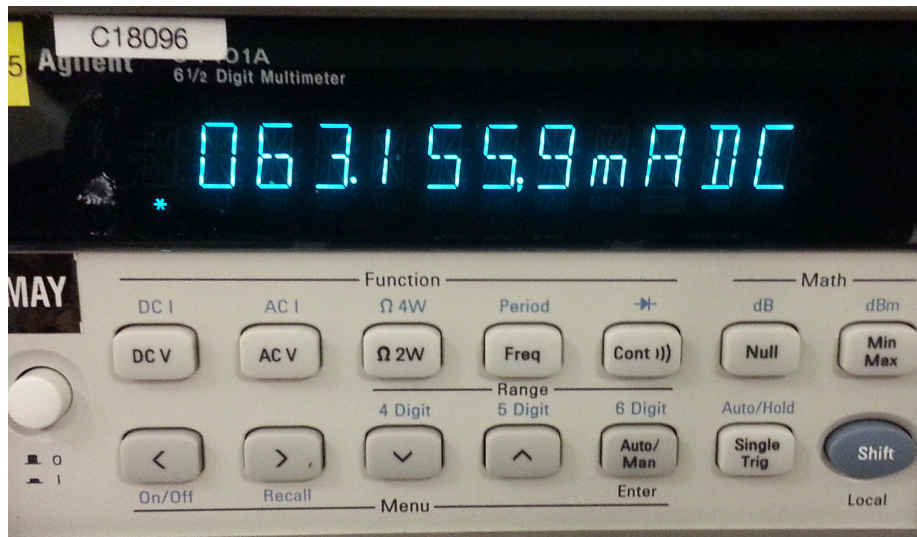


Figure 18. Normal mode total current (all switches closed)

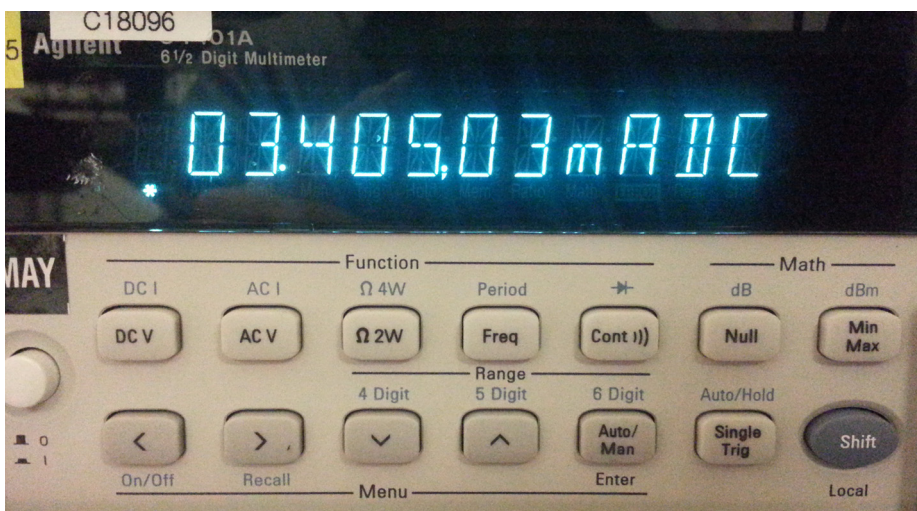


Figure 19. Total low-power mode current (all switches open)

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:

Document Number and Description		URL
MC33978	Data Sheet	www.nxp.com/files/analog/doc/data_sheet/MC33978.pdf
KIT33978UG	User Guide	http://www.nxp.com/files/analog/doc/user_guide/KT33978UG.pdf
Support Pages		URL
MC33978 Product Summary Page		http://www.nxp.com/webapp/sps/site/prod_summary.jsp?code=MC33978
Power Management Home Page		http://www.nxp.com/PMIC
Analog Home Page		http://www.nxp.com/analog

7 Revision history

Revision	Date	Description
1.0	3/2015	<ul style="list-style-type: none">• Initial release
	7/2016	<ul style="list-style-type: none">• Updated to NXP document form and style

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