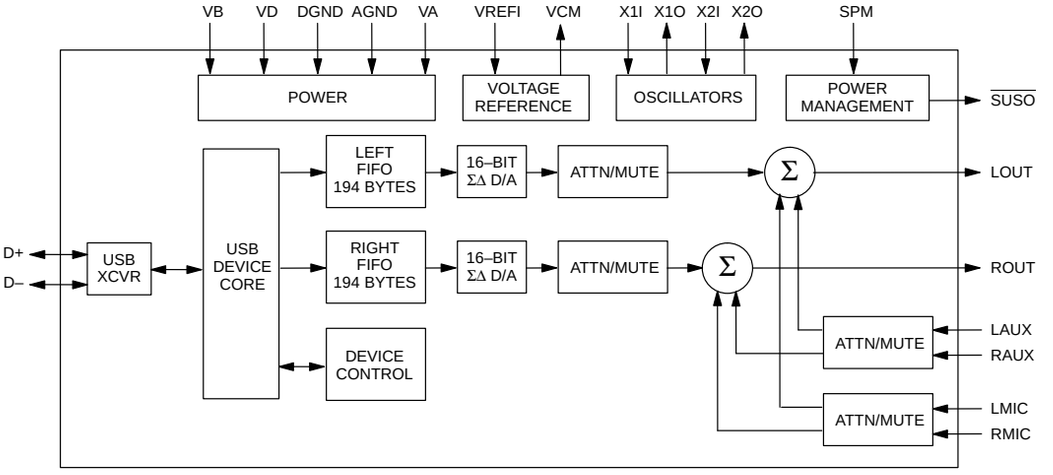
DALLAS SEMICONDUCTOR

# Application Note 111
## Power Options and Management with the DS4201

### OVERVIEW
The DS4201 combines multiple power inputs and power management modes to provide several power related design options for a USB digital audio system. As shown in Figure 1, the DS4201 has three separate power inputs and an I/O block for power management modes. Discussed in this application note are various DS4201 power configurations that support 3.3V – 5V operation and power management features that can be used to control power consumption of both the DS4201 and external audio system circuitry.

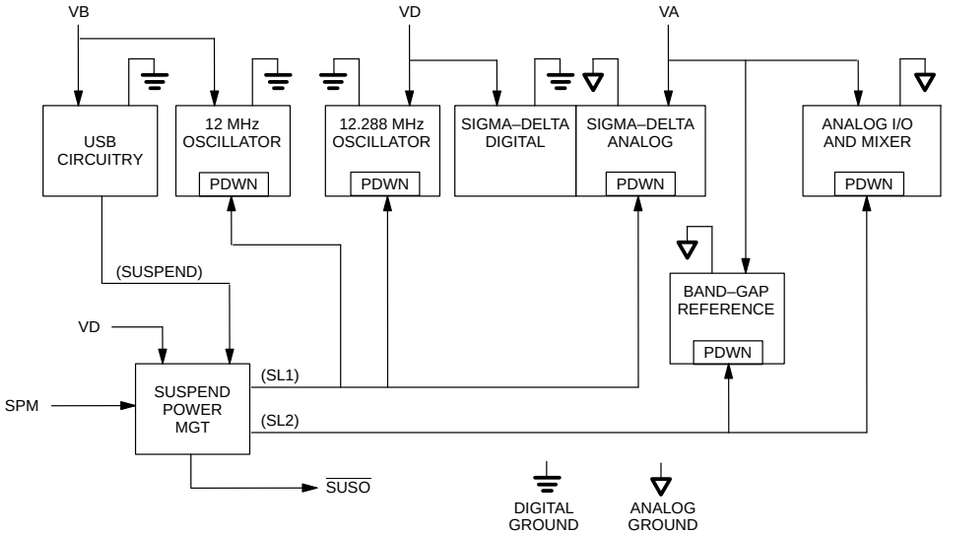
### RELATED DOCUMENTS
This application note references or summarizes requirements from the Universal Serial Bus Specification and the DS4201 USB AUDIO DAC data sheet. Copies of the USB specification may be obtained from the USB Implementers Forum web site at www.usb.org, contact Dallas Semiconductor or visit out web site at www.dalsemi.com for DS4201 product information.

**DS4201 BLOCK DIAGRAM** Figure 1




### POWER DISTRIBUTION AND CONTROL
Shown in Figure 2 is a simplified diagram of power distribution and control in the DS4201. As shown, three inputs exist to supply power to the mixed signal circuitry of the DS4201. USB circuitry consisting of the USB device core, 12 MHz oscillator, FIFOs, and device specific control logic are powered from the 3.3V VB input. The sigma–delta digital circuits, 12.288 MHz oscillator, and power management circuits are powered from the 3.3V/5V VD input. The sigma–delta analog circuits, analog I/O and mixer, and voltage reference circuits are powered from the 3.3V/5V VA input. Single, dual, or triple supply configurations are possible with 3.3V and 5V variations as listed in Table 1.

**POWER DISTRIBUTION AND MANAGEMENT** Figure 2




Power management in the DS4201 is controlled by the state of USB and the SPM (suspend power mode) input signal. The DS4201 was designed with the assumption that while the USB connection is active the device should be fully powered and ready to accept/convert digital audio data and during USB suspend conditions the device should provide capabilities to reduce internal and external circuit power consumption. As shown in Figure 2, power to several circuit blocks is controlled by management circuitry as a function of USB suspend and the SPM input. In addition, the suspend state is provided as an output signal to allow control of external audio system circuitry. Details of power application options and power management are addressed in the remainder of this application note.

**DS4201 RECOMMENDED DC OPERATING CONDITIONS** Table 1

| PARAMETER | SYMBOL | RANGE | NOTE |
|---|---|---|---|
| Analog Supply Voltage, 3.3V Operation | VA | 3.3V ± 10% | 1 |
| Analog Supply Voltage, 5V Operation | VA | 5.0V ± 10% | 1 |
| Digital Supply Voltage, 3.3V Operation | VD | 3.3V ± 10% | 1 |
| Digital Supply Voltage, 5V Operation | VD | 5.0V ± 10% | 1 |
| USB I/F Supply Voltage | VB | 3.3V ± 10% | |

**NOTES:**

1. Maximum allowable VA to VD differential is ±0.2V.

## POWER OPTIONS

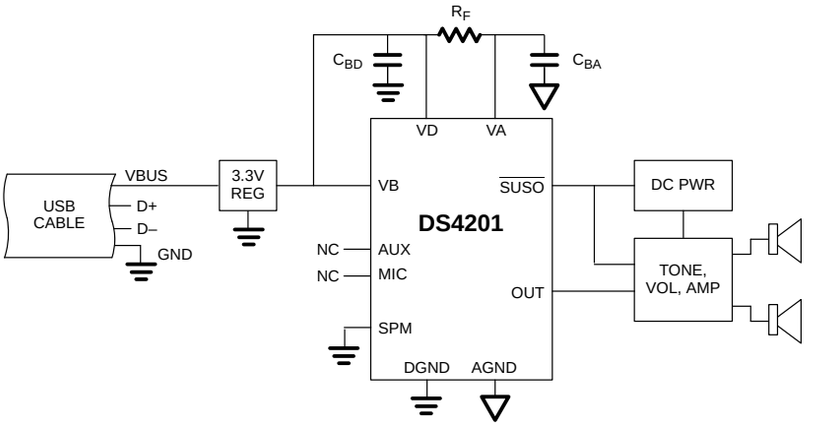
The options and variations for single, dual, or triple power supply configurations with the DS4201 are described in the following paragraphs. Connection and component details in the figures for each configuration have been purposefully omitted for clarity.

### Single Supply

Shown in Figure 3 is an example of the single supply configuration in which all three DS4201 power inputs are sourced from a single power supply. The allowable range of VB, see Table 1, requires that for this configuration the entire device be powered from 3.3V (nom). In this example the 3.3V power source is provided from regulated USB VBUS power which has a range of 4.40V – 5.25V at the device end of the USB cable. Also, the analog supply (VA) in the example is isolated from the digital supplies with some low pass filtering to reduce high frequency supply noise. In the figure, capacitor $C_{BD}$ represents the combined decoupling capacitance for the digital supplies, and resistor $R_F$ and capacitor $C_{BA}$ comprise the low pass filter used to isolate the digital and analog supplies. See the DS4201 data sheet for recommended component values.

A critical consideration for this configuration is USB power consumption. Table 2 lists USB device current requirements per the USB 1.0 core specification. As listed, when a USB device enters the suspend state, USB current consumption must be less than 500 µA. For all other states consumption is limited to 100 mA (or 500 mA for high–powered devices). To achieve the 500 µA suspend state level, the DS4201 SPM input must be logic low as shown in Figure 3. With the single supply configuration, SPM low, and the device suspended, the DS4201 will draw less than 100 µA. Note also in Figure 3 that the AUX and MIC analog inputs are not used in the single supply configuration. This is due to the low power mode the DS4201 enters in this configuration and is described in more detail in the Power Management section of this application note.

**SINGLE SUPPLY, USB BUS POWERED CONFIGURATION** Figure 3



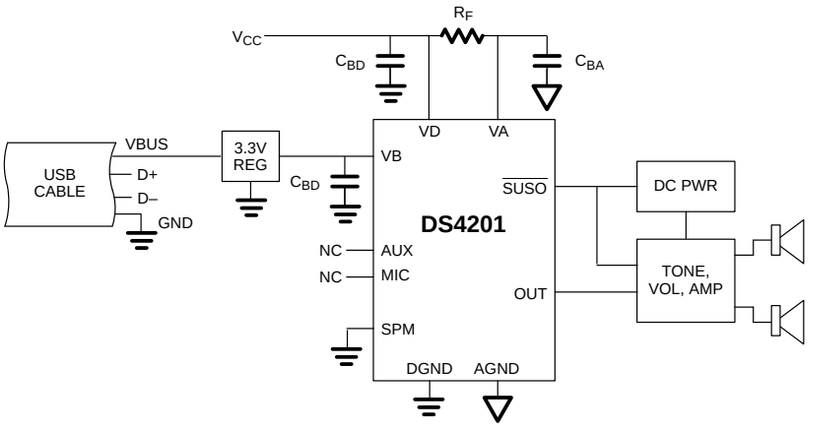

**USB DEVICE CURRENT SPECIFICATIONS** Table 2

| USB DEVICE STATE | MAX VBUS CURRENT |
|---|---|
| SUSPENDED | 500 µA |
| UNCONFIGURED | 100 mA |
| CONFIGURED – LOW POWER DEVICE | 100 mA |
| CONFIGURED – HIGH POWER DEVICE | 500 mA |

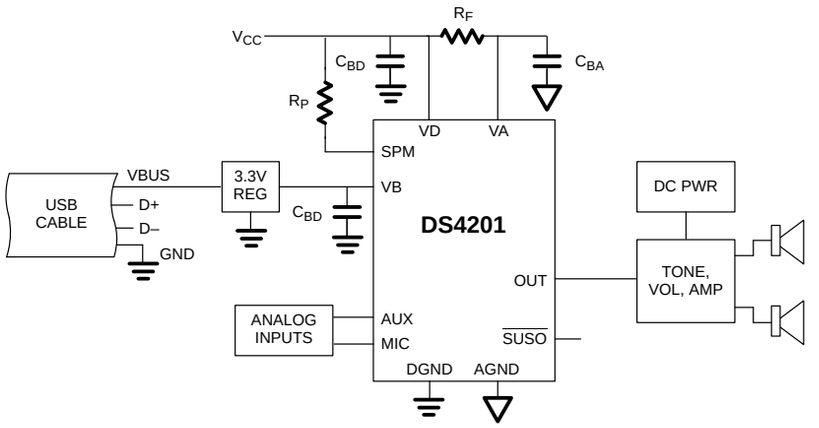
## Dual Supply

Shown in Figure 4a and 4b are an examples of the dual supply configuration in which USB power and an external source are used to power the DS4201. The VB power is derived from 3.3V regulated USB power and the digital (VD) and analog (VA) power are supplied from a separate $V_{CC}$ source at either 3.3V or 5V. As in the single supply example, VA is the low pass filtered version of VD to reduce high frequency supply noise. In the figures, capacitor $C_{BD}$ represents the combined decoupling capacitance for the digital supplies, resistor RF and capacitor $C_{BA}$ comprise the low pass filter used to isolate the digital and analog supplies, and resistor $R_P$ is a pull–up for the SPM input. See the DS4201 data sheet for recommended component values.

**DUAL SUPPLY CONFIGURATION, SPM=0** Figure 4a



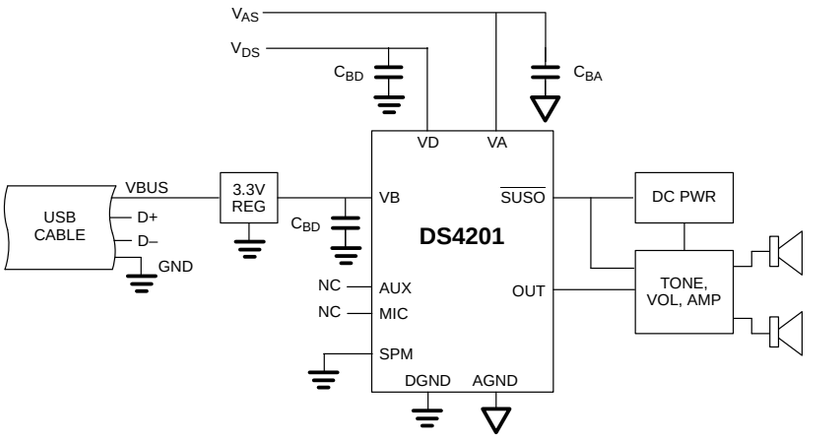

**DUAL SUPPLY CONFIGURATION, SPM=1** Figure 4b



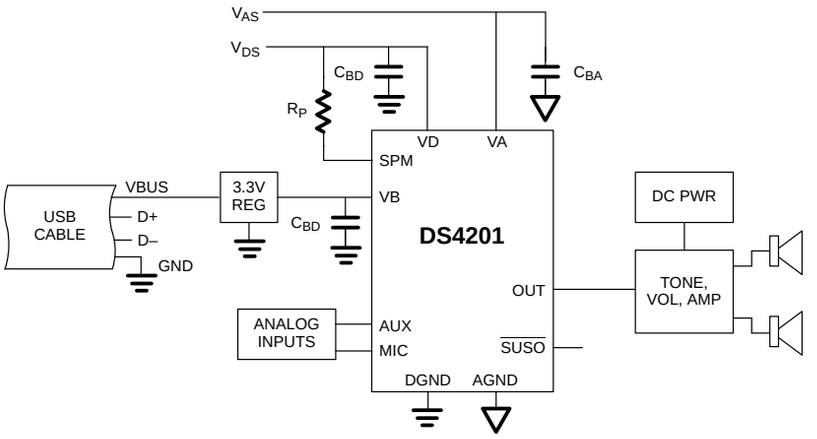
### Triple Supply

Shown in Figure 5 is an example of a triple supply configuration where each power input is sourced independently. Again, VB power is derived from 3.3V regulated USB power but the analog and digital power inputs are supplied from separate sources. This configuration can provide the advantage of an isolated low noise analog supply which will provide optimal DS4201 dynamic range performance. Although VA and VD are supplied from separate sources for this configuration, they must not differ by more than ±200 mV as noted in Table 1. In the figures, capacitor $C_{BD}$ and $C_{BA}$ represent the combined decoupling capacitance for the digital and analog supplies and resistor $R_P$ is a pull–up for the SPM input. See the DS4201 data sheet for recommended component values.

**TRIPLE SUPPLY CONFIGURATION, SPM=0** Figure 5a




**TRIPLE SUPPLY CONFIGURATION, SPM=1** Figure 5b



## POWER MANAGEMENT

Power management features of the DS4201, both automatic and configurable, are linked to the USB suspend state. Suspend is a defined USB device state upon which devices consuming USB power are required to reduce consumption to 500 μA or less. In addition, power friendly devices or functions will typically reduce or eliminate consumption of externally provided power during suspend. Devices must enter the suspend state when there has been an absence of bus activity for 3 ms. A device transitions from the suspend state to its previous state, presumably configured, within 20 ms of detected bus activity.

When the DS4201 enters the suspend state, the USB core circuit circuitry automatically enters into a low power mode with VB current consumption reduced to less than 50 μA. As shown in Figure 2, two levels of control are used by power management circuitry to disable circuit blocks when the suspend state is entered. Suspend level 1 (SL1) is automatically activated when transitioning to the suspend state and it is used to power down the two device oscillators and sigma–delta analog circuitry. Suspend level 2 (SL2) is controlled by both the suspend state and the suspend power mode (SPM) input signal. If SPM is high when transitioning to suspend, the SL2 output remains at a level which allows the band–gap, analog I/O, and mixer to remain operational. If SPM is low when transitioning to suspend, the SL2 output disables these circuit blocks. Additionally, the DS4201 suspend output signal ($\overline{SUSO}$) is driven low during the suspend state. As shown in Figures 4a and 5a, this signal could be used stand–alone or combined with other external signals to disable circuitry external to the DS4201, amplifiers, power sources, etc., to manage audio system power consumption during periods of inactivity. The $\overline{SUSO}$ signal is an open drain output and requires an external pull–up to a positive supply no greater than 6.0V

### SPM=0 Configuration

When SPM is logic low and the USB suspend state is entered, the DS4201 oscillators, sigma–delta analog, band–gap reference, analog I/O, and mixer circuitry are disabled. With the oscillators off, USB and sigma–delta digital circuitry are put into a low power CMOS static state. This combined with disabled analog circuitry significantly reduces IA, IB, and ID levels. In fact, in this state the sum of IA, IB, and ID is low enough to allow the entire device to be powered from regulated USB in this mode. The examples in Figures 1, 4a, and 5a show possible SPM=0 configurations. Note that in these three figures the AUX and MIC analog inputs are unused. This is the recommended configuration since the analog I/O path will be disabled if/when the device enters the suspend state. See the DS4201 data sheet for actual current consumption levels.

### SPM=1 Configuration

When SPM is logic high and the suspend state is entered, the DS4201 oscillators and sigma–delta analog circuitry are powered down. With the oscillators off, the USB device core and sigma–delta digital circuitry enter into a low power CMOS static state. In this mode IB and ID levels are significantly reduced. The analog I/O, mixer, and voltage reference circuit blocks remain active in this mode for continuous operation of external analog audio sources. Therefore the IA level remains nearly equal to the non–suspended USB state with a slight reduction due to the inactive sigma–delta analog circuitry. Figures 4b and 5b show possible SPM=1 configurations. See the DS4201 data sheet for actual current consumption levels.