

I²C Procedure For 5.1 Applications Using the DDX-8001

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1. Introduction

The DDX-8001 is an IC optimized for 5.1 channel digital amplification and post-processing. The following application note is intended to serve as a primer for the software control in a 5.1 application such as a DVD receiver. The DDX-8001 is capable of offering a wide range of features that can be used in the design of 5.1 applications - most prominent features being Bass management AutoMode™, Bass/treble tone control, EQ, 5.1 to 2 channel downmix, digital amplification, etc.

Figure 1 is a flow diagram of the common blocks and flow of a 5.1 system. It is important to recognize that this application uses no DACs, all analog outputs are handled by the DDX-8001.

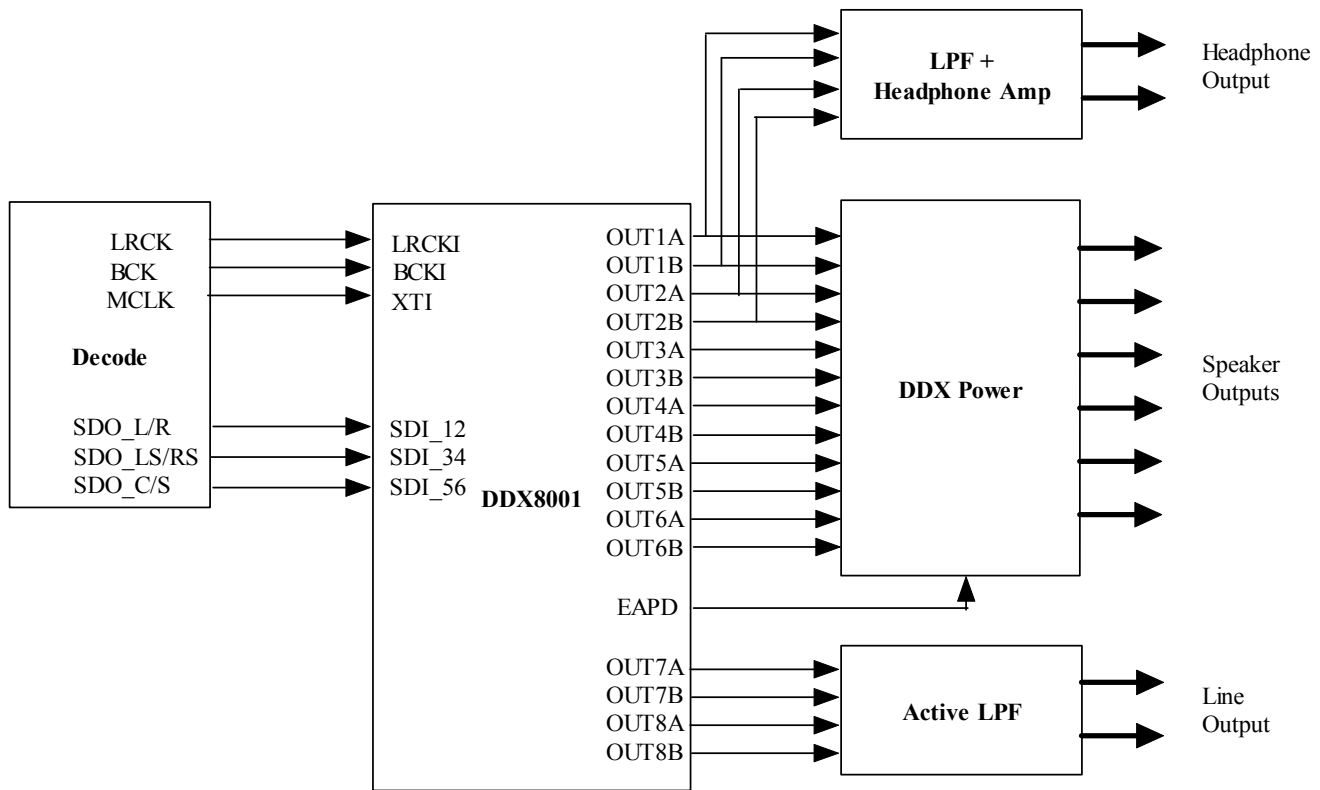


Figure 1 –Block Diagram of a 5.1 Channel System

2. DDX-8001 Initialization using I²C Protocol

Register Address	Register Data	Comment
00h	100xxxxxb	Configuration Register A, Set IR and MCS

The input sample frequency and the ratio of the input clock to this sample frequency will determine the settings of the IR and MCS bits. These must be set any time the input sample frequency or clock changes. The default setting for these bits are for 32-48 kHz sample rate and an input clock of 256Fs. The table below shows the settings for the IR and MCS bits in order to handle other sample rates.

Input Sample Rate – Fs (kHz)	IR (1...0)	MCS (2...0)				
		1xx	011	010	001	000
32, 44.1, 48	00	128Fs	256Fs	384Fs	512Fs	768Fs
88.2, 96	01	64Fs	128Fs	192Fs	256Fs	384Fs
176.4, 192	10	64Fs	128Fs	192Fs	256Fs	384Fs
DSD	11	2Fs	4Fs	6Fs	8Fs	12Fs

**THIS TABLE IS NOT A PART OF THE INITIALIZATION PROCEDURE, BUT IS ONLY PROVIDED FOR REFERENCE.*

Register Address	Register Data	Comment
01h	000xxxxxb	Configuration Register B, Set Serial Audio Input Format

The SAI bits determine the format of the serial audio interface. The default setting is for the I2S format, MSB first. If I2S is the format used this register does not have to be written.

3. Bass Management:

If bass management is to be performed in the DDX-8001 the following register settings should be implemented. If bass management is already performed in the audio decoder(MPEG) then either it should be disabled there or bass management of the DDX-8001 should not be enabled. The following settings are for Dolby Configuration #1, which is the most common setting. If configurations other than configuration #1 are needed these can be handled by changing the speaker size settings.

Register Address	Register Data	Comment
20h	10000011b	Enable AutoMode™ BM Mix and Crossover
22h	xxx00000b	Set the BM Crossover frequency
21h	00000010b	BM mix scale adjustment

The Crossover frequency is selected at initialization, see Appendix A for the Crossover Frequency Table.

When Using AutoMode™ Channels 1-6 must be arranged via Channel Mapping (CxIM) if necessary in the following manner for this operation.

- Channel 1 – Left
- Channel 2 – Right
- Channel 3 – Left Surround
- Channel 4 – Right Surround
- Channel 5 – Center
- Channel 6 – LFE

4. Channel Volume Settings:

Register Address	Register Data	Comment
0Bh	xxxxxxxxb	Channel 1 Volume/Gain
0Ch	xxxxxxxxb	Channel 2 Volume/Gain
0Dh	xxxxxxxxb	Channel 3 Volume/Gain
0Dh	xxxxxxxxb	Channel 4 Volume/Gain
0Fh	xxxxxxxxb	Channel 5 Volume/Gain
10h	xxxxxxxxb	Channel 6 Volume/Gain

Channel volume/gain settings default to a setting of 0dB. These settings are normally changed at initialization to add gain to these channels(set maximum volume) and perform volume offsets between these channels. Normally the Subwoofer channel 6 will be set to a higher volume/gain setting than the

other channels. How much higher this channel is set should be determined through listening tests of the system.

Below are suggested values that can be used as a basis for evaluating a system. Actual values and offsets should be determined through listening to the system. It should also be noted that certain features of the DDX-8001(EQ, Bass Management other than config #1) attenuate the signal and therefore when these features are used the channel gain settings will need to be set higher to provide the same output level.

Channel 1-5 – Satellite Channels +16dB gain : CxVol = 40h

Channel 6 – Subwoofer +24dB gain : C6Vol = 30h

5. Line Output:

Register Address	Register Data	Comment
1Fh	1xxxxxxx b	Enable AutoMode Downmix
19h	01010000 b	Bypass Master Volume on Channel 7
1Ah	01010000 b	Bypass Master Volume on Channel 8
2Bh	11000000 b	Bypass Tone Control on Channels 7 and 8

Since Channels 7 and 8 are used as a down-mixed (LtRt) stereo line output several settings need to be performed. These settings make it so that any master volume or tone control adjustments do not affect the line output channels 7 and 8.

Register Address	Register Data	Comment
08h	10000000 b	Configuration Register F, Set EAPD

Setting the EAPD disables the external amplifier power-down signal.

Register Address	Register Data	Comment
0Ah	xxxxxxx b	Master Volume

The default setting for Master volume is mute; therefore this must be set to the initial volume setting to obtain an output signal.

6. Sample Rate Switching/Selection

In order to switch to a different input sample rate certain steps need to be followed to effect the changes correctly. Based on the new sample rate and the desired input clock, determine the IR and MCS bit settings from the table given earlier. To make the change, first mute all the channels, set the IR and MCS bits to the new setting and then un-mute all channels to resume normal operation. Table below shows the I2C commands.

This does not have to be done when switching from 44.1kHz to 48kHz as the over sampling ratio remains the same. Only from either of these sample rates to a higher sample rate such as 96kHz, 192kHz, or DSD.

Register Address	Register Data	Comment
09h	xxxxxxx1 b	Mute all channels
00h	100xxxx b	Set the IR and MCS bits for the new sample rate
09h	xxxxxxx0 b	Un-mute all channels

7. Headphone Operation

Headphone output is provided on channels 1 and 2 DDX output. When a headphone is plugged in this should be sensed from the headphone jack. The microcontroller will provide the following commands once this has been detected. Also when in headphone operation Channels 1 and 2 need to be Lo/Ro downmix of the 5.1 source. This can be performed in the audio decoder(MPEG) or by using the mixing function of the DDX-8001.

Register Address	Register Data	Comment
09h	xxxxxxx1b	Mute all channels
08h	0000000b	Disable Power Devices by EAPD
09h	xxxxxxx0b	Un-mute all channels

When it is detected that the headphones have been removed the power devices should be re-enabled by EAPD.

8. AM Radio Operation

When an AM radio is used with a DDX amplifier several settings in the DDX-8001 can be used to drastically reduce the amount of AM interference . The following settings should be performed when AM is activated.

Register Address	Register Data	Comment
06h	00001000b	Enable AM Noise Reduction Mode
03h	10101011b	Change DDX Modulation Format
21h	xxx10001b	Enable AM AutoMode Frequency Shifting

The top three bits of register 21h are used to adjust the PWM switching frequency based upon the tuned AM frequency for best possible performance. The settings for these bits are determined by the frequency the AM radio is tuned to and should be updated when the AM tuned frequency changes. The proper settings for these bits can be found in the DDX-8001 datasheet.

The following settings should be performed when the AM radio is deactivated.

Register Address	Register Data	Comment
06h	00000000b	Disable AM Noise Reduction Mode
03h	10000010b	Change DDX Modulation Format
21h	Xxx00001b	Disable AM AutoMode Frequency Shifting

9. Channel Volume Trim

Register Address	Register Data	Comment
13h	000xxxxxb	Channel 1 Volume Trim, Mute, Bypass
14h	000xxxxxb	Channel 2 Volume Trim, Mute, Bypass
15h	000xxxxxb	Channel 3 Volume Trim, Mute, Bypass
16h	000xxxxxb	Channel 4 Volume Trim, Mute, Bypass
17h	000xxxxxb	Channel 5 Volume Trim, Mute, Bypass
18h	000xxxxxb	Channel 6 Volume Trim, Mute, Bypass
19h	000xxxxxb	Channel 7 Volume Trim, Mute, Bypass
1Ah	000xxxxxb	Channel 8 Volume Trim, Mute, Bypass

Channel Trim settings default to a setting of 0dB. The Channel Trim is normally controlled via the consumer for balancing the output of the channels in surround sound settings. The Channel Mutes provide a “soft mute” with the volume ramping down to mute. Channel Volume Bypass, bypasses the Master volume setting and only channel volume will affect the channel.

Appendix A: Crossover Filters

XO (2..0)	Bass Management Crossover Frequency
000	70 Hz
001	80 Hz
010	90 Hz
011	100 Hz
100	110 Hz
101	120 Hz
110	140 Hz
111	160 Hz