Dynamic Donut

ETEC 474 Hardware Description

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Introduction

The Dynamic Donut is a hardware device for the playback and manipulation of audio in a broadcast studio environment. It reads audio information from a Secure Digital card, and outputs balanced analog and AES/EBU digital audio. The Dynamic Donut is controlled by a nine button control pad and RS-232 connection. Status information is output via a 4 x 20 character display and RS-232. This document is designed to describe the operation of the hardware components.

Microcontroller

The Dynamic Donut uses the MCF52233 microcontroller from Freescale. It is a Coldfire V2 architecture. This microcontroller was chosen for its cost, speed, and communications modules. The MCF52233 contains UART, SPI, I²C, and GPIO communications modules, all used by the Dynamic Donut. The V2 core delivers 57 MIPS (million instructions per second), which is critical considering the frequency of interrupts coming from the audio modules.

Power and power conditioning including filtering capacitors and an inductor is provided as recommended by the MCF52235 reference manual. The microcontroller uses an external crystal oscillator operating at 25MHz. The on-chip PLL uses the external crystal as a reference, and generates an operating frequency of 60MHz. Signal paths and a pin header for the background debug module are also provided, as recommended by the reference manual.

Power

Most of the components on the Dynamic Donut use a +3.3 volt supply. A pair of products, the Newhaven LCD and the Freescale DAC, use a +5 volt supply. Additionally, the Analog Devices balanced line driver requires ±15 volts. In order to power all of these components, the power circuitry takes +5 volts in from a wall transformer and generates +3.3 volts and ±15 volts.

A toggle switch is immediately after the +5 volt power jack to control power to the entire system. The +5 volt supply is then fed to a linear regulator which steps the voltage down to +3.3 volts. The +5 volt supply is also fed to a switch mode regulator which boosts the voltage to +15 volts, and then inverts it to -15 volts. The supporting circuitry on the +3.3 volt linear regulator and the ±15 volt switch mode regulator are the recommended connections from the manufacturer data sheets.

Control Pad

A control pad of nine buttons is used to allow the user to control the Dynamic Donut. It is arranged into a matrix of three by three. The GPIO module of the MCF52233 does not have internal pull-up resistors, so external pull-ups are provided. The switches are read one row at a time by setting the corresponding row signal to output logic 0, while keeping the other row pins in a high impedance state. The switches will be debounced in software.
**LCD**

For the user interface the Dynamic Donut uses a Newhaven NHD-0420E2Z display. It is a large, backlit, 4 x 20 character display. It communicates with the microcontroller through eleven data and control lines. These are D0 through D8, RS, \( R/W \), and E. The LCD is operating in four-pin mode, so D0 through D3 are tied directly to ground. The remaining data and control lines are directly connected to the microcontroller. Power for the display is provided by VDD, and the backlight by LED+. The backlight has an internal current limiting resistor. Contrast is controlled by the voltage on V0, the potentiometer R2 provides contrast adjustment.

The LCD is a +5 volt device, communicating with a +3.3 volt microcontroller. The levels are compatible when communicating from microcontroller to LCD, however incompatible when communicating from LCD to microcontroller. Because of this, the microcontroller will never read from the LCD. Further, this allows the data lines D0 through D3 to be connected directly to ground without any current limiting resistors.

**RS-232**

In addition to input and output via the control pad and LCD, the Dynamic Donut can be controlled through a RS-232 serial link. This allows the Dynamic Donut to be controlled by broadcast automation systems. The UART module on the microcontroller is connected to an ICL3225 Intersil RS-232 driver. The driver converts the logic-level signals from the microcontroller to RS-232 levels. The attached capacitors are recommended by the reference manual for the ICL3225, and are used in the operation of the charge pump that generates the RS-232 level voltages.

**Secure Digital**

The microcontroller uses its QSPI module to communicate with a Secure Digital card in SPI mode. The QSPI module on the MCF52233 can operate at a clock rate of up to 15MHz. The SD card has nine pins: CD, CMD, Vss, Vdd, CLK, Vss, DAT0, DAT1, and DAT2. To use the SD card in SPI mode, DAT1 and DAT2 are not connected. CD, CMD, CLK, and DAT0 on the SD card are connected to the CS0, DOUT, CLK, and DIN QSPI signals on the microcontroller.

**Audio**

The master clock for both digital and analog audio is generated at 11.2896MHz by the external crystal oscillator. It is stepped down from +5 volts to +3 volts and fed to both the CS8406 and the CS4335. The CS8406 acts as a master, generating LRCLK and SCLK. The CS4335 and the microcontroller both take these signals as inputs. The microcontroller outputs serial digital audio on the SDIN line, which is fed to both the CS8406 and CS4335 simultaneously.

The Cirrus CS8406 is a AES/EBU interface. It receives serial audio in, encodes it into the AES/EBU format, and drives the output on an XLR cable. The microcontroller also communicates to the CS8406 over I2C to set registers controlling its operation. The output of the CS8406 passes
through a 1:1 transformer. This transformer provides impedance matching, DC blocking, as well as other properties that are described in Cirrus Logic’s application note AN134. The signal is then connected to an XLR3 jack, where an XLR cable can interface the Dynamic Donut with other digital professional audio equipment.

Serial audio information and clocks are also routed to the Cirrus CS4335, an audio DAC. The CS4335 converts serial digital audio into two channel, single ended analog audio. The output of the CS4335 is sent through a filter network consisting of both a high-pass filter for DC blocking, and low-pass filter to eliminate high frequency noise. At this point the full-scale signal is 1.23 volts RMS. The 10kΩ resistor combines with the 10kΩ input resistance of the SSM2142 to half the signal voltage. The Analog Devices SSM2142 is a balanced audio line driver, it takes single ended audio in, applies a +6dB gain, and outputs a differential signal uncoupled from ground. The +6dB gain of the SSM2142 combines with the +6dB attenuation of the input resistance to give a unity gain, and a nominal line level of 1.23 volts RMS. This is the standard for balanced analog professional audio equipment.