Crystal Technology, Inc.

AOTF Controllers and FSK Operation

Revision 1.3

2010/08/10

Document #60-00101-01

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Revision History			
Revision	**Date**	**Who**	**Comments**
1.0	2008/12/01	Calvin Hwung	Genesis.
1.1	2008/12/05	Dale Gifford	Release 2008-12-05.
1.2	2010/05/04	Dale Gifford	Fixed a couple of typos.
1.3	2010/08/10	Dale Gifford	Updated logo, fixed typos. Release 2010-08.

Table 1: Revision History

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1. Introduction

1.1. Purpose

This document contains information about using Crystal Technology's *Acousto-Optic Tunable Filter (AOTF) Controllers* in environments that utilize Frequency Shift Keying (FSK). This document provides guidelines for configuring and operating *AOTF Controllers* in an FSK mode of operation.

1.2. Related Documents

The following references may be useful in fully understanding and utilizing the *AOTF Controller*:

- Octal Channel AOTF Controller Integration Guide, Revision 1.1, 2010/08/10, www.CrystalTechnology.com, Crystal Technology, Inc. 1040 East Meadow Circle, Palo Alto, CA 94303-4230.
- Quad Channel AOTF Controller Integration Guide, Revision 1.1, 2010/08/10, www.CrystalTechnology.com, Crystal Technology, Inc. 1040 East Meadow Circle, Palo Alto, CA 94303-4230.
- Single Channel AOTF Controller Integration Guide, Revision 1.1, 2010/08/10, www.CrystalTechnology.com, Crystal Technology, Inc. 1040 East Meadow Circle, Palo Alto, CA 94303-4230.
- AOTF Controller Command Reference, Revision 1.3, www.CrystalTechnology.com, Crystal Technology, Inc. 1040 East Meadow Circle, Palo Alto, CA 94303-4230.
- AOTF Controllers and Temperature Compensation, Revision 1.2, www.CrystalTechnology.com, Crystal Technology, Inc. 1040 East Meadow Circle, Palo Alto, CA 94303-4230.
- AOTF Controllers and Light Intensity Tracking, Revision 1.2, www.CrystalTechnology.com, Crystal Technology, Inc. 1040 East Meadow Circle, Palo Alto, CA 94303-4230.
- AotfManager User's Guide, Revision 1.1, www.CrystalTechnology.com, Crystal Technology, Inc. 1040 East Meadow Circle, Palo Alto, CA 94303-4230.
- AotfCmd User's Guide, Revision 1.1, www.CrystalTechnology.com, Crystal Technology, Inc. 1040 East Meadow Circle, Palo Alto, CA 94303-4230.

1.3. Notation

- Numbers with an "h" suffix or "0x" prefix are hexadecimal. All other numbers are decimal.
- Register and bit names ending in "**[#]**" and "**[#:#]**" signify selection of a subset of the register (e.g. **I2CS[0]** represents bit 0 of the **I2CS** register, and **I2CS[5:3]** represents bit 5 through 3 of the **I2CS** register).
- Signal names ending with '#' (e.g. **INT0#**) indicates an active low signal.
- N/A is an abbreviation for Not Applicable.

- Register bits are either set (1) or cleared (0).

2. Historical Side Note About FSK Nomenclature

When first designing and architecting the *AOTF Controllers* it was thought that the primary usage of the FSK feature would be for two capabilities:

- Output Blanking – The RF output can be turned ON/OFF.
- Frequency Shift Keying (i.e. Frequency Modulation) – Selecting between two frequencies.

With these two concepts in mind the control signals on the schematics and connectors were named FSK and BLANK. These names seemed appropriate at that time.

As engineers, developers, and customers began using the *AOTF Controllers* it became necessary to develop new nomenclature to describe and discuss the new ways that *AOTF Controllers* were being utilized. The DDS chip at the heart of the *AOTF Controllers* utilized two profile select pins. The hardware implementation of the FSK and BLANK capability was implemented via the profile select pins of the DDS chip.

What eventually evolved was the concept of "Profiles". A "Profile" is a collection of configuration settings that are grouped together, and selected by the profile select pins of the DDS chip. Using the Profile concept it's possible to implement not only the original concepts of BLANK and FSK, but much more flexibility.

The end result is nomenclature that might seem confusing to new users, but has historical roots that are difficult to eradicate.

3. Frequency Shift Keying (FSK)

A very useful feature of the *AOTF Controllers* is the ability to utilize a Frequency Shifting Key (FSK) capability. Frequency Shift Keying is the ability to rapidly switch the output of the *AOTF Controller* between multiple frequencies. Some of the applications that utilize FSK capability are:

- **Output Blanking**
  The RF output of the AOTF Controller can rapidly be turned ON and OFF, also known as output Blanking.
- **Frequency Modulation**
  Rapidly selecting between multiple output frequencies. The ability to rapidly select between a set of preset frequencies.
- **Crystal Temperature Stabilization**
  Temperature stabilization of AOTF Crystals is accomplished by configuring the FSK capability to select between a frequency that diffracts the laser light and a nearby frequency that maintains the temperature of the crystal, but is far enough away from the diffraction frequency that light is not diffracted. This allows the diffracted laser light to rapidly be turned ON an OFF without changing the temperature of the AOTF Crystal.

All of *the AOTF Controllers* (Octal, Quad, and Single Channel) provide quadrature FSK capability, by utilizing four profiles, with each profile containing a different frequency. A profile is the nomenclature used for managing a group of configuration settings, the most important setting being the frequency. There are 4 profiles, numbered 0 to 3.

4. Single Profile Mode and Multi Profile Mode

The *AOTF Controllers* operate in one of two modes:

- **Single Profile Mode (also known as Single Tone Mode)**
  In Single Tone Mode the profile selection is ignored, profile 0 is the only profile used. The configuration settings of profile 0 are used to control the RF output.
- **Multi Profile Mode (also known as Multi Tone Mode)**
  In Multi Tone Mode the profile selection is used to select one of the profiles. The configuration settings of the selected profile are used to control the RF output.

Profiles can be configured, but may not be enabled, depending on the mode of operation. For example, it is possible to use the "`DDS Frequency`" command to configure the frequency of all four profiles, but if the *AOTF Controller* is operating in Single Tone Mode, the only frequency present in the RF output will be the frequency of profile 0.

Enabling Single Profile Mode or Multi Profile Mode s accomplished with the "`DDS FSK`" command. Each channel of the *AOTF Controller* operates independently, and it's possible (although not common) that some channels are operating in Single Profile Mode while other channels are operating in Multi Profile Mode. Most environments will operate all channels in the same mode.

5. Virtual Profiles

The architecture of the *AOTF Controllers* provides maximum flexibility for interfacing to various host environments by implementing the concept of Virtual Profiles Mode. The Virtual Profiles Mode provides a layer of indirection between the host environment and the DDS chip. *Figure 1* shows how the Virtual Profiles Mode provides flexibility for interfacing with various host environments:

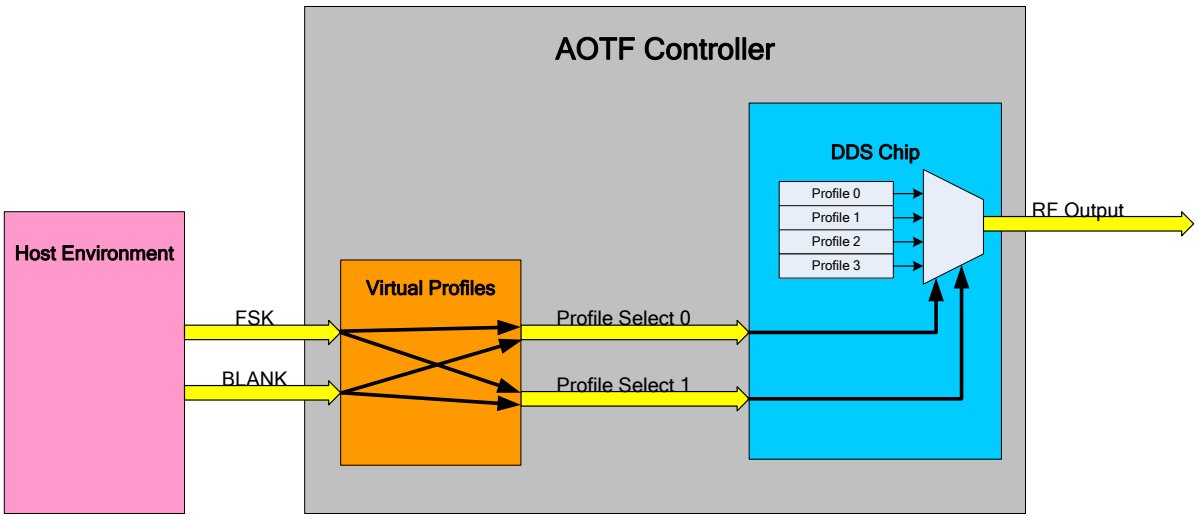

Figure 1: Virtual Profiles Mode

The Virtual Profiles Mode provides the mapping from the FSK and BLANK signals that originate in the host environment into the Profile Select pins of the DDS chip. The Virtual Profiles Mode allows any combination of the FSK and BLANK signals to be mapped into the Profile Select pins to the DDS chips. Controlling the Virtual Profile Mode mapping is accomplished with the same command that enables Multi Profile Mode, the "`DDS FSK`" command.

The Virtual Profile Mode capability provides the host environment the ability to control which profile is selected by the various combinations of the FSK and BLANK signals. *Table 2* summarizes the Virtual Profiles Modes and the mapping from FSK and BLANK signals into Profile Select pins of the DDS chip.

Virtual Profiles Mode				
Virtual Profiles Mode	**BLANK (Input from Host)**	**FSK (Input from Host)**	**DDS Profile**	**RF Output Frequency**
0 (Single Profile Mode)	Not Used	Not Used	Profile 0	Frequency 0
	Not Used	Not Used	Profile 0	Frequency 0
	Not Used	Not Used	Profile 0	Frequency 0
	Not Used	Not Used	Profile 0	Frequency 0
1 (Invert BLANK)	0	0	Profile 2	Frequency 2
	0	1	Profile 3	Frequency 3
	1	0	Profile 0	Frequency 0
	1	1	Profile 1	Frequency 1
3 (Identity Mapping)	0	0	Profile 0	Frequency 0
	0	1	Profile 1	Frequency 1
	1	0	Profile 2	Frequency 2
	1	1	Profile 3	Frequency 3
5 (Inverse Mapping)	0	0	Profile 3	Frequency 3
	0	1	Profile 2	Frequency 2
	1	0	Profile 1	Frequency 1
	1	1	Profile 0	Frequency 0
7 (Invert FSK)	0	0	Profile 1	Frequency 1
	0	1	Profile 0	Frequency 0
	1	0	Profile 3	Frequency 3
	1	1	Profile 2	Frequency 2

Table 2: Virtual Profiles Modes

6. Enabling Single Profile Mode or Multi Profile Mode

Enabling Single Profile Mode or Multi Profile Mode is accomplished with the following command:

```
DDS FSK Channel* Mode
```

The command arguments are:

- `Channel*`
  This is the channel number. Channel numbers range from 0 to 7 for the *Octal AOTF Controller*, 0 to 3 for the *Quad AOTF Controller*, and 0 for the *Single AOTF Controller*. An asterisk ('*') can be used to select all channels.
- `Mode`
  This is the Virtual Profile Mode. Choose the Virtual Profile Mode appropriate for the host environment from *Table 2*.

After Multi Profile Mode has been enabled the host environment can control the RF Frequency of the AOTF Controller by driving the appropriate values onto the FSK and BLANK pins. The FSK and BLANK pins are routed through the Virtual Profile Mode circuit and control the profile select pins of the DDS Chip. The DDS Chip uses the Profile Select pins to decide which profile to use. The frequency that has been programmed into the selected profile will be the frequency in the *AOTF Controller's* RF output.

7. Octal and Quad BLANK Signal

For the Octal and Quad *AOTF Controllers* the BLANK signal is common to all channels. Because of limited pins on the host modulation interface connector, the host modulation interface does not contain individual BLANK signals for each channel.

8. Microcontroller Interaction

The embedded microcontroller of the *AOTF Controller* can also manipulate the FSK and BLANK pins, but not at the same time as the host. This is useful for debugging and testing the Multi Profile capability. Because of the different implementations of the hardware for the Single Channel AOTF Controller and the Octal/Quad AOTF Controllers, the multiplexing between the host access and the microcontroller access is implemented via different commands as follows:

For Single Channel AOTF Controllers

To enable the Microcontroller to access and control the FSK and BLANK signals use this command:

`Modulation Analog 0 –m`
This will disable the analog host interface and at the same time will force the analog modulation to maximum (highest RF output level) and allow the microcontroller to manipulate the FSK and BLANK signals. The RF output level can be further manipulated via the "`Dds Amplitude`" command and the "`Dds gain`" command.

To enable the host to access and control the FSK and BLANK signals use one of these commands:

`Modulation Analog 0`
This will enable the analog host interface. The host will be in control of the modulation level (RF output level) and the FSK and BLANK signals. The modulation level is sourced from the differential analog modulation pins of the host modulation interface connector on the front panel of the *AOTF Controller*. The FSK and BLANK signals are sourced from the FSK and BLANK pins of the host modulation interface connector on the front panel of the *AOTF Controller*.

`Modulation Digital 0`
This will enable the digital host interface. The host will be in control of the modulation level (RF output level) and the FSK and BLANK signals. The modulation level is sourced from the digital data stream provided by the host on the LVDS modulation pins, CLK_P/N and DIN_P/N, of the host modulation interface connector on the front panel of the *AOTF Controller*. The FSK and BLANK signals are also sourced from digital data stream.

For Octal and Quad Channel AOTF Controllers

To enable the Microcontroller to access and control the FSK and BLANK signals use this command:

`Daughter Enable`
This will enable the microcontroller interface and simultaneously disable the host interface thereby allowing the microcontroller to manipulate the FSK and BLANK signals. The FSK and BLANK pins of the host modulation interface connector on the front panel of the *AOTF Controller* will not be able to control the FSK and BLANK signals.

To enable the host to access and control the FSK and BLANK signals use this command:

`Daughter Disable`
This will disable the microcontroller interface and simultaneously enable the host interface thereby allowing the host to manipulate the FSK and BLANK signals. The microcontroller will no longer be able to control the FSK and BLANK signals. The FSK and BLANK pins of the host modulation

interface connector on the front panel of the *AOTF Controller* will be able to control the FSK and BLANK signals.

Once the microcontroller has access to the FSK and BLANK signals; they can be manipulated with these commands:

```
Modulation FSK 0 0
Modulation FSK 0 1
Modulation BLANK 0 0
Modulation BLANK 0 1
```

9. Examples

The following commands will configure the four profile frequencies of channel 0 to 80, 90, 100, and 110 MHz:

```
DDS frequency -p0 0 80
DDS frequency -p1 0 90
DDS frequency -p2 0 100
DDS frequency -p3 0 110
```

The following command will display the frequencies for the four profiles of channel 0:

```
DDS frequency -p* 0
Channel 0 profile 0 frequency 8.000000e+07Hz (Ftw 858993472)
Channel 0 profile 1 frequency 9.000000e+07Hz (Ftw 966367616)
Channel 0 profile 2 frequency 1.000000e+08Hz (Ftw 1073741824)
Channel 0 profile 3 frequency 1.100000e+08Hz (Ftw 1181116032)
```

The following command will enable FSK Multi Profile Mode and place the *AOTF Controller* into Virtual Profile Mode 3, which is the identity mapping mode:

```
DDS fsk 0 3
```

The following commands will cause profile 0 to be the selected profile, and will cause the RF output frequency of channel 0 to be 80MHz because 80MHz has been programmed into profile 0 (a spectrum analyzer is necessary to verify the RF output of the *AOTF Controller*):

```
Modulation FSK 0 0
Modulation BLANK 0 0
```

The following commands will cause profile 3 to be the selected profile, and will cause the RF output frequency of channel 0 to be 110MHz because 110MHz has been programmed into profile 3 (a spectrum analyzer is necessary to verify the RF output of the *AOTF Controller*):

```
Modulation FSK 0 1
Modulation BLANK 0 1
```

