

# *TrueTime*

## Model 560-5203-5 OSCILLATOR CONTROL MODULE MANUAL

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# SECTION ONE

## 1. FUNCTIONAL DESCRIPTION

### 1.1. PURPOSE OF EQUIPMENT

The Model 560-5203-5 Oscillator Control Module provides an accurate frequency source - an Ultra Low Noise Crystal Oscillator - which is disciplined (locked) by either external frequency reference(s) or by GPS (if a GPS module is installed in the system).

The external frequency reference, which will be called Aux Ref in this manual, may be enabled or disabled by on-card DIP switches depending on the system requirements.

### 1.2. OVERVIEW

This manual only covers the 560-5203-5 Oscillator Control Module when operating in Aux Ref mode. Note that this card is designed to work exclusively with the 560-19700 rear assembly.

### 1.3. PHYSICAL SPECIFICATIONS

Dimensions: 1.6"W X 3.94"H X 8.66"D (4 cm X 10 cm X 22 cm)  
Weight: Approximately 0.7 pound (0.4 kg)

### 1.4. ENVIRONMENTAL SPECIFICATIONS

Operating Temp: 0° to +50°C  
Storage Temp: -40° to +85°C  
Humidity: Up to 95% relative, non-condensing  
Cooling Mode: Convection

### 1.5. POWER REQUIREMENTS

Voltage: 18-72 VDC  
Power: 5 Watts

### 1.6. AUXILIARY REFERENCE INPUT(S) REFA, REFB, 7F, 8F

Function: REFA or 7F -- Primary External Disciplining  
Reference for Oscillator  
REFB or 8F -- Secondary External Disciplining  
Reference for Oscillator  
Input Amp/Freq: 3-5 Vp-p at 1 MHz  
Input Amp/Freq: 2-5 Vp-p at 5 or 10 MHz

## 1.7. OUTPUT FREQUENCY SPECIFICATIONS

Function: Reference Mode: must be set to drive REFC  
(switch-selectable)  
Output Frequency: Reference Mode: set for REFA & REFB frequency  
(switch-selectable)  
Output Amplitude: 3 Vp-p minimum into 50 ohms  
Frequency Stability: Equal to input reference  
To Initial Lock: < 20 minutes

## SECTION TWO

### 2. OPERATION AND INSTALLATION

#### 2.1. AUX REF DISCIPLINING MODE

When the Aux Ref mode is enabled (DIP switch), the oscillator uses the 56000 DRC backplane frequency reference bus to receive the oscillator disciplining reference(s) and to distribute the oscillator's output. The 56000 DRC chassis has up to five frequency reference bus lines -- REFA, REFB, REFC (standard) and the optional buses 7F and 8F. The 560-5203-5 Oscillator uses up to two of the frequency reference bus lines as inputs (primary and secondary) to discipline the local oscillator. Note that only one Aux Ref (external frequency reference) input is required to discipline the local oscillator -- the second Aux Ref input provides disciplining redundancy.

This card must be operated in Aux Ref mode, and configured via SW2 to use Reference. Reference mode is used when the 56000 system has only one oscillator installed, Input mode is not available in this system. Reference mode offers the oscillator card two Aux Ref disciplining inputs (primary and secondary).

The 560-5203-5 Oscillator Control Module performs automatic frequency detection (1, 5 or 10 MHz) of the Aux Ref disciplining inputs and also provides automatic switching between the primary and, if enabled, secondary Aux Ref sources based on a coarse frequency detection circuit. The oscillator card cannot determine with any accuracy which frequency source should be used and depends on the Aux Ref source's fault status to switch input references.

Fault status is a logic level output from external Aux Ref sources that connect to the 560-5179-1 Fault Monitor CPU card (refer to the 560-5179-1 manual). Connections to the P (primary) and S (secondary) Fault Status inputs on the Fault Monitor CPU card allows switching the 560-5203-5 Oscillator to steer and lock to a known good frequency. If the primary Aux Ref source provides a fault to the Fault Monitor CPU card and the secondary Aux Ref source is enabled (with no fault), the CPU commands the oscillator card to switch to the secondary Aux Ref source. If only a primary Aux Ref source is used, the S (secondary) Fault Status input on the Fault Monitor CPU card and the secondary Aux Ref input on the oscillator card must be disabled (DIP switch).

In Reference mode, the oscillator provides a continuous, stable reference that flywheels through any external reference perturbations and provides backup during any loss of external reference. The 560-5203-5 Oscillator's phase-locking and long-term averaging technique provides a very stable frequency source that has a long-term stability equal to the external reference.

## 2.2. REFERENCE MODE

In a system that has only one 560-5203-5 Oscillator card installed, and Aux Ref mode is enabled, the Aux Ref operating mode should be set to Reference. In this mode the Aux Ref disciplining signals are distributed on backplane bus lines REFA (primary) and REFB (secondary). The primary Aux Ref disciplining signal must be connected to the REFA input and if a second Aux Ref source is desired, to the REFB input. The oscillator will steer and lock to the highest priority Aux Ref signal that is usable. If the secondary Aux Ref source (REFB) is not used, the input should be disabled on the oscillator card (DIP switch).

When the 560-5203-5 Oscillator card is operated in Reference mode, the frequency output from the oscillator card must be set to match the frequency of the Aux Ref source(s) (REFA and REFB). In Reference mode, the oscillator must be set to distribute its output on REFC.

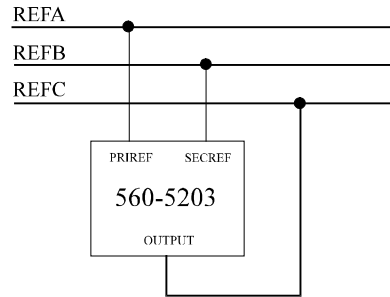
### REFERENCE MODE FAULT STATUS

The primary Aux Ref signal REFA and if used, the secondary Aux Ref signal REFB, are monitored for fault status by the 560-5179-1 Fault Monitor CPU card. Fault status is a logic level output from the external Aux Ref source that should be connected to the Fault Monitor CPU card. The Fault status terms are used by the Fault monitor CPU card to control primary/secondary Aux Ref switching on the 560-5203-5 Oscillator card.

In Reference mode, the 560-5203-5 Oscillator uses the disciplining reference inputs from REFA and REFB. When the REFA disciplining source's fault status is detected by the CPU (via status input "P" (primary), the REFA (primary) disciplining reference input on the oscillator card is disabled. The REFB (secondary) disciplining reference input on the oscillator card is controlled similarly via status input "S" (secondary) -- the REFB disciplining reference input is turned off whenever a fault condition exists. If the REFA and/or REFB reference input is used, but the fault status from the external oscillator(s) is not used, the status inputs for these references should be disabled on the 560-5179-1 Fault Monitor CPU card (PSRC=D, SSRC=D commands). Refer to the 560-5179-1 manual. The CPU's fault status inputs "P" and "S" control feature ensures that only a viable external reference oscillator is used to discipline the 560-5203-5 Oscillator.

If only one Aux Ref disciplining input is used, this input must be connected to REFA (primary). The secondary Aux Ref input on the oscillator card should be disabled (DIP switch SEN = OFF) as well as the secondary status input on the Fault Monitor CPU card. When a primary fault status signal is detected by the CPU card, the primary Aux Ref input on the 560-5203-5 Oscillator card is turned off and the oscillator will flywheel at the current frequency. If the primary Aux Ref source becomes viable again, CPU fault status and on-card frequency detection is OK, the disciplining source for the oscillator will switch back on and the oscillator will steer and lock to the primary Aux Ref source.

The following diagram depicts the 560-5203-5 in Reference mode.



### 2.3. FRONT PANEL LED

The Oscillator card has a bicolor RED/GREEN LED mounted to the front panel. This LED has the following states due to various fault conditions on the card:

SOLID RED = a local power supply failure.

BLINKING ORANGE = Aux Ref faults:

1. Primary Aux Ref source bad.
2. Secondary (when enabled) Aux Ref source bad.
3. PLL (on XL2) not locked. This PLL must be locked for Aux Ref Oscillator disciplining to occur.

SOLID ORANGE = No Aux Ref faults but the Oscillator has not locked to the external oscillator disciplining source.

GREEN (or OFF) = No Aux Ref faults and the oscillator is locked to the external oscillator disciplining source. The GREEN LED enable switch "GRN" must be ON for the GREEN LED to illuminate. When the GREEN enable switch is OFF, the GREEN indication is replaced by LED OFF.

### 2.4. SETUP

The following setup applies to the 560-5203-5 card that is set to use Aux Ref mode to discipline the oscillator. The setup involves selection of the Aux Ref operating mode (Reference or Input), secondary Aux Ref input enable/disable, the oscillator output frequency, the backplane frequency bus to drive and the Green LED control switch.

Use steps 1 through 8 to perform the setup procedure:

1. 560-5203-5 Required Settings      SW1-5 thru 8 (BRD0 - BRD3)
2. Aux Ref Mode (enable)              SW2-2              (AUX)
3. Operating Mode (Set to Reference) SW2-3              (REF/IN)
4. Secondary Aux Ref Input (ON/OFF) SW2-4              (SEN)



#### 2.4.5. TIMING OUTPUT LATCH ENABLE

Use SW2-7 to latch the 1 PPS and IRIG B signals to the timing bus when GPS unlocks. Otherwise, these outputs are disabled when GPS is in unlocked status.

Timing Output Latch Enable (#7)	
SW2-7 ON	Enabled
SW2-7 OFF	Disabled

#### 2.4.6. OUTPUT FREQUENCY SELECT (1, 5, 10 MHz)

Set SW1-1 and SW1-2 (FRQ0 and FRQ1) to select the Oscillator's output frequency. NOTE: When the oscillator is operated using Reference mode, the oscillator's output frequency must be set to match the REFA frequency.

Output Freq	10 MHz	5 MHz	1 MHz	0
SW1-1 (FRQ0)	ON	OFF	ON	OFF
SW1-2 (FRQ1)	OFF	ON	ON	OFF

#### 2.4.7. OSCILLATOR DRIVE SELECT (REFA,B,C)

Set SW1-3 and SW1-4 (DRV0 and DRV1) to select which frequency bus to distribute the oscillator's output. NOTE: When using Reference mode, the driven output must be REFC.

Drive Select	REFA	REFB	REFC	0
SW1-3 (DRV0)	ON	OFF	ON	OFF
SW1-4 (DRV1)	OFF	ON	ON	OFF

#### 2.4.8. GREEN LED CONTROL

Use SW2-8 (GRN) to control the front panel status LED. When the switch is ON, a GREEN LED indication is displayed when the oscillator is locked to the Aux Ref source. When the switch is turned OFF, oscillator lock is displayed as LED OFF.

Green LED Control (GRN)	
SW2-8 ON	GREEN
SW2-8 OFF	OFF

#### 2.4.9. DAC CONTROL

Set S2 on the 87-902 Assembly to achieve proper DAC Control voltages.

87-902 DAC Control	
S2-1	OFF
S2-2	OFF
S2-3	OFF
S2-4	OFF



2.5.

## OPERATION

Upon installation, the oscillator locks to the currently-highest priority (primary/secondary) disciplining reference. This occurs automatically after oscillator power is cycled via hot swap or power-up. The process involves local oscillator warm-up and steering. Initial lock-up time, which varies with temperature, is typically < 20 minutes. Prior to Aux Ref lock, the oscillator output is enabled but the oscillator FAULT is active (indicated by front panel LED = ORANGE). Once locked, the fault condition is deactivated (indicated by front panel LED = GREEN or OFF). If the disciplining reference is lost, the oscillator flywheels at the current frequency.

### 2.6. HOT SWAPPING

All cards, input cables and output cables are hot swappable. It is not necessary to remove chassis power during insertion or removal. Hot swapping and reference-source changes are abrupt, the effects difficult to characterize; however, the system is designed to protect against permanent effects and minimize temporary effects of these events.

Adjacent-card hot swapping has a negligible effect on the oscillator. The oscillator is highly-isolated from transient effects; and, the hot swapping event typically lasts less than one clock-period. The effect of redundant power supply switch-over is also negligible.

The effect of a reference-source change does not affect the oscillator; however, it has varying effects on various function cards as discussed in specific manuals.

The disciplining reference input is delivered via backplane buses REFA, and REFB when operating using Reference mode. The oscillator uses the currently-highest priority reference signal (REFA, 7F = primary and REFB, 8F = secondary) to discipline the local oscillator. If a switch is made from the primary to the secondary input reference, the oscillator locks to the new reference with negligible effect on the output frequency due to the long-term average that is made on the disciplining reference input frequency.

Hot swapping of an oscillator affects the system in varying ways depending upon whether the oscillator is configured to drive REFA, REFB, or REFC. These effects are discussed in individual card manuals. If the oscillator that is being hot swapped is the primary frequency source for the system (REFA), the user should use the REFB! or REFC! command (560-5179-1 Fault monitor CPU serial port) to temporarily switch the system frequency cards to a viable source. After the hot swapped primary (REFA) oscillator card has locked, the user should restore the automatic frequency selection by using the REF command. Refer to the 560-5179-1 manual.

## 2.7. REMOVAL AND INSTALLATION

**CAUTION: Individual components on this card are sensitive to static discharge. Use proper static discharge procedures during removal and installation.**

Refer to CARD COMPATIBILITY section prior to installing a new card.

To remove a card, loosen the retaining hardware at the top and bottom of the assembly, then firmly pull on the handle at the bottom of the card. Slide the card out of the chassis. Refer to the SETUP section for any required switch settings or set them identically to the card being replaced. Reinstall the card by fitting it into the card guides at the top and bottom of the chassis and sliding it in slowly, avoiding contact between the bottom side of the card and the adjacent card front panel, until it mates with the connector. Seat the card firmly to avoid contact bounce. Secure the screws at the top and bottom of the card assembly.

## 2.8. DETAILED STATUS VIA CPU

The Fault Monitor CPU has access to detailed 560-5203-5 card status. When the CPU card provides the verbose mode serial report, fault status is available in a 2-byte format, with each binary nibble displayed as a hexadecimal (HEX) character. The 2-byte fault status has the following meaning:

nibble4				nibble3				nibble2				nibble1			
Card				Oscillator				GPS				Aux Ref			
8	4	2	1	8	4	2	1	8	4	2	1	8	4	2	1
Powercycle	spare (0)	spare (0)	spare (0)	Rb Lockmon	Lock	PLL	Osc Tune	spare (0)	+5V/MON	Receiver	Antenna	spare (0)	Secondary	Primary	Aux Ref

Each of the four nibbles is grouped by category for easy visual identification of an offending fault. All faults are asserted as a logic 1. The faults are latched on the oscillator card and must be cleared by the 560-5179-1 Fault Monitor CPU "CL" command.

Aux Ref faults are suppressed when the Aux Ref operating mode is disabled (AUX DIP switch OFF). GPS faults are suppressed when the GPS operating mode is disabled (GPS DIP switch OFF).

(Aux Ref) Nibble1 bit 0 -- Aux Ref:

Primary and if enabled, secondary disciplining source(s) not usable by the 87-902 XL2 card (oscillator disciplining card). This fault may be due to the external oscillator being off frequency or not connected.

(Aux Ref) Nibble1 bit 1 -- Primary:

The primary disciplining source is bad (frequency or amplitude).

(Aux Ref) Nibble1 bit 2 -- Secondary ("SEN" = ON):  
When enabled, the secondary disciplining source is bad (frequency or amplitude).

(Aux Ref) Nibble1 bit 3 -- spare (0):  
This bit is always 0.

(GPS) Nibble2 bits 0-3 -- Not applicable to the 560-5203-5

(Oscillator) Nibble3 bit 0 -- Osc Tune:  
This fault is asserted when the tuning voltage for the disciplined local oscillator has nearly reached the maximum (or minimum) value. When this fault persists, the oscillator card may need to be returned to the factory for calibration.

(Oscillator) Nibble3 bit 1 -- PLL:  
The PLL on the 87-902 XL2 (oscillator disciplining card) is not locked. This PLL must be locked (no fault asserted) before the local oscillator can be disciplined to the external frequency reference (Aux Ref).

(Oscillator) Nibble3 bit 2 -- Lock:  
This fault is asserted when the local oscillator is not locked.

(Oscillator) Nibble3 bit 3 -- Not Used  
This bit is always 0 on the 560-5203-5 card.

(Card) Nibble4 bit 0-3:  
These three bits are always 0.

(Card) Nibble4 bit 3 -- Powercycle:  
This bit is initially set when the oscillator is powered-up and is immediately cleared (0 value) after the Fault Monitor CPU card detects the card.

The following is an example of a Fault Monitor CPU serial verbose mode report:

```

TrueTime 56000 Site 01
Automatic Reports Enabled
Periodic Reports Disabled
Primary Inputs Selected REFA No REFB No REFC Off PRI OK SEC OK TER Off
1. Undefined                OK                Undefined        OK
2. Undefined                OK                Undefined        OK
3. 5203-5 XL2 LOCAL OSC    FAULT 0407      Undefined        OK
4. Undefined                OK                Undefined        OK
(card slots 5 through 20 not shown)

```

Refer to card slot three The 5203-5 is an abbreviation of the 560-5203-5 Oscillator Control Module. The fault status for this card (0407) represents the following:

<u>Bit Weight</u>	<u>Meaning</u>
1	Aux Ref (primary and secondary) sources bad
2	Primary reference bad
+4	Secondary reference bad
7	
0	GPS faults = none (or mode disabled)
4	Oscillator not locked
0	No Card type faults

The Fault Monitor CPU has another serial output mode called machine report mode. This mode is usually used with a computer program to interrogate the 56000 system status. All faults are asserted as a logic 1. The faults are latched on the Oscillator card and must be cleared by the 560-5179-1 Fault Monitor CPU "CL" command.

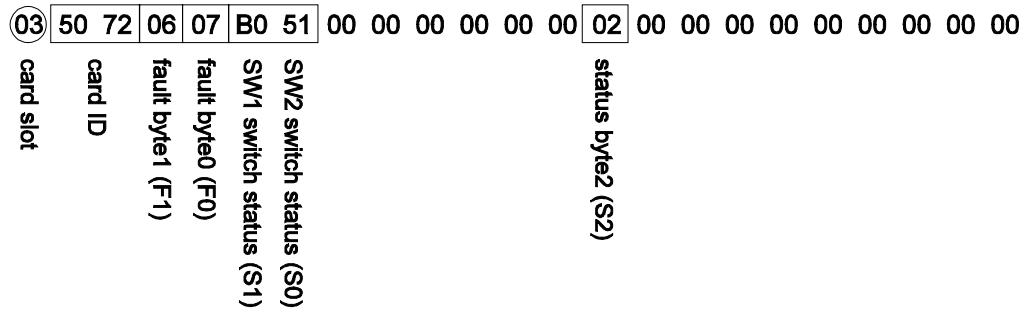
The machine report mode displays hexadecimal (HEX) characters like the verbose mode report. (Refer to the fault descriptions mentioned previously). The following is an example of a Fault Monitor CPU serial machine mode report:

```

TrueTime 56000 Site 01
AR1
PR10
P A1 B1 Co P1 S1 To
01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
02 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
03 50 72 05 07 B051 00 00 00 00 00 00 02 00 00 00 00 00 00 00
04 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
(card slots 05 through 14 HEX not shown)

```

Example from card slot 3 above:



1. 560-5203-5 card ID: 0x5072

2. Fault byte1 (F1) description:

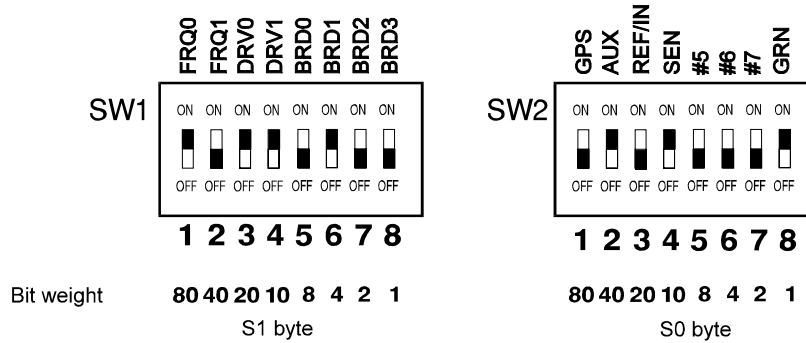
Bit	Weight HEX	Fault Meaning	From Example
0	01	Osc Tune	00
1	02	PLL	02
2	04	Lock	04
3	08	Rb. Lockmon	00
4	10	always 0	00
5	20	always 0	00
6	40	always 0	00
7	80	Powercycle	+ 00
			06

3. Fault byte0 (F0) description:

Bit	Weight HEX	Fault Meaning	From Example
0	01	Aux Ref	01
1	02	Primary	02
2	04	Secondary	04
3	08	always 0	00
4	10	Antenna	00
5	20	Receiver	00
6	40	+5Vmon	00
7	80	always 0	+ 00
			07

GPS mode only  
GPS mode only  
GPS mode only

4. Status byte1 (S1) and status byte0 (S0) descriptions:  
 SW1 and SW2 switch status (settings) are displayed as four HEX nibbles. The switches are mapped to the machine report display in the following manner:



From the example:

$  \begin{array}{r}  \text{Status byte1} = 80 \\  \phantom{\text{Status byte1}} = 20 \\  \phantom{\text{Status byte1}} = 10 \\  + 04 \\  \hline  \text{B4}  \end{array}  $	$  \begin{array}{r}  \text{Status byte0} = 40 \\  \phantom{\text{Status byte0}} = 10 \\  + 01 \\  \hline  51  \end{array}  $
--	--

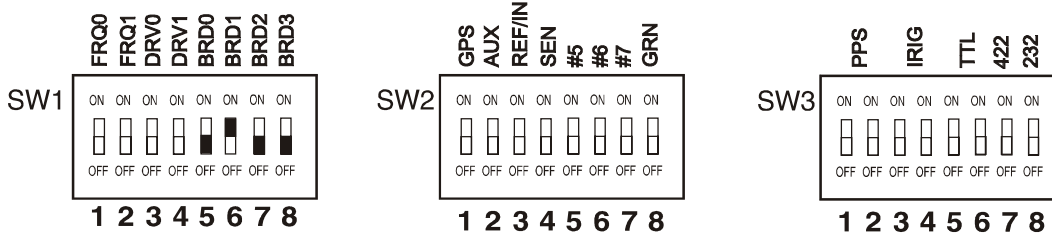
5. Status byte2 (S2) description:  
 The least significant nibble of this byte includes 3 status bits.

Bit 0 = Oscillator has been locked to GPS = 1  
 Bit 1 = The Oscillator has been locked (first time) = 1  
 Bit 2 = GPS/AUX = 1 when using GPS to discipline the oscillator  
           = 0 when using Aux Ref to discipline the oscillator  
 Bit 4 = not used = 0

2.9.

# 560-5203-5 Switch Settings

(fill in the switch positions after configuring the card)



### Output Frequency Select -- SW1-1,2 (FRQ0,FRQ1)

- 10 MHz = 1 ON, 2 OFF
- 5 MHz = 1 OFF, 2 ON
- 1 MHz = 1 ON, 2 ON

### Output Drive Select -- SW1-3,4 (DRV0,DRV1)

- REFA = 3 ON, 4 OFF
- REFB = 3 OFF, 4 ON
- REFC = 3 ON, 4 ON

### GPS Mode -- SW2-1 (GPS)

- OFF = Disabled
- ON = Enabled

### Aux Ref Mode -- SW2-2 (AUX)

- OFF = Disabled
- ON = Enabled

### Operating Mode -- SW2-3 (REF/IN)

- OFF = Reference Mode
- ON = Input Mode

### Secondary Aux Ref control -- SW2-4 (SEN)

- OFF = Secondary Aux Ref Input Disabled
- ON = Secondary Aux Ref Input Enabled

### Timing Output Latch Enable -- SW2-7 (#7)

- OFF = Timing outputs will not latch
- ON = Timing outputs latch at GPS lock

### GREEN LED -- SW2-8 (GRN)

- OFF = No Green when locked
- ON = Green when locked

NOTE: SW3 selections only viable with GPS option.



## SECTION THREE

### 3. THEORY OF OPERATION

#### 3.1. GENERAL INFORMATION

This section contains a detailed description of the circuits in this card. These descriptions should be used in conjunction with the drawings in SECTION FOUR.

#### 3.2. CIRCUIT BOARD DESCRIPTION

The 560-5203-5 card is, in its simplest form, an Oscillator Control Module (the oscillator is part of 560-19700 assembly) whose disciplining frequency is provided by two separate frequency sources in such a way that no glitches are generated when either of the inputs are lost. The 560-5203-5 Oscillator uses an 87-902 card, which is piggybacked onto it, to provide the oscillator disciplining function.

#### 3.3. POWER SUPPLY

This card utilizes DC to DC Converters to provide the required voltages from the input 48 VDC. The power supplies are protected from overloads by a Polyswitch fuse device and a diode provides protection against polarity reversal of the input power. A PI section LC filter on the input of each converter reduces conducted emissions from the converters back into the mains. The input inductor and diode also minimize the effects of inrush current during hot-swapping. The output of each supply is filtered to reduce switching noise. The +15 VDC converter supplies +15 VDC power and connects to a voltage inverter which provides -15 VDC power.

#### 3.4. OSCILLATORS AND BUFFERS

The oscillator, located on the 560-19700 assembly, is disciplined to the Aux Ref input frequency. Voltage comparators provide isolation, voltage gain, and level translation. The Aux Ref disciplining signal may be 1, 5, or 10 MHz, but the 87-902 card requires 1 MHz. The Aux Ref disciplining input is frequency detected automatically and a divider is employed to count 5 and 10 MHz down to 1 MHz. The 87-902 card provides a 10 MHz (XL10MHZ) output locked to the Aux Ref input. Again, a divider is employed to generate 1, 5 or 10 MHz (see OUTPUT FREQUENCY SELECT Section) for output via one of the three frequency signal buses FREQA/B/C (see OSCILLATOR OUTPUT DRIVE SELECT). A 1.5 second time delay network is used to hold off the application of this frequency to the selected frequency bus (after reset has stabilized during power up or during a hot swap event).

#### 3.5.

## FRONT PANEL STATUS LED

Refer to section 2.4, FRONT PANEL LED for possible indications. The bicolor LED is powered by the isolated 48 VDC that is the input power to the card. The RED / GREEN LED is controlled by an optically isolated dual solid state relay. This LED control method allows the solid RED LED fault indication to occur when local card power is bad.

### 3.6. BACKPLANE FAULT OUTPUT

The Backplane FAULT output (/FLTOUT) is a bi-directional signal used by the Fault Monitor CPU in conjunction with BD7:0, DIR and /STB for bi-directional serial communications with fault detection and status/control logic within the Xilinx FPGA.

## **SECTION FOUR**

### 4. DETAILED DRAWINGS

#### 4.1. 560-5203-5 BILL OF MATERIALS