

## 1:1 Digital Interface Transceiver with PLL

### DESCRIPTION

The WM8804 is a high performance consumer mode S/PDIF transceiver with support for 1 received channel and 1 transmitted channel.

A crystal derived, or externally provided high quality master clock is used to allow low jitter recovery of S/PDIF supplied master clocks.

Generation of all typically used audio clocks is possible using the high performance internal PLL. A dedicated CLKOUT pin provides a high drive clock output.

A pass through option is provided which allows the device simply to be used to clean up (de-jitter) the received digital audio signals.

The device may be used under software control or stand alone hardware control modes. In software control mode, both 2-wire with read back and 3-wire interface modes are supported.

Status and error monitoring is built-in and results can be read back over the control interface, on the GPO pins or streamed over the audio data interface in 'With Flags' mode (audio data with status flags appended).

The audio data interface supports I<sup>2</sup>S, left justified, right justified and DSP audio formats of 16-24 bit word length, with sample rates from 32 to 192ks/s.

The device is supplied in a 20-lead Pb-free SSOP package.

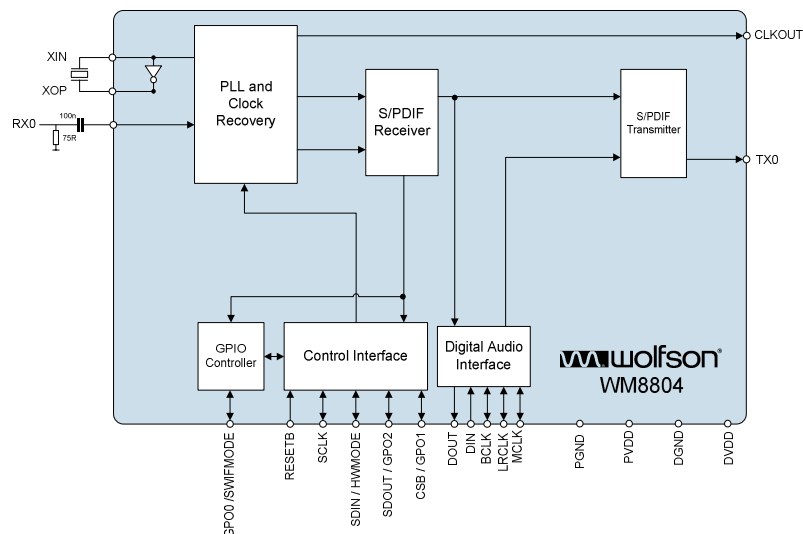
### FEATURES

- S/PDIF (IEC60958-3) compliant.
- Advanced jitter attenuating PLL with low intrinsic period jitter of 50 ps RMS.
- S/PDIF recovered clock using PLL, or stand alone crystal derived clock generation.
- Supports 10 – 27MHz crystal clock frequencies.
- 2-wire / 3-Wire serial or hardware control interface.
- Programmable audio data interface modes:
  - I<sup>2</sup>S, Left, Right Justified or DSP
  - 16/20/24 bit word lengths
- 1 channel receiver input and 1 channel transmit output.
- Auto frequency detection / synchronisation.
- Selectable output status data bits.
- Up to 3 configurable GPO pins.
- De-emphasis flag output.
- Non-audio detection including DOLBY™ and DTS™.
- Channel status changed flag.
- Configurable clock distribution with selectable output MCLK rate of 512fs, 256fs, 128fs and 64fs.
- 2.7 to 3.6V digital and PLL supply voltages.
- 20-lead SSOP package.

### APPLICATIONS

- AV processors and Hi-Fi systems
- Music industry applications
- DVD-P/DVD-RW
- Digital TV

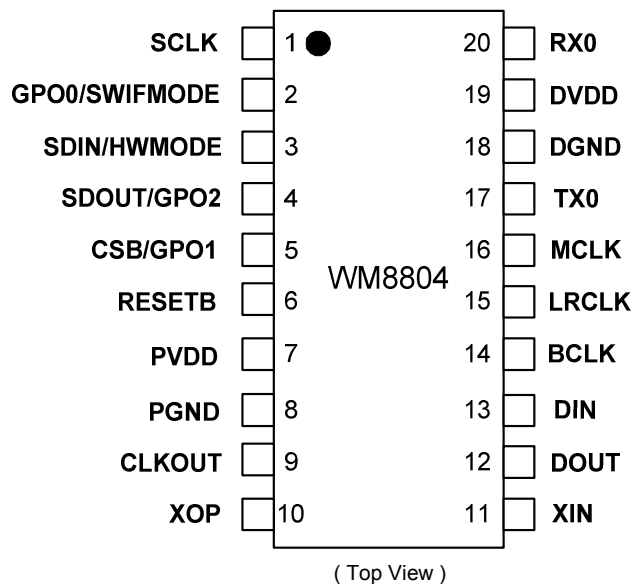
### BLOCK DIAGRAM



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## PIN CONFIGURATION



## ORDERING INFORMATION

| DEVICE        | TEMPERATURE RANGE | PACKAGE                                  | MOISTURE SENSITIVITY LEVEL | PEAK SOLDERING TEMPERATURE |
|---------------|-------------------|--|----------------------------|----------------------------|
| WM8804GEDS/V  | -40 to +85°C      | 20-lead SSOP<br>(Pb-free)                | MSL3                       | 260°C                      |
| WM8804GEDS/RV | -40 to +85°C      | 20-lead SSOP<br>(Pb-free, tape and reel) | MSL3                       | 260°C                      |

**Note:**

Reel quantity = 2,000

**PIN DESCRIPTION**

| PIN | NAME            | TYPE           | DESCRIPTION  |
|-----|-----------------|----------------|--|
| 1   | SCLK            | Digital In/Out | Control interface clock / GPO in hardware control mode. See note 2.  |
| 2   | GPO0 / SWIFMODE | Digital In/Out | General purpose digital output or selected functionality at hardware reset. See note 2.  |
| 3   | SDIN / HWMODE   | Digital Input  | Control interface data input and hardware/software mode select at hardware reset. See note 2.  |
| 4   | SDOUT / GPO2    | Digital In/Out | Control interface data output in 3-wire software control mode/ GPO in hardware control mode or 2-wire software control mode. See note 2. |
| 5   | CSB / GPO1      | Digital In/Out | Chip select / GPO in hardware control mode or 2-wire software control Mode. See note 2   |
| 6   | RESETB          | Digital Input  | System reset (active low)  |
| 7   | PVDD            | Supply         | PLL core supply  |
| 8   | PGND            | Supply         | PLL ground   |
| 9   | CLKOUT          | Digital Out    | High drive clock output at 64fs, 128fs, 256fs and 512fs  |
| 10  | XOP             | Digital Output | Crystal output   |
| 11  | XIN             | Digital Input  | Crystal input  |
| 12  | DOUT            | Digital Out    | Audio interface data output  |
| 13  | DIN             | Digital In     | Audio interface data input   |
| 14  | BCLK            | Digital In/Out | Audio interface bit clock  |
| 15  | LRCLK           | Digital In/Out | Audio interface left/right word clock  |
| 16  | MCLK            | Digital In/Out | Master clock input or output   |
| 17  | TX0             | Digital Out    | S/PDIF transmit channel  |
| 18  | DGND            | Supply         | Digital ground   |
| 19  | DVDD            | Supply         | Digital core supply  |
| 20  | RX0             | Digital In     | S/PDIF receive channel   |

**Notes:**

1. Digital input pins have Schmitt trigger input buffers.
2. Refer to Table 6 Device Configuration at Power up or Hardware Reset

## ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings are stress ratings only. Permanent damage to the device may be caused by continuously operating at or beyond these limits. Device functional operating limits and guaranteed performance specifications are given under Electrical Characteristics at the test conditions specified.



ESD Sensitive Device. This device is manufactured on a CMOS process. It is therefore generically susceptible to damage from excessive static voltages. Proper ESD precautions must be taken during handling and storage of this device.

Wolfson tests its package types according to IPC/JEDEC J-STD-020B for Moisture Sensitivity to determine acceptable storage conditions prior to surface mount assembly. These levels are:

MSL1 = unlimited floor life at <30°C / 85% Relative Humidity. Not normally stored in moisture barrier bag.

MSL2 = out of bag storage for 1 year at <30°C / 60% Relative Humidity. Supplied in moisture barrier bag.

MSL3 = out of bag storage for 168 hours at <30°C / 60% Relative Humidity. Supplied in moisture barrier bag.

The Moisture Sensitivity Level for each package type is specified in Ordering Information.

| CONDITION                                   | MIN        | MAX        |
|---|------------|------------|
| Digital core and I/O buffer supply voltage  | -0.3V      | +5V        |
| PLL supply voltage                          | -0.3V      | +5V        |
| Voltage range digital inputs                | DGND -0.3V | DVDD +0.3V |
| Master Clock Frequency                      |            | 37MHz      |
| Operating temperature range, T <sub>A</sub> | -40°C      | +85°C      |
| Storage temperature                         | -65°C      | +150°C     |

**Note:**

1. PLL and digital supplies must always be within 0.3V of each other.
2. PLL and digital grounds must always be within 0.3V of each other.

**RECOMMENDED OPERATING CONDITIONS**

| PARAMETER            | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|----------------------|--------|-----------------|-----|-----|-----|------|
| Digital supply range | DVDD   |                 | 2.7 |     | 3.6 | V    |
| Ground               | DGND   |                 |     | 0   |     | V    |
| PLL supply range     | PVDD   |                 | 2.7 |     | 3.6 | V    |
| Ground               | PGND   |                 |     | 0   |     | V    |

**Notes:**

1. PLL and digital supplies must always be within 0.3V of each other.
2. PLL and digital grounds must always be within 0.3V of each other.

**SUPPLY CURRENT**

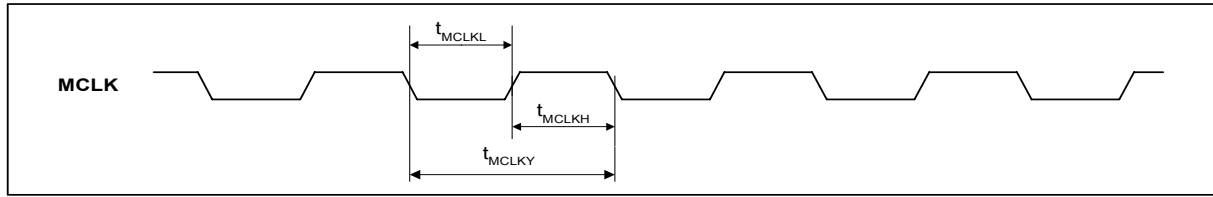
| PARAMETER                 | SYMBOL     | TEST CONDITIONS                         | MIN | TYP  | MAX | UNIT |
|---------------------------|------------|---|-----|------|-----|------|
| Digital supply current    | $I_{DVDD}$ | DVDD = 3.3V                             |     | 14.9 |     | mA   |
| PLL supply current        | $I_{PVDD}$ | PVDD = 3.3V                             |     | 1.7  |     | mA   |
| Power Consumption         |            | DVDD/PVDD = 3.3V                        |     | 54.8 |     | mW   |
| Standby Power Consumption |            | DVDD/PVDD = 3.3V<br>Device powered down |     | 0.11 |     | mW   |

**ELECTRICAL CHARACTERISTICS****Test Conditions**

PVDD = 3.3V, DVDD = 3.3V, PGND = 0V, DGND = 0V,  $T_A = +25^\circ\text{C}$ ,  $f_s = 48\text{kHz}$ , MCLK = 256fs unless stated.

| PARAMETER                                 | SYMBOL       | TEST CONDITIONS   | MIN        | TYP | MAX        | UNIT       |
|---|--------------|-------------------|------------|-----|------------|------------|
| <b>Jitter Characteristics</b>             |              |                   |            |     |            |            |
| Intrinsic Period Jitter                   | $J_i$        |                   |            | 50  |            | ps         |
| <b>Digital Logic Levels (CMOS Levels)</b> |              |                   |            |     |            |            |
| Input LOW level                           | $V_{IL}$     |                   |            |     | 0.3 x DVDD | V          |
| Input HIGH level                          | $V_{IH}$     |                   | 0.7 x DVDD |     |            | V          |
| Output LOW                                | $V_{OL}$     |                   |            |     | 0.1 x DVDD | V          |
| Output HIGH                               | $V_{OH}$     |                   | 0.9 x DVDD |     |            | V          |
| CLOCKOUT buffer drive capability          | $I_{source}$ | CMOS<br>20pF load | 25         |     |            | mA         |
|   | $I_{sink}$   |                   | 25         |     |            | mA         |
| <b>S/PDIF Receiver Characteristics</b>    |              |                   |            |     |            |            |
| Input Resistance                          |              |                   |            | 23  |            | k $\Omega$ |

**MASTER CLOCK TIMING**



**Figure 1 Slave Mode MCLK Timing Requirements**

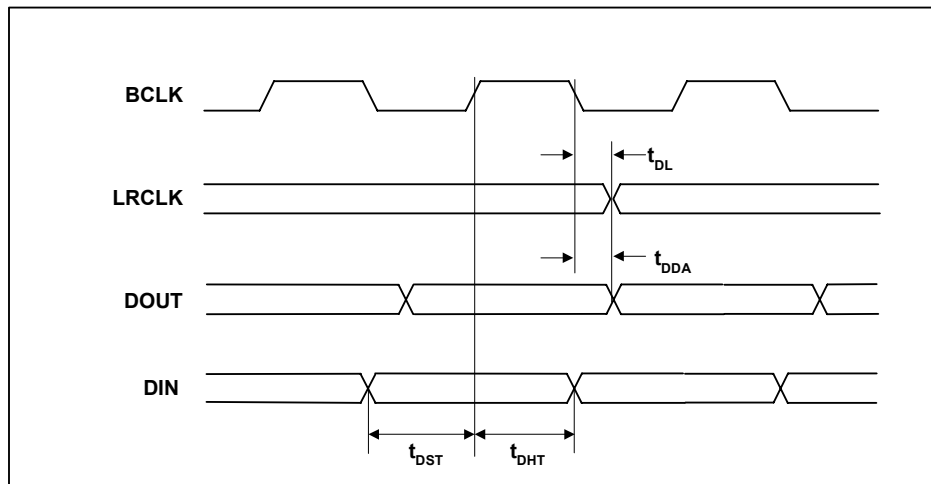
**Test Conditions**

PVDD = 3.3V, DVDD = 3.3V, PGND = 0V, DGND = 0V,  $T_A = +25^\circ\text{C}$ ,  $f_s = 48\text{kHz}$ , MCLK = 256fs unless stated.

| PARAMETER   | SYMBOL      | TEST CONDITIONS | MIN   | TYP | MAX   | UNIT |
|---|-------------|-----------------|-------|-----|-------|------|
| <b>System Clock Timing Information – Slave Mode</b> |             |                 |       |     |       |      |
| MCLK System clock cycle time                        | $t_{MCLKY}$ |                 | 27    |     |       | ns   |
| MCLK System clock pulse width high                  | $t_{MCLKH}$ |                 | 11    |     |       | ns   |
| MCLK System clock pulse width low                   | $t_{MCLKL}$ |                 | 11    |     |       | ns   |
| MCLK Duty cycle                                     |             |                 | 40:60 |     | 60:40 | %    |

**Table 1 Master Clock Timing Requirements**

**DIGITAL AUDIO INTERFACE – MASTER MODE**



**Figure 2 Digital Audio Data Timing – Master Mode**

**Test Conditions**

PVDD = 3.3V, DVDD = 3.3V, PGND = 0V, DGND = 0V,  $T_A = +25^\circ\text{C}$ ,  $f_s = 48\text{kHz}$ , MCLK = 256fs unless stated.

| PARAMETER                                      | SYMBOL    | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|-----------|-----------------|-----|-----|-----|------|
| <b>Audio Data Input Timing Information</b>     |           |                 |     |     |     |      |
| LRCLK propagation delay from BCLK falling edge | $t_{DL}$  |                 | 0   |     | 10  | ns   |
| DOUT propagation delay from BCLK falling edge  | $t_{DDA}$ |                 | 0   |     | 10  | ns   |
| DIN setup time to BCLK rising edge             | $t_{DST}$ |                 | 10  |     |     | ns   |
| DIN hold time from BCLK rising edge            | $t_{DHT}$ |                 | 10  |     |     | ns   |

**Table 2 Digital Audio Data Timing – Master Mode**

DIGITAL AUDIO INTERFACE – SLAVE MODE

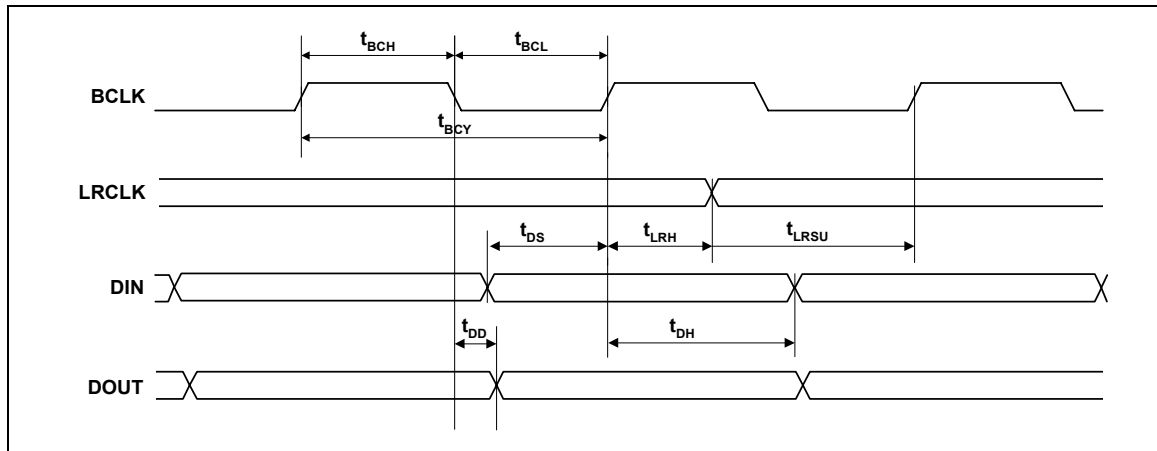


Figure 3 Digital Audio Data Timing – Slave Mode

Test Conditions

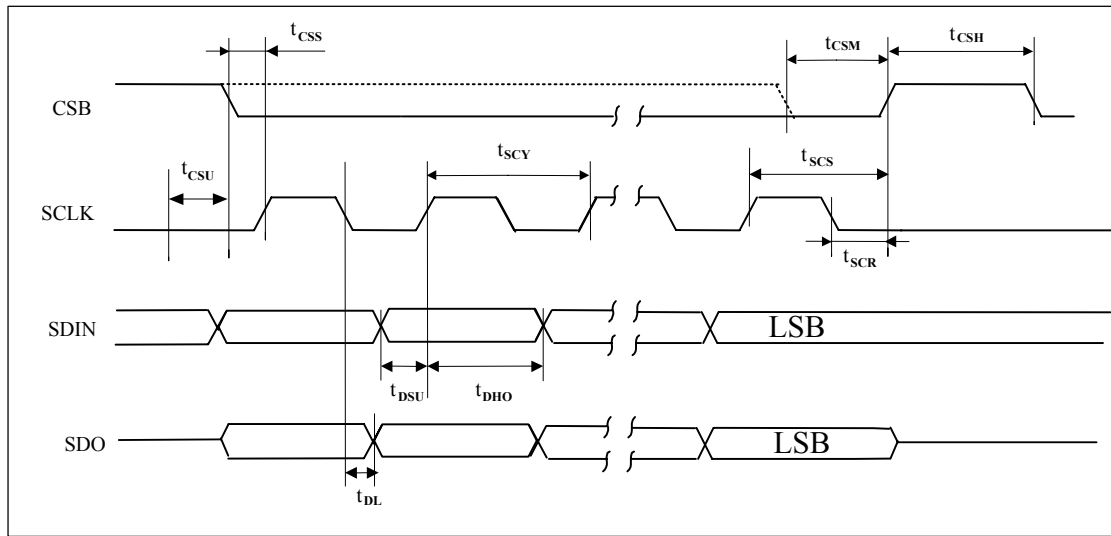
PVDD = 3.3V, DVDD = 3.3V, PGND = 0V, DGND = 0V, T<sub>A</sub> = +25°C, fs = 48kHz, MCLK = 256fs unless stated.

| PARAMETER                                     | SYMBOL            | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|-------------------|-----------------|-----|-----|-----|------|
| <b>Audio Data Input Timing Information</b>    |                   |                 |     |     |     |      |
| BCLK cycle time                               | t <sub>BCY</sub>  |                 | 50  |     |     | ns   |
| BCLK pulse width high                         | t <sub>BCH</sub>  |                 | 20  |     |     | ns   |
| BCLK pulse width low                          | t <sub>BCL</sub>  |                 | 20  |     |     | ns   |
| LRCLK set-up time to BCLK rising edge         | t <sub>LRSU</sub> |                 | 10  |     |     | ns   |
| LRCLK hold time from BCLK rising edge         | t <sub>LRH</sub>  |                 | 10  |     |     | ns   |
| DIN set-up time to BCLK rising edge           | t <sub>DS</sub>   |                 | 10  |     |     | ns   |
| DIN hold time from BCLK rising edge           | t <sub>DH</sub>   |                 | 10  |     |     | ns   |
| DOUT propagation delay from BCLK falling edge | t <sub>DD</sub>   |                 | 0   |     | 10  | ns   |

Table 3 Digital Audio Data Timing – Slave Mode



**CONTROL INTERFACE – 3-WIRE MODE**



**Figure 4 Control Interface Timing – 3-Wire Serial Control Mode**

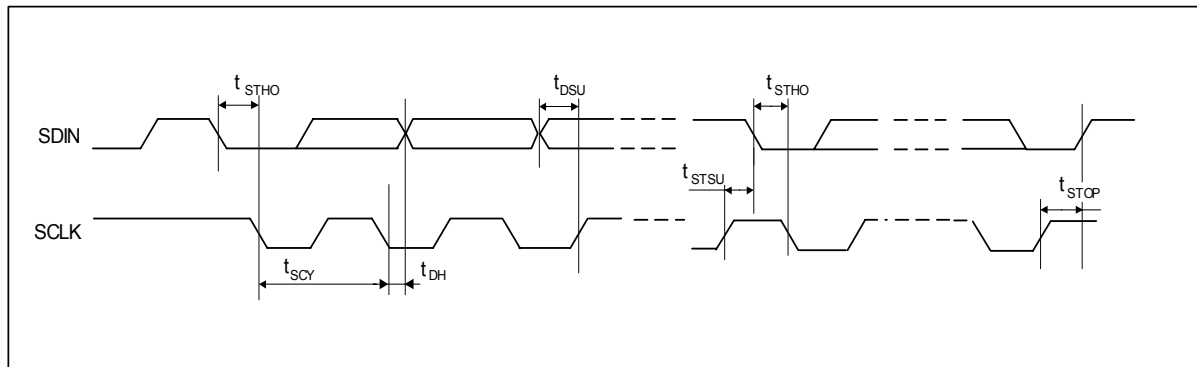
Test Conditions

PVDD = 3.3V, DVDD = 3.3V, PGND = 0V, DGND = 0V,  $T_A = +25^\circ\text{C}$ ,  $f_s = 48\text{kHz}$ , MCLK = 256fs unless stated.

| PARAMETER   | SYMBOL    | MIN             | TYP | MAX   | UNIT |
|---|-----------|-----------------|-----|-------|------|
| <b>Program Register Input Information</b>             |           |                 |     |       |      |
| SCLK rising edge to CSB rising edge                   | $t_{SCS}$ | 60              |     |       | ns   |
| SCLK cycle time                                       | $t_{SCY}$ | 80              |     |       | ns   |
| SCLK duty cycle                                       |           | 40/60           |     | 60/40 | %    |
| SDIN to SCLK set-up time                              | $t_{DSU}$ | 20              |     |       | ns   |
| SDIN hold time from SCLK rising edge                  | $t_{DHO}$ | 20              |     |       | ns   |
| SDOUT propagation delay from SCLK rising edge         | $t_{DL}$  |                 |     | 5     | ns   |
| CSB pulse width high                                  | $t_{CSH}$ | 20              |     |       | ns   |
| SCLK to CSB low (required for read cycle) set-up time | $t_{CSU}$ | 20              |     |       | ns   |
| CSB min (write cycle only)                            | $t_{CSM}$ | $0.5 * t_{SCY}$ |     |       | ns   |
| SCLK fall to CSB high                                 | $t_{SCR}$ | 20              |     |       | ns   |
| CSB rising/falling to SCLK rising                     | $t_{CSS}$ | 20              |     |       | ns   |
| SCLK glitch suppression                               | $t_{ps}$  | 2               |     | 8     | ns   |

**Table 4 Control Interface Timing – 3-Wire Serial Control Mode**

**CONTROL INTERFACE – 2-WIRE MODE**



**Figure 5 Control Interface Timing – 2-Wire Serial Control Mode**

Test Conditions

PVDD = 3.3V, DVDD = 3.3V, PGND = 0V, DGND = 0V,  $T_A = +25^\circ\text{C}$ ,  $f_s = 48\text{kHz}$ , MCLK = 256fs unless stated.

| PARAMETER                                 | SYMBOL     | MIN   | TYP | MAX   | UNIT |
|---|------------|-------|-----|-------|------|
| <b>Program Register Input Information</b> |            |       |     |       |      |
| SCLK cycle time                           | $t_{SCY}$  | 2500  |     |       | ns   |
| SCLK duty cycle                           |            | 40/60 |     | 60/40 | %    |
| SCLK frequency                            |            |       |     | 400   | kHz  |
| Hold Time (Start Condition)               | $t_{STHO}$ | 600   |     |       | ns   |
| Setup Time (Start Condition)              | $t_{STSU}$ | 600   |     |       | ns   |
| Data Setup Time                           | $t_{DSU}$  | 100   |     |       | ns   |
| SDIN, SCLK Rise Time                      |            |       |     | 300   | ns   |
| SDIN, SCLK Fall Time                      |            |       |     | 300   | ns   |
| Setup Time (Stop Condition)               | $t_{STOP}$ | 600   |     |       | ns   |
| Data Hold Time                            | $t_{DH}$   |       |     | 900   | ns   |
| SCLK glitch suppression                   | $t_{ps}$   | 2     |     | 8     | ns   |

**Table 5 Control Interface Timing – 2-Wire Serial Control Mode**

## DEVICE DESCRIPTION

### INTRODUCTION

#### FEATURES

- IEC-60958-3 compatible with 32 to 192k frames/s support.
- Supports AES-3 data frames.
- Support for reception and transmission of S/PDIF data.
- Clock synthesis PLL with reference clock input and low jitter output.
- Supports input reference clock frequencies from 10MHz to 27MHz.
- Dedicated high drive clock output pin.
- Register controlled channel status bit configuration.
- Register read-back of recovered channel status bits and error flags.
- Detection of non-audio data, sample rate and de-emphasis.
- Programmable GPOs for error flags and frame status flags.

The WM8804 is an IEC-60958 compatible S/PDIF transceiver with support for one received S/PDIF data stream and one transmitted S/PDIF data stream.

The receiver performs data and clock recovery, and transmits recovered data from the chip either through the digital audio interface or, alternatively, the device can loop the received S/PDIF data back out through the S/PDIF transmitter producing a de-jittered S/PDIF transmit data stream. The recovered clock may be routed to a high drive output pin for external use. If there is no S/PDIF input data stream the PLL can be configured to output all standard MCLK frequencies or it can be configured to maintain the frequency of the last received S/PDIF data stream.

The transmitter generates S/PDIF frames where audio data may be sourced from the S/PDIF receiver or the digital audio interface. Timing for the S/PDIF transmitter interface can be sourced from the internally derived MCLK in loop through mode or it can be taken from an external source.

#### S/PDIF FORMAT

S/PDIF is a serial, bi-phase-mark encoded data stream. An S/PDIF frame consists of two sub-frames. Each sub-frame is made up of:

- Preamble – a synchronization pattern used to identify the start of a 192-frame block or sub-frame
- 4-bit Auxiliary Data (AUX) – ordered LSB to MSB
- 20-bit Audio Data (24-bit when combined with AUX) – ordered LSB to MSB
- Validity Bit – a 1 indicates invalid data in the associated sub-frame
- User Bit – over 192-frames, this forms a User Data Block
- Channel Bit – over 192-frames, this forms a Channel Status Block
- Parity Bit – used to maintain even parity over the sub-frame (not including the preamble)

An S/PDIF Block consists of 192 frames. Channel and user blocks are incorporated within the 192-frame S/PDIF Block. For Consumer mode only the first 40-frames are used to make up the Channel and User blocks. Figure 6 illustrates the S/PDIF format. The WM8804 does not support transmission of user channel data. Received user channel data may be accessed via GPO pins.

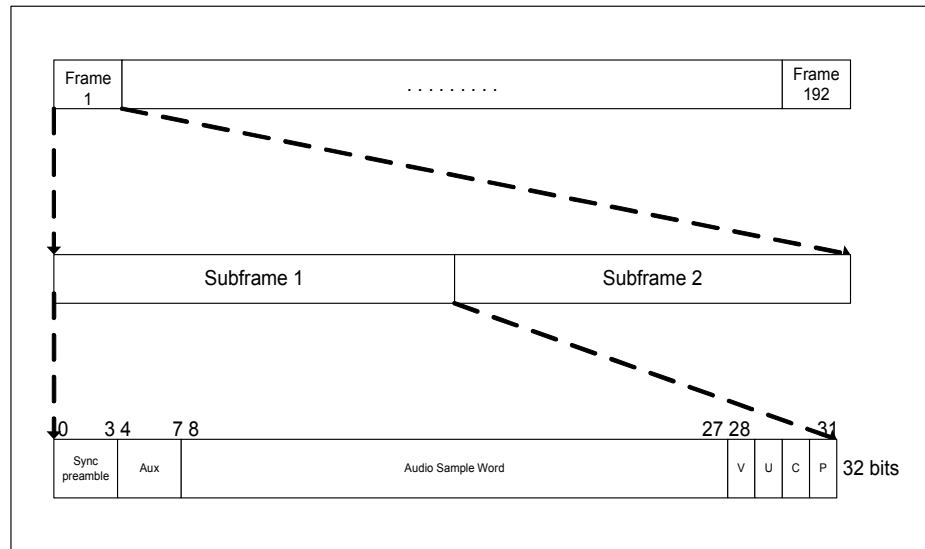


Figure 6 S/PDIF Format

### POWER UP CONFIGURATION

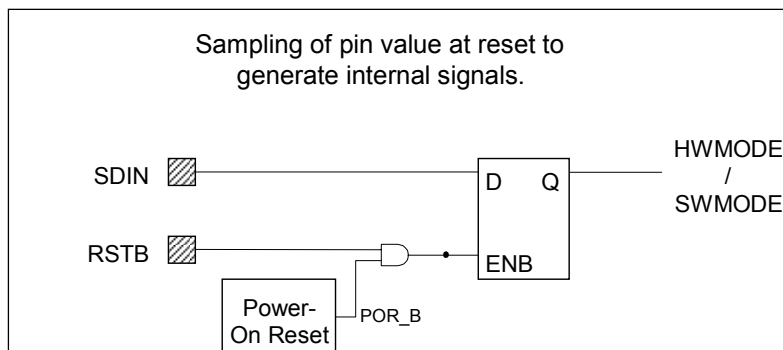
The operating mode of the WM8804 is dependent upon the state of SDIN, SCLK, SDOUT, CSB and GPO0 when the device is powered up or a hardware reset occurs. Table 6 summarises the configuration options.

|                |                           | HW RESET = 0           |             | HW RESET = 1 |                 |                 |
|----------------|---------------------------|------------------------|-------------|--------------|-----------------|-----------------|
|                |                           | SWMODE                 | HWMODE      | SWMODE       | HWMODE          |                 |
| <b>PIN</b>     | <b>SDIN</b>               | HWMODE / SWMODE Select |             | SDIN         | N/A             |                 |
|                | <b>SCLK</b>               | N/A                    |             | SCLK         | GPO (TRANS_ERR) |                 |
|                | <b>SDOUT</b>              | N/A                    |             | AIF_CONF[0]  | 2-wire          | GPO (NON_AUDIO) |
|                |                           |                        |             |              | GPO             |                 |
|                | <b>CSB</b>                | 2-wire                 | 3-wire      | TXSRC        | 2-wire          | GPO (UNLOCK)    |
| Device Address |                           | N/A                    | GPO         |              | CSB             |                 |
| <b>GPO0</b>    | 2-wire/3-wire Mode Select |                        | AIF_CONF[1] | GPO          | GPO (GEN_FLAG)  |                 |

**Note:** AIF\_CONF[1:0] configures the audio interface when the device operates in hardware mode. Refer to Table 16 for description of modes.

Table 6 Device Configuration at Power up or Hardware Reset

When the device powers up, all power up configuration pins are configured as inputs for a minimum of 9.4 $\mu$ s and a maximum of 25.6 $\mu$ s following the release of the external reset. The times are based on 27MHz and 10MHz crystal clock frequencies respectively. This enables the pins to be sampled and the device to be configured before the pins are released to their selected operating conditions. Figure 7 illustrates how SDIN is sampled.



**Figure 7 Pin Sampling On Power Up or Hardware Reset**

If the device is powered up in software control mode, all functions of the device are powered down by default and must be powered up individually by writing to the relevant bits of the PWRDN register (Table 7). In hardware control mode, all functions of the device are powered up by default.

| REGISTER ADDRESS    | BIT | LABEL         | DEFAULT | DESCRIPTION  |
|---------------------|-----|---------------|---------|--|
| R30<br>PWRDN<br>1Eh | 0   | PLLPD         | 1       | <b>PLL powerdown</b><br>0 = PLL enabled<br>1 = PLL disabled  |
|                     | 1   | SPDIFRXP<br>D | 1       | <b>S/PDIF receiver powerdown</b><br>0 = S/PDIF receiver enabled<br>1 = S/PDIF receiver disabled          |
|                     | 2   | SPDIFTXPD     | 1       | <b>S/PDIF transmitter powerdown</b><br>0 = S/PDIF transmitter enabled<br>1 = S/PDIF transmitter disabled |
|                     | 3   | OSCPD         | 0       | <b>Oscillator power down</b><br>0 = Power Up<br>1 = Power Down   |
|                     | 4   | AIFPD         | 0       | <b>Digital audio interface power down</b><br>0 = Power Up<br>1 = Power Down                              |
|                     | 5   | TRIOP         | 0       | <b>Tri-state all outputs</b><br>0 = Outputs not tri-stated<br>1 = Outputs tri-stated                     |

**Table 7 Power Down Register**

## CONTROL INTERFACE OPERATION

Control of the WM8804 is implemented in either hardware control mode or software control mode. The method of control is determined by sampling the state of the SDIN/HWMODE pin at power up or at a hardware reset. If SDIN/HWMODE is low during power up the device is configured in hardware control mode, otherwise the device is configured in software control mode.

| SDIN/HWMODE |               |
|-------------|---------------|
| 0           | Hardware mode |
| 1           | Software mode |

**Table 8 Hardware or Software Mode Select**

Software control is achieved using a 3-wire (3-wire write, 4-wire read) or a 2-wire serial interface.

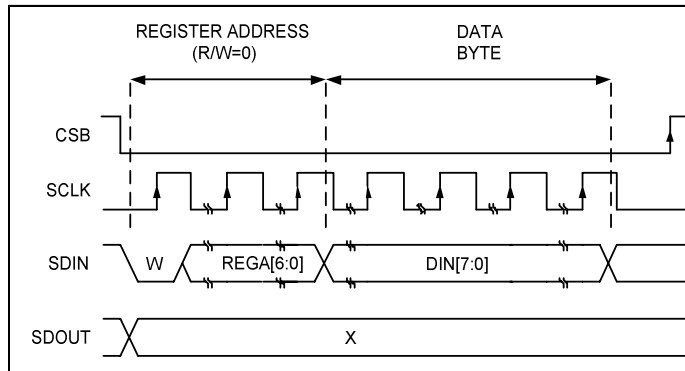
The serial interface format is configured by sampling the state of the GPO0/SWIFMODE pin on power up or at a hardware reset. If the GPO0/SWIFMODE pin is low the interface is configured in 2-wire mode, otherwise the interface is configured in 3-wire SPI compatible mode.

| GPO0/SWIFMODE |                  |
|---------------|------------------|
| 0             | 2-wire interface |
| 1             | 3-wire interface |

**Table 9 Software Mode Control Interface Select**

### 3-WIRE (SPI COMPATIBLE) SERIAL CONTROL MODE – REGISTER WRITE

SDIN is used for the program data, SCLK is used to clock in the program data and CSB is used to latch in the program data. SDIN is sampled on the rising edge of SCLK. The 3-wire interface write protocol is shown in Figure 8. The CSB can be low for the duration of the write cycle or it can be a short CSB pulse at the end of the write cycle.



**Figure 8 3-Wire Serial Interface Register Write Protocol**

- W is a control bit indicating a read or write operation. 0 =write operation, 1 = read operation
- REGA[6:0] is the register address.
- DIN[7:0] is the data to be written to the register being addressed.
- CSB is edge sensitive – the data is latched on the rising edge of CSB.

**3-WIRE SERIAL CONTROL MODE REGISTER READ-BACK**

Not all registers can be read. Only the device ID (registers R0, R1 and R2) and the status registers can be read. These status registers are labelled as “read only” in the Register Map section.

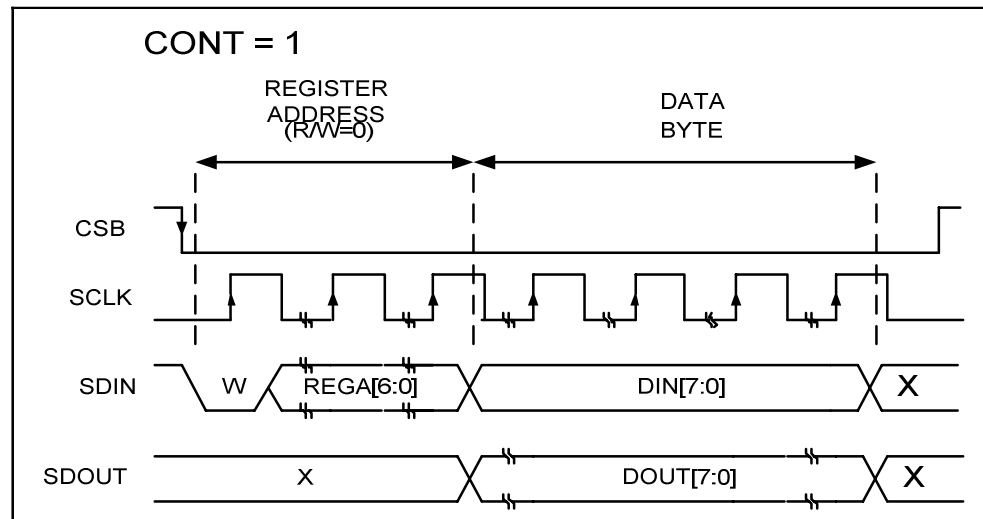
The read-only status registers can be read back via the SDOUT pin. The registers can be read by one of two methods, selected by the CONT register bit and the ‘W’ control bit. The oscillator must be powered up before 3-wire control interface read-back is possible.

When CONT =1 and ‘W’=0, a single read-only register can be read back by writing to any other register or to a dummy register. The register to be read is determined by the READMUX[2:0] bits. When a write to the device is performed, the device will respond by returning the status byte in the register selected by the READMUX register bits. This 3-wire interface read back method using a write access is shown in Figure 9.

| REGISTER ADDRESS     | BIT | LABEL            | DEFAULT | DESCRIPTION   |
|----------------------|-----|------------------|---------|---|
| R29<br>SPDRX1<br>1Dh | 2:0 | READMUX<br>[2:0] | 000     | <b>Status Register Select</b><br>Determines which status register is to be read back:<br>000 = Interrupt Status Register<br>001 = Channel Status Register 1<br>010 = Channel Status Register 2<br>011 = Channel Status Register 3<br>100 = Channel Status Register 4<br>101 = Channel Status Register 5<br>110 = S/PDIF Status Register |
|                      | 3   | CONT             | 0       | <b>Continuous Read Enable</b><br>0 = Continuous read-back mode disabled<br>1 = Continuous read-back mode enabled  |

**Table 10 Read-Back Control Register**

The SDOUT pin is tri-state unless CSB is held low; therefore CSB must be held low for the duration of the read.



**Figure 9 3-Wire Control Interface Read-Back Method 1**

The second method of reading the read only status registers is If CONT=0 and ‘W’=1. Using this method the user can read back directly from a register by reading the register address. The device will respond with the contents of the register. The protocol for this read-back method is shown in Figure 10.

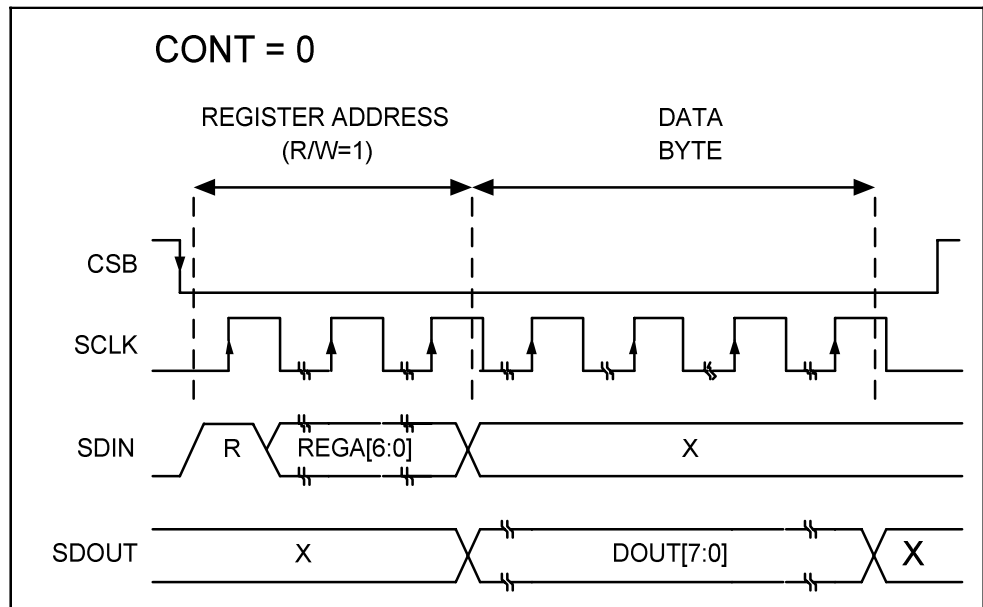


Figure 10 3-Wire Control Interface Read-Back Method 2

**2-WIRE SERIAL CONTROL MODE - REGISTER WRITE**

The WM8804 supports software control via a 2-wire serial bus. Many devices can be controlled by the same bus and each device has a unique 7-bit address (see Table 11).

The controller indicates the start of data transfer with a high to low transition on SDIN while SCLK remains high. This indicates that a device address, DEVA(7:1), and data, REG(6:0), will follow. All devices on the 2-wire bus will shift in the next eight bits on SDIN (7-bit address DEVA(7:1), + read/write 'W' bit, MSB first). If the device address received matches the address of the WM8804, the WM8804 responds by driving SDIN low on the next clock pulse (ACK). This is a device acknowledgement of an address match. If the address does not match that of the WM8804, the device returns to the idle condition and waits for a new start condition and valid address.

Once the WM8804 has acknowledged a matching address, the controller sends the first byte of control data, which is the WM8804 register address (REGA[6:0]). The WM8804 then acknowledges reception of the control data byte by pulling SDIN low for one clock pulse (another ACK). The controller then sends the second byte of control data (DIN[7:0], i.e. the eight bits of register data to be written), and the WM8804 acknowledges again by pulling SDIN low (another ACK).

The transfer of data is complete when there is a low to high transition on SDIN while SCLK is high. After receiving a complete address and data sequence the WM8804 returns to the idle state and waits for another start condition. If a start or stop condition is detected out of sequence at any point during data transfer (i.e. SDIN changes while SCLK is high), the device returns to the idle condition.

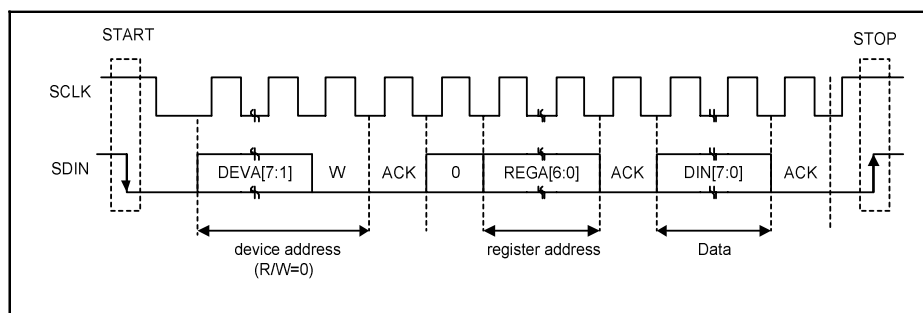


Figure 11 2-Wire Serial Control Interface Write



Multiple consecutive register writes can be performed in 2-wire control mode by setting the CONT bit high. This method allows the entire register map to be defined in a one continuous write operation.

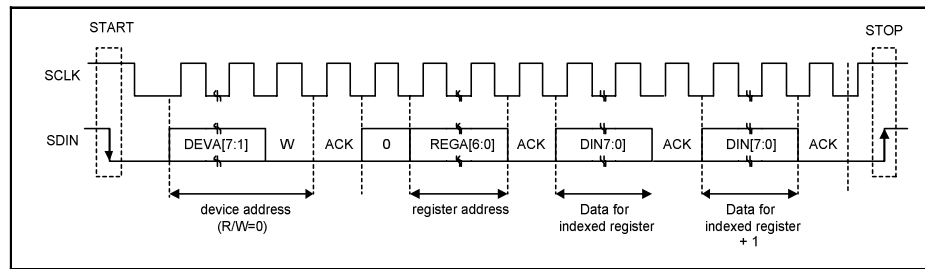


Figure 12 2-Wire Serial Control Interface Multi-Write

The WM8804 has two possible device addresses, which can be selected using the CSB pin during hardware reset.

| CSB STATE | DEVICE ADDRESS IN 2-WIRE MODE | ADDRESS (X=R/W BIT) |      |
|-----------|-------------------------------|---------------------|------|
|           |                               | X=0                 | X= 1 |
| Low       | 0111010x                      | 0x74                | 0x75 |
| High      | 0111011x                      | 0x76                | 0x77 |

Table 11 2-Wire Interface Address Selection

**2-WIRE SERIAL CONTROL MODE -REGISTER READ-BACK**

The WM8804 allows read-back of certain registers in 2-wire mode. The protocol is similar to that used to write to the device. The controller will issue the device address followed by a write bit, the register index will then be passed to the WM8804. At this point the controller will issue a repeated start condition and resend the device address along with a read bit. The WM8804 will acknowledge this and the WM8804 will become a slave transmitter. The WM8804 will transmit the data from the indexed register on SDIN MSB first. When the controller receives the data it will not acknowledge receipt of the data indicating that it will resume master transmitter control of SDIN. The controller will then issue a stop command completing the read cycle. Figure 13 illustrates the read protocol.

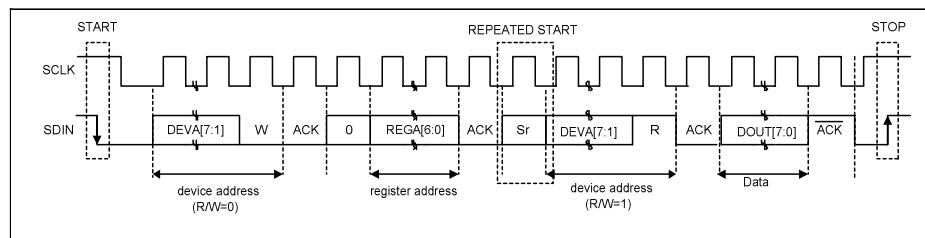


Figure 13 2-Wire Serial Control Interface Read (CONT=0)

**2-WIRE SERIAL CONTROL MODE – CONTINUOUS READ-BACK**

As in 3-wire mode, there are two methods of reading back data: continuous and non-continuous read-back. Continuous read-back is selected by setting CONT to 1. In continuous read-back mode, the device will return the indexed register first followed by consecutive registers in increasing index order until the controller does not acknowledge the data then issues a stop sequence. This is shown in Figure 14

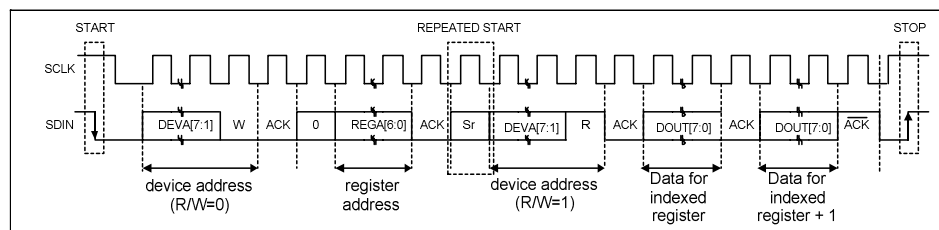


Figure 14 2-Wire Serial Interface Continuous Read-Back (CONT=1)

### SOFTWARE REGISTER RESET

Writing to register 0000000 will reset the WM8804. This will reset all register bits to their default values. The WM8804 is powered down by default so writing to this register will power down the device.

### DEVICE ID AND REVISION IDENTIFICATION

Registers 0,1 and 2 can be read to identify the device ID and IC revision number. Refer to Table 12 for details.

| REGISTER ADDRESS                    | BIT | LABEL           | DEFAULT  | DESCRIPTION  |
|-------------------------------------|-----|-----------------|----------|--|
| R00<br>RST/DEVID1<br>00h            | 7:0 | RESET           | N/A      | Writing to this register will apply a reset to the device.                                 |
|                                     |     | DEVID1[7:0]     | 00000101 | Reading from this register will return the second part of the device ID<br>00000101 = 0x05 |
| R01<br>DEVID2<br>01h<br>(read only) | 7:0 | DEVID2[7:0]     | 10001000 | Reading from this register will return the first part of the device ID<br>10001000 = 0x88  |
| R02<br>DEVREV<br>02h                | 3:0 | DEVREV<br>[3:0] | N/A      | Reading from this register will return the device revision.<br>0x1 = revision 1            |

Table 12 Software Reset Register and Device ID

### HARDWARE CONTROL MODE

The WM8804 can be operated in either software or hardware control modes. The method of control is determined by sampling the state of the SDIN pin during power up or hard reset. If SDIN is LOW during power up or hardware reset, the WM8804 will be switched into hardware control mode.

| PIN  | 0                     | 1                     |
|------|-----------------------|-----------------------|
| SDIN | Hardware control Mode | Software control Mode |

Table 13 Hardware / Software Mode Configuration

In hardware control mode the user has limited control over the configuration of the device. Most of the features will assume default values but some can be configured using external pins. When the device is configured in hardware control mode, all functions of the device are powered up.

**The clock and data recovery module requires a 12 MHz crystal derived clock reference as the default values for this module cannot be altered in hardware control mode.**

### MASTER / SLAVE MODE SELECTION

The WM8804 can be configured in either master or slave mode. In software control mode this is set by writing to AIF\_MS in the AIFRX register. In hardware control mode this is controlled by sampling the SCLK pin on power up or hardware reset.

| PIN<br>(HARDWARE MODE) | REGISTER<br>(SOFTWARE MODE) | 0          | 1           |
|------------------------|-----------------------------|------------|-------------|
| SCLK                   | AIF_MS                      | Slave mode | Master mode |

Table 14 Master / Slave Mode Configuration in Hardware Mode

**DIGITAL ROUTING CONTROL**

See page 20 for a full description of the signal routing options available in the WM8804. In Software control mode the value set in register TXSRC determines the S/PDIF transmitter data source. In hardware control mode the value of TXSRC can be set using the CSB pin.

| PIN<br>(HARDWARE<br>MODE) | REGISTER<br>(SOFTWARE<br>MODE) | 0         | 1      |
|---------------------------|--------------------------------|-----------|--------|
| CSB                       | TXSRC                          | S/PDIF Rx | AIF Rx |

**Table 15 S/PDIF Transmitter Digital Routing Control Configuration**

**AUDIO INTERFACE CONTROL**

In software control mode the audio data word length and audio data format can be set independently for the receiver and transmitter sides of the interface. However, in hardware control mode both sides of the interface are combined and the configuration is set using SDOUT and GPO0 pins as described in Table 6 and Table 16. Note that AIF\_CONF[1:0] configures the audio interface when the device operates in hardware mode.

| GPO0 /<br>AIFCONF[1] | SDOUT /<br>AIFCONF[0] | DESCRIPTION                      |
|----------------------|-----------------------|----------------------------------|
| 0                    | 0                     | 16-bit I <sup>2</sup> S          |
| 0                    | 1                     | 24-bit I <sup>2</sup> S          |
| 1                    | 0                     | 24-bit Left Justified With Flags |
| 1                    | 1                     | 16-bit Right Justified           |

**Table 16 Digital Audio Interface Control in Hardware Control Mode**

**STATUS INFORMATION**

In hardware control mode the WM8804 outputs a selection of status flags for the user. Table 17 describes the flags which are available and the output pins on which they are available.

| PIN   | STATUS FLAG |
|-------|-------------|
| SCLK  | TRANS_ERR   |
| SDOUT | NON_AUDIO   |
| CSB   | UNLOCK      |
| GPO0  | GEN_FLAG    |

**Table 17 Hardware Control Mode Status Flag Configuration**

A full description of the status flags is given in Table 45.

DIGITAL ROUTING CONTROL

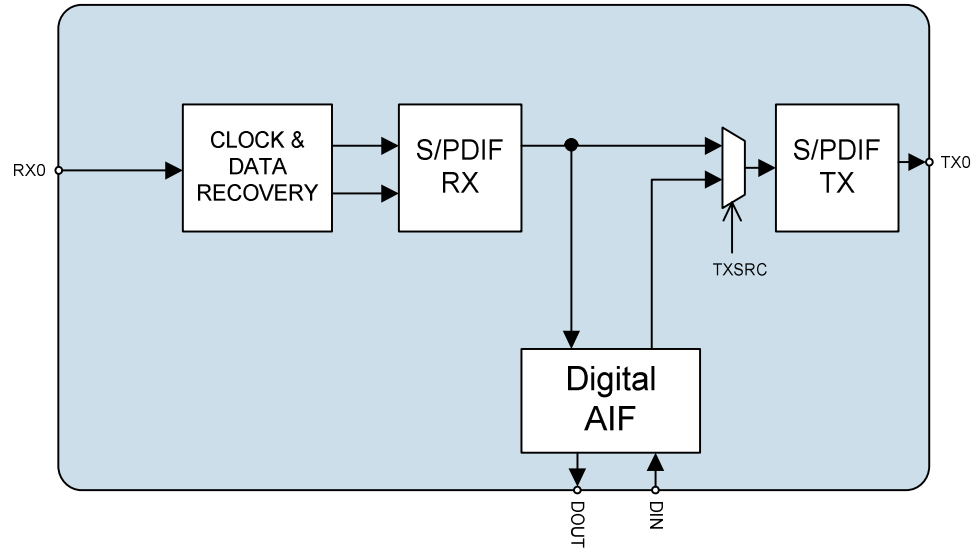


Figure 15 Digital Routing Paths within the WM8804

Digital signal routing within the WM8804 is controlled by the TXSRC register. In order to ensure proper operation when changing TXSRC, the S/PDIF transmitter module should be powered down prior to changing the TXSRC control register and powered up again once the routing path has been changed.

| REGISTER ADDRESS      | BIT | LABEL     | DEFAULT | DESCRIPTION  |
|-----------------------|-----|-----------|---------|--|
| R30<br>PWRDN<br>1Eh   | 2   | SPDIFTXPD | 1       | <b>S/PDIF Transmitter Powerdown</b><br>0 = S/PDIF transmitter enabled<br>1 = S/PDIF transmitter disabled   |
| R21<br>SPDCTX4<br>15h | 6   | TXSRC     | 1       | <b>S/PDIF Transmitter Data Source</b><br>0 = S/PDIF Received Data – SPDIFTXCLK Source = CLK2<br>1 = Digital Audio Interface Received Data – SPDIFTXCLK Source = MCLK Input/Output Signal at MCLK Pin |

Table 18 Digital Signal Routing Control Registers

## MASTER CLOCK AND PHASE LOCKED LOOP

### SOFTWARE MODE INTERNAL CLOCKING

The WM8804 is equipped with a comprehensive clocking scheme that provides maximum flexibility and many configurable routing possibilities for the user in software mode. An overview of the software mode clocking scheme is shown in Figure 16.

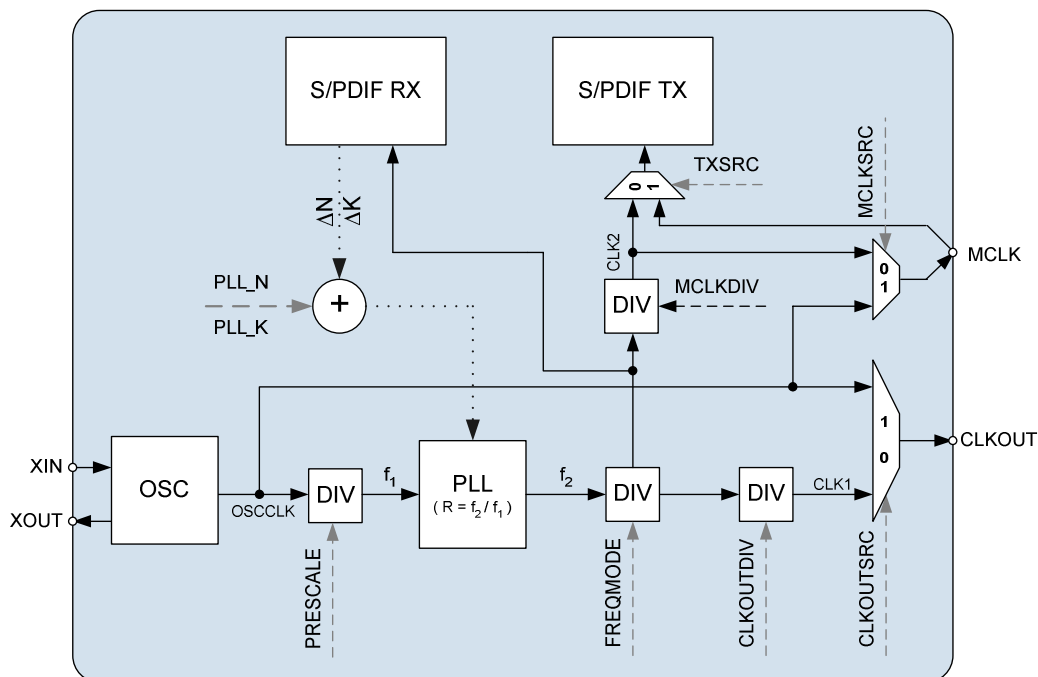


Figure 16 Software Mode Clocking Scheme

The clocking scheme can be divided into four sections. These are detailed as follows:

#### OSCILLATOR

The primary function of the oscillator is to generate the oscillator clock (OSCCLK) for the PLL input. Whenever the PLL or the S/PDIF receiver is enabled, the oscillator must be used to generate the OSCCLK signal for the PLL.

The secondary function of the oscillator is to generate the OSCCLK so that it can be selected internally as the clock source for:

- The MCLK output pin, when the pin is configured as an output.
- The CLKOUT output pin, when enabled.

The oscillator has one control bit as shown in Table 19. The oscillator must be powered up to generate the OSCCLK signal.

| REGISTER ADDRESS    | BIT | LABEL | DEFAULT | DESCRIPTION  |
|---------------------|-----|-------|---------|--|
| R30<br>PWRDN<br>1Eh | 3   | OSCPD | 1       | <b>Oscillator Power Down Control</b><br>0 = Power up<br>1 = Power down |

Table 19 Oscillator Control

The oscillator uses a Pierce type oscillator drive circuit. This circuit requires an external crystal and appropriate external loading capacitors. The oscillator circuit contains a bias generator within the WM8804 and hence an external bias resistor is not required. Crystal frequencies between 10 and 14.4MHz or 16.28 and 27MHz can be used in software mode. The recommended circuit is shown in the recommended components diagram, please refer to Figure 28.

Alternatively, an external CMOS compatible clock signal can be applied to the XIN pin in the absence of a crystal, although this is not recommended when using the PLL as the PLL requires a jitter-free OSCCLK signal for optimum performance.

#### PHASE-LOCKED LOOP (PLL)

The WM8804 has an on-chip phase-locked loop (PLL) circuit that can be used to synthesise clock signals from the external oscillator clock. The PLL can be used to:

- Generate clocks necessary for the S/PDIF receiver to lock on to and recover S/PDIF data from an incoming S/PDIF data stream.
- Generate clocks which may be used to drive the MCLK and/or CLKOUT pins.
- Generate clocks which may be used by the S/PDIF transmitter to encode and transmit a S/PDIF data stream.

The PLL can be enabled or disabled using the PLLPD register bit as shown in Table 20.

| REGISTER ADDRESS    | BIT | LABEL | DEFAULT | DESCRIPTION   |
|---------------------|-----|-------|---------|---|
| R30<br>PWRDN<br>1Eh | 0   | PLLPD | 1       | <b>PLL Power Down Control</b><br>0 = Power up PLL<br>1 = Power down PLL |

**Table 20 PLL Power Down Control**

The PLL has two modes of operation:

- **S/PDIF Receive Mode (Automatic PLL Mode – Selected if S/PDIF Receiver Enabled)**

In S/PDIF receive mode, the PLL is automatically controlled by the S/PDIF receiver to allow the receiver to use the PLL to lock on to and track the incoming S/PDIF data stream.

Please refer to the S/PDIF Receiver section within the Internal Clocking description for full details.

If the CLKOUT or MCLK clocks are sourced from either CLK1 or CLK2 in this mode, the frequency of these signals will be modified based on the clock rate of the incoming S/PDIF data stream. If the sample rate of the incoming stream is changed, the MCLK and CLKOUT signals will continue to be output, but will not be valid until the S/PDIF receiver has locked to the incoming stream at the new sample rate. If the incoming S/PDIF stream stops, the PLL N and K values will be frozen and the output clocks will continue at the frequency set by the last recovered S/PDIF stream. If the S/PDIF input stream is removed then it is possible for the PLL to detect small pulse as the data is being removed. This may result in the output clocks changing to an invalid frequency. Note also that if the device is power-on and configured with no S/PDIF input data stream, then the PLL will default to approximately 24MHz.

- **User Mode (Manual PLL Mode – Selected if S/PDIF Receiver Disabled)**

In user mode, the user has full control over the PLL function and operation. In this mode, the user can accurately specify the PLL N and K multiplier values (using the PLL\_N and PLL\_K registers), divider values (PRESCALE and FREQMODE) and can hence control the generated CLK1 and CLK2 frequencies. Refer to Table 21 for details of the registers available for configuration in this mode.

| REGISTER ADDRESS  | BIT | LABEL        | DEFAULT  | DESCRIPTION  |
|-------------------|-----|--------------|----------|--|
| R3<br>PLL1<br>03h | 7:0 | PLL_K[7:0]   | 00100001 | Fractional (K) part of PLL frequency ratio (R).<br>Value K is one 22-digit binary number spread over registers R3, R4 and R5 as shown.   |
| R4<br>PLL2<br>04h | 7:0 | PLL_K[15:8]  | 11111101 | <b>Note: PLL_K must be set to specific values when the S/PDIF Receiver clocking section for details.</b>   |
| R5<br>PLL3<br>05h | 5:0 | PLL_K[21:16] | 00110110 |  |
| R6<br>PLL4<br>06h | 3:0 | PLL_N[3:0]   | 0111     | Integer (N) part of PLL frequency ratio (R).<br>Use values in the range $5 \leq \text{PLL\_N} \leq 13$ as close as possible to 8<br><b>Note: PLL_N must be set to specific values when the S/PDIF Receiver clocking section for details.</b> |

Table 21 User Mode PLL\_K and PLL\_N Multiplier Control

#### PLL CONFIGURATION

The PLL performs a configurable frequency multiplication of the input clock signal ( $f_1$ ). The multiplication factor of the PLL (denoted by 'R') is variable and is defined by the relationship:  $R = (f_2 \div f_1)$ .

The multiplication factor is set using register bits PLL\_N and PLL\_K (refer to Table 21). The multiplication effect of both the N and K multipliers are additive (i.e. if N is configured to provide a multiplication factor of 8 and K is configured to provide a multiplication factor of 0.192, the overall multiplication factor is  $8 + 0.192 = 8.192$ ).

In order to choose and configure the correct values for PLL\_N and PLL\_K, multiplication factor R must first be calculated. Once value R is calculated, the value of PLL\_N is the integer (whole number) value of R, ignoring all digits to the right of the decimal point. For example, if R is calculated to be 8.196523, PLL\_N is simply 8.

Once PLL\_N is calculated, the PLL\_K value is simply the integer value of  $(2^{22} (R - \text{PLL\_N}))$ . For example, if R is 8.196523 and PLL\_N is 8, PLL\_K is therefore  $(2^{22} (8.196523 - 8))$ , which is 824277 (ignoring all digits to the right of the decimal point).

**Note:** The PLL is designed to operate with best performance (shortest lock time and optimum stability) when  $f_2$  is between 90 and 100MHz and PLL\_N is 8. However, acceptable PLL\_N values lie in the range  $5 \leq \text{PLL\_N} \leq 13$ . Do not use values outwith this range and it is recommended that the chosen value of PLL\_N is as close to 8 as possible for optimum performance.

An output divider is provided to allow the  $f_2$  clock signal to be divided to a frequency suitable for use as the source for the MCLK, CLKOUT or S/PDIF transmitter. The divider output is configurable and is set by the FREQMODE bits. The PLL is also equipped with a pre-scale divider which offers frequency divide by one or two before the OSCCLK signal is fed to the PLL. Please refer to

| REGISTER ADDRESS  | BIT | LABEL         | DEFAULT | DESCRIPTION  |
|-------------------|-----|---------------|---------|--|
| R6<br>PLL4<br>06h | 4   | PRESCALE      | 0       | <b>PLL Pre-scale Divider Select</b><br>0 = Divide by 1 (PLL input clock = oscillator clock)<br>1 = Divide by 2 (PLL input clock = oscillator clock ÷ 2)  |
| R7<br>PLL5<br>07h | 1:0 | FREQMODE[1:0] | 10      | <b>PLL Post-scale Divider Select</b><br>Selects the PLL output divider value in conjunction with MCLKDIV and CLKOUTDIV.<br>Refer to Table 23 for details of FREQMODE operation.<br><b>Note: FREQMODE[1:0] bits are automatically set in S/PDIF Receive Mode.</b> |

Table 22 Pre and Post PLL Clock Divider Control

### PLL CONFIGURATION EXAMPLE

Consider the situation where the oscillator clock (OSCCLK) input frequency is fixed at 12MHz and the required MCLK frequency is 12.288MHz.

#### 1. Calculate the $f_2$ , FREQMODE and MCLKDIV Values

The PLL is designed to operate with best performance when the  $f_2$  clock is between 90 and 100MHz. The necessary MCLK frequency is 12.288MHz. Choose MCLKDIV and FREQMODE values to set the  $f_2$  frequency in the range of 90 to 100MHz. In this case, the default values (MCLKDIV = 0 and FREQMODE[1:0] = 10) will set the  $f_2$  frequency at 98.304MHz; this value is within the 90 to 100MHz range and is hence acceptable.

- MCLKDIV = 0
- FREQMODE[1:0] = 10
- $f_2 = 98.304\text{MHz}$

#### 2. Calculate R Value

Using the relationship:  $R = (f_2 \div f_1)$ , the value of R can be calculated.

- $R = (f_2 \div f_1)$
- $R = (98.304 \div 12)$
- $R = 8.192$

#### 3. Calculate PLL\_N Value

The value of PLL\_N is the integer (whole number) value of R, ignoring all digits to the right of the decimal point. In this case, R is 8.192, hence PLL\_N is 8.

#### 4. Calculate PLL\_K Value

The PLL\_K value is simply the integer value of  $(2^{22} (R - \text{PLL\_N}))$ .

- $\text{PLL\_K} = \text{integer part of } (2^{22} \times (8.192 - 8))$
- $\text{PLL\_K} = \text{integer part of } 805306.368$
- $\text{PLL\_K} = 805306 \text{ (decimal)} / \text{C49BA (hex)}$

A number of example configurations are shown in Table 23. Many other configurations are possible; Table 23 shows only a small number of valid possibilities.



| OSC CLK (MHz) | PRE-SCALE | F <sub>1</sub> (MHz) | F <sub>2</sub> (MHz) | R      | PLL_N (Hex) | PLL_K (Hex) | FREQ MODE [1:0] | MCLK DIV | MCLK (MHz) | CLKOUT DIV [1:0] | CLK OUT (MHz) |
|---------------|-----------|----------------------|----------------------|--------|-------------|-------------|-----------------|----------|------------|------------------|---------------|
| 12            | 0         | 12                   | 98.304               | 8.192  | 8           | C49BA       | 00              | 1        | 24.576     | 01               | 49.152        |
| 12            | 0         | 12                   | 98.304               | 8.192  | 8           | C49BA       | 10              | 0        | 12.288     | 00               | 24.576        |
| 12            | 0         | 12                   | 98.304               | 8.192  | 8           | C49BA       | 10              | 1        | 6.144      | 01               | 12.288        |
| 12            | 0         | 12                   | 98.304               | 8.192  | 8           | C49BA       | 10              | 0        | 12.288     | 10               | 6.144         |
| 12            | 0         | 12                   | 98.304               | 8.192  | 8           | C49BA       | 10              | 1        | 6.144      | 11               | 3.072         |
| 24            | 1         | 12                   | 90.3168              | 7.5264 | 7           | 21B089      | 01              | 0        | 22.5792    | 00               | 45.1584       |
| 24            | 1         | 12                   | 90.3168              | 7.5264 | 7           | 21B089      | 10              | 0        | 11.2896    | 00               | 22.5792       |
| 24            | 1         | 12                   | 90.3168              | 7.5264 | 7           | 21B089      | 10              | 1        | 5.6448     | 01               | 11.2896       |
| 24            | 1         | 12                   | 90.3168              | 7.5264 | 7           | 21B089      | 10              | 0        | 11.2896    | 10               | 5.6448        |
| 24            | 1         | 12                   | 90.3168              | 7.5264 | 7           | 21B089      | 10              | 1        | 5.6448     | 11               | 2.8224        |
| 27            | 1         | 13.5                 | 98.304               | 7.2818 | 7           | 1208A5      | 10              | 0        | 12.288     | 01               | 12.288        |
| 27            | 1         | 13.5                 | 98.304               | 7.2818 | 7           | 1208A5      | 10              | 1        | 6.144      | 10               | 6.144         |
| 27            | 1         | 13.5                 | 90.3168              | 6.6901 | 6           | 2C2B24      | 10              | 0        | 11.2896    | 01               | 11.2896       |
| 27            | 1         | 13.5                 | 90.3168              | 6.6901 | 6           | 2C2B24      | 10              | 1        | 5.6448     | 10               | 5.6448        |

Table 23 User Mode PLL Configuration Examples

When considering settings not shown in this table, the key configuration parameters which must be selected for optimum operation are:

- $90\text{MHz} \leq f_2 \leq 100\text{MHz}$
- $5 \leq \text{PLL\_N} \leq 13$
- $\text{OSCCLOCK} = 10 \text{ to } 14.4\text{MHz} \text{ or } 16.28 \text{ to } 27\text{MHz}$

#### PLL INTEGER AND FRACTIONAL CONTROL MODES

The PLL can be operated in either fractional or integer control modes. In PLL User Mode, it is recommended that the PLL should be operated in fractional control mode at all times. When the S/PDIF receiver is enabled, the PLL **must** be operated in fractional control mode.

| REGISTER ADDRESS  | BIT | LABEL  | DEFAULT | DESCRIPTION   |
|-------------------|-----|--------|---------|---|
| R7<br>PLL5<br>07h | 2   | FRACEN | 1       | <b>Integer/Fractional PLL Mode Select</b><br>0 = Integer PLL (PLL_N value used, PLL_K value ignored)<br>1 = Fractional PLL (both PLL_N and PLL_K values used)<br><b>Note: FRACEN must be set to enable the fractional PLL when using S/PDIF Receive Mode.</b> |

Table 24 PLL Fractional/Integer Mode Select

#### MASTER CLOCK (MCLK)

The master clock (MCLK) signal is used to supply reference clock signals to the following circuit blocks:

- The Digital Audio Interface
- The S/PDIF Transmitter

The master clock (MCLK) pin can be configured as either a clock input or output depending on the digital audio interface mode as shown in Table 25.

| REGISTER ADDRESS    | BIT | LABEL  | DEFAULT | DESCRIPTION  |
|---------------------|-----|--------|---------|--|
| R28<br>AIFRX<br>1Ch | 6   | AIF_MS | 0       | <b>Audio Interface Mode Select</b><br>0 = Slave mode – MCLK Input<br>1 = Master mode – MCLK Output |

Table 25 Audio Interface Mode Select

When MCLK is configured as an output, the MCLK source and rate can be selected using the control bits shown in Table 26. The MCLK rate select can only be used when the MCLK output source is selected as the PLL clock. If the oscillator clock is selected as the PLL source, the MCLK frequency is equal to the oscillator clock frequency.

| REGISTER ADDRESS  | BIT | LABEL   | DEFAULT | DESCRIPTION  |
|-------------------|-----|---------|---------|--|
| R7<br>PLL5<br>07h | 3   | MCLKDIV | 0       | <b>MCLK Divider Select</b><br>(Only valid when CLK2 is selected as MCLK output source)<br>See Table 27 for MCLKDIV configuration in PLL user mode.<br>See Table 28 for MCLKDIV configuration in PLL S/PDIF receive mode. |
| R8<br>PLL6<br>08h | 7   | MCLKSRC | 0       | <b>MCLK Output Source select</b><br>0 = Select CLK2<br>1 = Select OSCCLK   |

Table 26 Master Clock Output Control

| FREQMODE[1:0] | F <sub>2</sub> TO CLK1 DIVISION FACTOR |     |     |     | F <sub>2</sub> TO CLK2 DIVISION FACTOR |     |
|---------------|--|-----|-----|-----|--|-----|
|               | CLKOUTDIV[1:0]                         |     |     |     | MCLKDIV                                |     |
|               | 00                                     | 01  | 10  | 11  | 0                                      | 1   |
| 00            | +2                                     | +2  | +4  | +8  | +2                                     | +4  |
| 01            | +2                                     | +4  | +8  | +16 | +4                                     | +8  |
| 10            | +4                                     | +8  | +16 | +32 | +8                                     | +16 |
| 11            | +6                                     | +12 | +24 | +48 | +12                                    | +24 |

Table 27 PLL User Mode Clock Divider Configuration

| CLKOUTDIV[1:0] | CLK1 FREQUENCY | MCLKDIV | CLK2 FREQUENCY |
|----------------|----------------|---------|----------------|
| 00             | 512fs          | 0       | 256fs          |
| 01             | 256fs          | 1       | 128fs          |
| 10             | 128fs          |         |                |
| 11             | 64fs           |         |                |

Table 28 PLL S/PDIF Receive Mode Clock Divider Configuration

**Note:** The fs values shown above are relative to the S/PDIF recovered sample rate.

When MCLK is configured as an input, the reference clock rate for the S/PDIF transmitter (when the digital audio interface received data is configured as the S/PDIF transmitter data source) is controlled by the frequency of the MCLK signal at the MCLK pin.

Refer to the “Digital Audio Interface” datasheet section for details of configuring MCLK for appropriate digital audio interface operation.

#### CLOCK OUTPUT (CLKOUT)

The high-drive clock output (CLKOUT) pin can be used as a clock output. This pin is intended to be used as a clock source pin for providing the central clock reference for an audio system.

The CLKOUT clock source can be selected from either the OSCCLK or CLK1 signals. The control bits for the CLKOUT signal are shown in Table 29.

| REGISTER ADDRESS  | BIT | LABEL          | DEFAULT | DESCRIPTION  |
|-------------------|-----|----------------|---------|--|
| R7<br>PLL5<br>07h | 5:4 | CLKOUTDIV[1:0] | 01      | <b>CLKOUT Divider Select</b><br>(Only valid when CLK1 is selected as CLKOUT output source)<br>See for Table 27 CLKOUTDIV[1:0] configuration in PLL user mode.<br>See Table 28 for CLKOUTDIV[1:0] configuration in PLL S/PDIF receive mode. |
| R8<br>PLL6<br>08h | 3   | CLKOUTSRC      | 1       | <b>CLKOUT Pin Source Select</b><br>0 = Select CLK1<br>1 = Select OSCCLK  |
|                   | 4   | CLKOUTDIS      | 1       | <b>CLKOUT Pin Disable</b><br>0 = Pin Disabled (Pin tri-stated)<br>1 = Pin Enabled  |

Table 29 Clock Output (CLKOUT) Control

**S/PDIF TRANSMITTER**

When the S/PDIF transmitter is enabled and configured (using TXSRC) to use the S/PDIF received data, the S/PDIF transmitter is clocked from the CLK2 signal. When the transmitter's data source is the digital audio interface, the transmitter reference clock source is the MCLK signal at the MCLK input/output pin. Refer to Table 30 for details.

| REGISTER ADDRESS      | BIT | LABEL | DEFAULT | DESCRIPTION  |
|-----------------------|-----|-------|---------|--|
| R21<br>SPD TX4<br>15h | 6   | TXSRC | 1       | <b>S/PDIF Transmitter Data Source</b><br>0 = S/PDIF Received Data – SPDIF TXCLK Source = CLK2<br>1 = Digital Audio Interface Received Data – SPDIF TXCLK Source = MCLK Input/Output Signal at MCLK Pin |

Table 30 S/PDIF Transmitter Data/MCLK Source Control

The S/PDIF transmitter requires a clock reference signal (either CLK2 or MCLK) when enabled. The applied MCLK signal can be either 128fs, 256fs, 384fs, 512fs, 768fs or 1152fs relative to the sample rate of the transmitted data.

**S/PDIF RECEIVER**

In S/PDIF receive mode, the PLL\_N and PLL\_K values are automatically modified by the S/PDIF receiver to allow the receiver to use the PLL to lock on to and track the incoming S/PDIF data stream.

The S/PDIF receiver has four clocking modes based on the incoming S/PDIF stream sample rate. The modes are:

- Mode 1: Incoming S/PDIF sample rate = 176.4kHz – 1% to 192kHz +1%
- Mode 2: Incoming S/PDIF sample rate = 88.2kHz -1% to 96kHz +1%
- Mode 3: Incoming S/PDIF sample rate = 44.1kHz -1% to 48kHz +1%
- Mode 4: Incoming S/PDIF sample rate = 32kHz +/- 1%

Before the S/PDIF receiver is enabled, it is important that the PLL\_N and PLL\_K register values are manually configured in a specific default state so that the S/PDIF receiver can correctly modify the PLL\_N and PLL\_K values and hence establish correct PLL control.

The PLL\_N and PLL\_K register values must also be manually re-configured when a change of the clocking mode is detected and the change is to mode 1 or from mode 1.

The specified  $f_2$  frequencies that must be configured using the PLL\_N and PLL\_K register values for reception of specific S/PDIF sample rates are as follows:

- Mode 1 (176.4/192kHz sample rate):  $f_2 = 94.3104\text{MHz}$  (for 176.4KHz) or  $98.304\text{MHz}$  (for 192KHz) \*Refer to sections headed 176.4KHz OPERATION and 192MHz OPERATION.
- Modes 2/3/4 (32/44.1/48/88.2/96kHz sample rates):  $f_2 = 94.3104\text{MHz}$

The FREQMODE[1:0] bits are automatically controlled by the S/PDIF receiver when the receiver is enabled and do not need to be configured in any particular initial state by the user before the S/PDIF receiver is enabled.

Refer to Table 27 and Table 28 for details of MCLKDIV and CLKOUTDIV configuration when the S/PDIF receiver is enabled.

The PLL register settings are configured by default to allow 32/44.1/48/88.2/96kHz (modes 2/3/4) sample rate S/PDIF receiver operation using a 12MHz crystal clock. The PLL register settings must be updated if:

- Any crystal clock frequency other than 12MHz is used.

**OR**

- A S/PDIF stream with 192kHz sample rate (mode 1) is detected.

In either case, reprogramming of the PLL\_N and PLL\_K values (and the PRESCALE value, depending on the crystal frequency) is necessary.

Refer to Table 31 for details of a number of recommended PLL configurations. Many other configurations are possible; please refer to PLL Configuration section for details regarding how to calculate alternative settings.

| OSC CLK (MHz) | PRE-SCALE | S/PDIF RECEIVER SAMPLE RATE(S) (kHz) | F1 (MHz) | F2 (MHz) | R      | PLL_N (Hex) | PLL_K (Hex) | COMMENT            |
|---------------|-----------|--------------------------------------|----------|----------|--------|-------------|-------------|--------------------|
| 11.2896       | 0         | 32 / 44.1 / 48 / 88.2 / 96           | 11.2896  | 94.3104  | 8.3537 | 8           | 16A3B3      | Set N, K           |
| 11.2896       | 0         | 192                                  | 11.2896  | 98.304   | 8.7075 | 8           | 2D4766      | Set N, K           |
| 12            | 0         | 32 / 44.1 / 48 / 88.2 / 96           | 12       | 94.3104  | 7.8592 | 7           | 36FD21      | Default Setting    |
| 12            | 0         | 192                                  | 12       | 98.304   | 8.192  | 8           | C49BA       | Set N, K           |
| 12.288        | 0         | 32 / 44.1 / 48 / 88.2 / 96           | 12.288   | 94.3104  | 7.675  | 7           | 2B3333      | Set K              |
| 12.288        | 0         | 192                                  | 12.288   | 98.304   | 8      | 8           | 0           | Set N, K           |
| 19.2          | 1         | 32 / 44.1 / 48 / 88.2 / 96           | 9.6      | 94.3104  | 9.824  | 9           | 346C6A      | Set Prescale, N, K |
| 19.2          | 1         | 192                                  | 9.6      | 98.304   | 10.24  | A           | F5C28       | Set Prescale, N, K |
| 24            | 1         | 32 / 44.1 / 48 / 88.2 / 96           | 12       | 94.3104  | 7.8592 | 7           | 36FD21      | Set Prescale       |
| 24            | 1         | 192                                  | 12       | 98.304   | 8.192  | 8           | C49BA       | Set Prescale, N, K |
| 27            | 1         | 32 / 44.1 / 48 / 88.2 / 96           | 13.5     | 94.3104  | 6.986  | 6           | 3F19E5      | Set Prescale, N, K |
| 27            | 1         | 192                                  | 13.5     | 98.304   | 7.2818 | 7           | 1208A5      | Set Prescale, K    |

**Table 31 S/PDIF Receive Mode PLL Initial Configuration Examples**

The recommended configuration sequences are as follows:

**TO INITIALLY CONFIGURE THE SYSTEM FOR S/PDIF RECEIVER STARTUP:**

1. Write appropriate calculated values (relative to oscillator frequency) to PRESCALE, PLL\_N and PLL\_K registers for 32/44.1/48/88.2/96kHz (modes 2/3/4) S/PDIF receiver sample rate operation.
2. Enable PLL by clearing PLLPD bit.
3. Enable S/PDIF receiver by clearing SPDIFRXP bit.
4. Read S/PDIF Status Register REC\_FREQ[1:0] bits to identify recovered S/PDIF sample frequency and clocking mode.

- If indicated sample rate is 192kHz, then the user must know what the sampling frequency is (176.4kHz or 192kHz) since these cannot be distinguished. The user should then write appropriate calculated values (relative to oscillator frequency) to PRESCALE, PLL\_N and PLL\_K for 176.4/192kHz (mode 1) S/PDIF receiver sample rate operation.

#### TO CONFIGURE THE SYSTEM WHEN CLOCKING MODE (SAMPLE RATE) CHANGES TO OR FROM MODE 1 (176.4/192KHZ):

Any sample rate change between clocking modes (for example, from 44.1kHz (mode 3) to 192kHz (mode 1)) will be flagged to the application processor via the INT\_N interrupt flag. The application processor must then read the Interrupt Status Register. If the UPD\_REC\_FREQ flag is set, indicating that the clocking mode has changed, proceed as follows:

- Read S/PDIF Status Register REC\_FREQ[1:0] bits to identify recovered S/PDIF sample rate frequency and clocking mode. If "192kHz" is indicated then since this is indistinguishable from 176.4kHz, the user must be aware of what the sampling frequency is.
- Write appropriate calculated values (relative to oscillator frequency) to PLL\_N and PLL\_K based on indicated recovered S/PDIF sample frequency and clocking mode.

This procedure is only strictly necessary when switching to or from mode 1 because the PLL\_N and PLL\_K values are the same for 32/44.1/48/88.2/96kHz (modes 2/3/4) sample rate operation. It is, however, good interrupt service routine practice to write the appropriate PLL\_N and PLL\_K values when every clocking mode change is detected. The setup for 176.4 kHz and 192kHz are however slightly different. The setting up of these different configurations are described in the following paragraphs.

#### 176.4KHZ OR 192K MODE ENABLE

The difference between a sample rate of 176.4kHz and 192kHz requires the system to be configured slightly differently. This requires that the S/PDIF Rx sample rates are known (176.4kHz or 192kHz). Both sampling frequencies also require that the register bit SPD\_192K\_EN is set to a 1. If the SPD\_192K\_EN register bit is not set to a 1, then TRANS\_ERR errors will be generated and this will result in the UNLOCK status being continually set (indicating an UNLOCK status).

#### 176.4KHZ OPERATION

To operate at fs=176.4 kHz, then the PLL\_K and PLL\_N settings should be set up as in mode 2/3/4. In this case the the PLL will lock onto the S/PDIF Rx data stream correctly if fs=176.4kHz. If however the sample rate is changed to fs=192kHz (and the PLL is not reconfigured) then the S/PDIF Rx interface will indicate UNLOCK and TRANS\_ERR. The UNLOCK signal will continually toggle between a locked and unlocked state.

#### 192KHZ OPERATION

To operate at fs=192kHz, then the PLL\_K and PLL\_N settings should be set up as in mode 1. In this case the the PLL will lock onto the S/PDIF Rx data stream correctly if fs=192kHz. If however the sample rate is changed to fs=176.4kHz (and the PLL is not reconfigured) then the S/PDIF Rx interface will indicate UNLOCK and TRANS\_ERR. The UNLOCK signal will continually toggle between a locked and unlocked state. Note that this is the default setting for hardware mode.

| REGISTER ADDRESS     | BIT | LABEL       | DEFAULT | DESCRIPTION  |
|----------------------|-----|-------------|---------|--|
| R29<br>SPDRX1<br>1Dh | 7   | SPD_192K_EN | 1       | <b>S/PDIF Receiver 192kHz support enable</b><br>0 = disabled, S/PDIF receiver maximum supported sampling frequency is 96kHz<br>1 = enabled, S/PDIF receiver maximum supported sampling frequency is 192kHz |

Table 32 176.4/192 kHz Sample Rate Enable



## S/PDIF TRANSMITTER

The S/PDIF transmitter generates the S/PDIF frames, and outputs on the TX0 pin. The transmitted data can be sourced from one of two places, selectable using the TXSRC register. The transmitter can be powered down using the SPDIFTXD register bit.

| REGISTER ADDRESS      | BIT | LABEL      | DEFAULT | DESCRIPTION  |
|-----------------------|-----|------------|---------|--|
| R6<br>PLL4<br>06H     | 5   | TXVAL_SF0  | 0       | <b>Override Mode S/PDIF Transmitter Validity Sub-Frame 0</b><br>0 = transmit validity = 0<br>1 = transmit validity = 1   |
|                       | 6   | TXVAL_SF1  | 0       | <b>Override Mode S/PDIF Transmitter Validity Sub-Frame 1</b><br>0 = transmit validity = 0<br>1 = transmit validity = 1   |
|                       | 7   | TXVAL_OVWR | 0       | <b>S/PDIF Transmitter Validity Override Mode Enable</b><br>0 = disabled, validity bit is 0 when the S/PDIF transmitter sources PCM audio interface, or it matches the S/PDIF input validity when the S/PDIF transmitter sources the S/PDIF receiver.<br>1 = enabled, validity bit transmitted for subframe 0 is defined by TXVAL_SF0, validity bit transmitted for subframe 1 is defined by TXVAL_SF1. |
| R21<br>SPDITX4<br>15h | 6   | TXSRC      | 1       | <b>S/PDIF Transmitter Data Source</b><br>0 = S/PDIF received data.<br>1 = Audio interface received data  |
|                       | 7   | TXSTATSRC  | 0       | <b>S/PDIF Transmitter Channel Status Data Source</b><br>0 = Received channel status data<br>1 = Transmit channel status registers<br>Note 1: Only used if TXSRC=0<br>Note 2: See section User Data below   |
| R30<br>PWRDN<br>1Eh   | 2   | SPDIFTXPD  | 1       | <b>S/PDIF Transmitter Powerdown Enable</b><br>0 = S/PDIF transmitter enabled<br>1 = S/PDIF transmitter disabled  |

**Table 33 S/PDIF Transmitter Control**

The WM8804 also transmits the preamble and VUCP bits (Validity, User Data, Channel Status and Parity bits).

### VALIDITY BIT

By default, set to 0 (to indicate valid data) with the following exceptions:

1. TXSRC=0 (S/PDIF receiver), where Validity is the value recovered from the S/PDIF input stream by the S/PDIF receiver.
2. TXVAL\_OVWR=1, where Validity is the value set in registers TXVAL\_SF0 and TXVAL\_SF1.

### USER DATA

Set to 0 as User Data configuration is not supported in the WM8804 – if TXSRC=0 and TXSTATSRC=0 (S/PDIF receiver) User Data is set by the receiver.

**CHANNEL STATUS**

The Channel Status bits form a 192-frame block transmitted one bit per sub-frame. Each sub-frame forms its own 192-frame block. The WM8804 is a consumer mode device and only the first 40 bits of the block are used. All data transmitted from the WM8804 is stereo, so the channel status data is the same for both channels. The only exception to this is the channel number bits [23:20] which can be changed to indicate if the channel is left or right in the stereo image. Bits within this block can be configured by setting the S/PDIF Transmitter Control registers (see Table 34 to Table 38). If TXSRC is set to configure the S/PDIF receiver as the transmit data source, the channel status bits are transmitted with the same values recovered by the receiver – unless TXSTATSRC is set, in which case they are set by the S/PDIF Transmitter Control registers.

**PARITY BIT**

This bit maintains even parity for data as a means of basic error detection. It is generated by the transmitter.

| REGISTER ADDRESS      | BIT | LABEL             | CHANNEL STATUS BIT | DEFAULT | DESCRIPTION   |
|-----------------------|-----|-------------------|--------------------|---------|---|
| R18<br>SPD TX1<br>12h | 0   | CON/PRO           | 0                  | 0       | <b>Use Of Channel Status Block</b><br>0 = Consumer Mode<br>1 = Professional Mode (not supported by WM8804).   |
|                       | 1   | AUDIO_N           | 1                  | 0       | <b>Linear PCM Identification.</b><br>0 = S/PDIF transmitted data is audio PCM.<br>1 = S/PDIF transmitted data is not audio PCM.   |
|                       | 2   | CPY_N             | 2                  | 0       | <b>Copyright Information</b><br>0 = Transmitted data has copyright asserted.<br>1 = Transmitted data has no copyright assertion.  |
|                       | 5:3 | DEEMPH[2:0]       | 5:3                | 000     | <b>Additional Format Information</b><br>000 = Data from Audio interface has no pre-emphasis.<br>001 = Data from Audio interface has pre-emphasis.<br>All other modes are reserved and should not be used. |
|                       | 7:6 | CHSTMODE<br>[1:0] | 7:6                | 00      | <b>Channel Status Mode</b><br>00 = Only valid mode for consumer applications.   |

Table 34 S/PDIF Transmitter Channel Status Bit Control Register 1

| REGISTER ADDRESS      | BIT | LABEL            | CHANNEL STATUS BIT | DEFAULT  | DESCRIPTION  |
|-----------------------|-----|------------------|--------------------|----------|--|
| R19<br>SPD TX2<br>13h | 7:0 | CATCODE<br>[7:0] | 15:8               | 00000000 | <b>Category Code</b><br>Refer to S/PDIF specification (IEC 60958-3) for full details.<br>0x00h indicates "general" mode. |

Table 35 S/PDIF Transmitter Channel Status Bit Control Register 2



| REGISTER ADDRESS      | BIT | LABEL           | CHANNEL STATUS BIT | DEFAULT | DESCRIPTION   |                           |
|-----------------------|-----|-----------------|--------------------|---------|---|---------------------------|
| R20<br>SPD TX3<br>14h | 3:0 | SRCNUM<br>[3:0] | 19:16              | 0000    | <b>Source Number</b><br>Refer to S/PDIF specification (IEC 60958-3) for full details. |                           |
|                       | 5:4 | CHNUM1[1:0]     | 21:20              | 00      | <b>Channel Number for Subframe 1</b>  |                           |
|                       |     |                 |                    |         | <b>CHNUM1</b> <b>Channel Status Bits[21:20] Function</b>                              |                           |
|                       |     |                 |                    |         | 00  | Do not use channel number |
|                       |     |                 |                    |         | 01  | Send to Left Channel      |
|                       | 7:6 | CHNUM2[1:0]     | 23:22              | 00      | <b>Channel Number for Subframe 2</b>  |                           |
|                       |     |                 |                    |         | <b>CHNUM2</b> <b>Channel Status Bits[23:22] Function</b>                              |                           |
|                       |     |                 |                    |         | 00  | Do not use channel number |
|                       |     |                 |                    |         | 01  | Send to Left Channel      |
|                       |     |                 |                    |         |   | 10                        |
|                       |     |                 |                    |         | 11  | Do not use channel number |

Table 36 S/PDIF Transmitter Channel Status Bit Control Register 3

| REGISTER ADDRESS      | BIT | LABEL       | CHANNEL STATUS BIT | DEFAULT | DESCRIPTION   |
|-----------------------|-----|-------------|--------------------|---------|---|
| R21<br>SPD TX4<br>15h | 3:0 | FREQ[3:0]   | 27:24              | 0001    | <b>Indicated Sampling Frequency</b><br>Refer to S/PDIF specification (IEC 60958-3) for full details.<br>0001 = Sampling Frequency not indicated.              |
|                       | 5:4 | CLKACU[1:0] | 29:28              | 11      | <b>Clock Accuracy of Transmitted Clock</b><br>00 = Level II<br>01 = Level I<br>10 = Level III<br>11 = Interface frame rate not matched to sampling frequency. |

Table 37 S/PDIF Transmitter Channel Status Bit Control Register 4

| REGISTER ADDRESS      | BIT                                       | LABEL     | CHANNEL STATUS BIT | DEFAULT   | DESCRIPTION   |
|-----------------------|---|-----------|--------------------|---|---|
| R22<br>SPD TX5<br>16h | 0   | MAXWL     | 32                 | 1   | <b>Maximum Audio Sample Word Length</b><br>0 = 20 bits<br>1 = 24 bits   |
|                       | 3:1                                       | TXWL[2:0] | 35:33              | 101   | <b>Audio Sample Word Length.</b><br>Used with MAXWL to indicate Tx word length<br>000 = Word length not indicated |
|                       |   |           |                    |   | <b>TXWL[2:0]</b> <b>MAXWL==1</b> <b>MAXWL==0</b>  |
|                       |   |           |                    |   | 001            20 bits            16 bits   |
|                       |   |           |                    |   | 010            22 bits            18 bits   |
|                       |   |           |                    |   | 100            23 bits            19 bits   |
|                       |   |           |                    |   | 101            24 bits            20 bits   |
|                       | 110            21 bits            17 bits |           |                    |   |   |
|                       |   |           |                    |   | All other combinations reserved   |
| 7:4                   | ORGSAMP<br>[3:0]                          | 39:36     | 0000               | <b>Original Sampling Frequency</b><br>Refer to S/PDIF specification (IEC 60958-3) for full details. |   |

Table 38 S/PDIF Transmitter Channel Status Bit Control Register 5

## S/PDIF RECEIVER

The S/PDIF receiver has one input. This input can be configured as either single ended CMOS or as a 500mVp-p comparator input, depending upon the state of the SPDIFINMODE register. The S/PDIF receiver can be powered down if not in use by setting the SPDIFRXP register bit. If the S/PDIF receiver is powered down the system will wait until the end of the current S/PDIF frame before powering down.

| REGISTER ADDRESS     | BIT | LABEL       | DEFAULT | DESCRIPTION   |
|----------------------|-----|-------------|---------|---|
| R30<br>PWRDN<br>1Eh  | 1   | SPDIFRXP    | 1       | <b>S/PDIF Receiver Powerdown</b><br>0 = S/PDIF receiver enabled<br>1 = S/PDIF receiver disabled   |
| R9<br>SPDMODE<br>09h | 0   | SPDIFINMODE | 1       | <b>S/PDIF Input Mode Select</b><br>Selects the input circuit type for the receiver input.<br>0 = CMOS input<br>1 = Comparator input. Compatible with 500mVppAC coupled consumer S/PDIF input signals. Refer to S/PDIF specification (IEC 60958-3) for full details. |

Table 39 S/PDIF Receiver Input Selection Registers

### AUDIO DATA HANDLING

The S/PDIF receiver recovers the data and VUCP bits from each sub-frame. The WM8804 can detect when the data is not in PCM format. See Non-Audio Detection section for more detail.

The received data can also be output over the audio interfaces in any of the data formats supported, or data may also be re-transmitted on TX0, de-jittering the data stream.

### USER DATA

The WM8804 can output recovered user data via the GPO pins. See Table 52 for General Purpose Pin control.

### CHANNEL STATUS DATA

The channel status bits are recovered from the incoming S/PDIF Rx data stream and are used to control various functions of the device.

The S/PDIFRx interface always receives 24 bits of data in bits 4 to 27 of the SPDIF payload. The audio sample can be either 20 bits if AUX bits not used or up to 24bits if AUX bits used. So the audio sample can be 20,21,22,23 or 24 bit. The source (wherever the S/PDIF data is coming from) of the S/PDIF data stream must set the MAXWL and RXWL within the status bits to indicate the size of the audio sample. This is then recovered by the S/PDIF Rx interface. The S/PDIF Rx interface ALWAYS receives 24 bits, but if the actual length of the audio data sample (indicated by MAXWL and RXWL) is less than 24 bits, then the user has the option to truncate these 24 bits to the actual size. These truncated bits are then sent to either the SPDIF Tx or the AIF. Truncation may allow users to process data faster. If the user does not want this truncation to happen then they must mask the truncation using the WL\_MASK. In this case all 24 bits of data received are transferred.

The audio data sample can be transferred to either the AIF or the SPDIF Tx.

When the audio data sample is transferred to the AIF, and if the AIF is operating in a mode which has less data bits, then the WM8804 will reduce the audio data sample to the length of the AIF. For example, if the AIF is operating in 16 bit mode, but the SPDIF Rx receives an audio data sample length of 21 bits, then the WM8804 will reduce the 21 bits to 16 bits by removing the LSBs. This cannot be masked. If the AIF is operating in 24 bit mode, then the full 21 bits are transferred on the AIF, with the LSBs set to 000.

When the audio data sample is transferred to the SPDIF TX, then the full audio data sample (24 bits) is written to the SPDIF Tx. Unless it has been truncated using the WL-MASK bits

It is assumed that the channel status is stereo and hence only channel one data is read. The channel status data is stored in five read-only registers which can be read back over the serial interface (see Serial Interface Read-back). The CSUD interrupt is asserted when the recovered channel status data is different to that currently stored in the read only registers. The registers are updated and the interrupt is asserted when the last bit of channels status data is recovered. The interrupt will remain asserted until one of the channel status registers is read. If another change to channel status data occurs before the last block has been read, the interrupt will de-assert when the first bit of differing channel status is received and will be asserted again when the last bit of the current channel status block is received.

The register descriptions for the channel status bits are given in Table 40 to Table 44.

| REGISTER ADDRESS                     | BIT | LABEL             | CHANNEL STATUS BIT | DEFAULT | DESCRIPTION  |
|--------------------------------------|-----|-------------------|--------------------|---------|--|
| R13<br>RXCHAN1<br>0Dh<br>(read-only) | 0   | CON/PRO           | 0                  | 0       | <b>Use Of Channel Status Block</b><br>0 = Consumer Mode<br>1 = Professional Mode<br>The WM8804 is a consumer mode device. Detection of professional mode may give erroneous behaviour. |
|                                      | 1   | AUDIO_N           | 1                  | 0       | <b>Linear PCM Identification</b><br>0 = Data word represents audio PCM samples.<br>1 = Data word does not represent audio PCM samples.   |
|                                      | 2   | CPY_N             | 2                  | 0       | <b>Copyright Information</b><br>0 = Copyright is asserted for Rx data.<br>1 = Copyright is not asserted for Rx data.   |
|                                      | 3   | DEEMPH            | 3                  | 0       | <b>Additional Format Information</b><br>0 = Recovered S/PDIF data has no pre-emphasis.<br>1 = Recovered S/PDIF data has pre-emphasis.  |
|                                      | 5:4 | Reserved          | 5:4                | 00      | Reserved for additional de-emphasis modes.   |
|                                      | 7:6 | CHSTMODE<br>[1:0] | 7:6                | 00      | <b>Channel Status Mode</b><br>00 = Only valid mode for consumer applications.  |

Table 40 S/PDIF Receiver Channel Status Register 1

| REGISTER ADDRESS                     | BIT | LABEL            | CHANNEL STATUS BIT | DEFAULT  | DESCRIPTION  |
|--------------------------------------|-----|------------------|--------------------|----------|--|
| R14<br>RXCHAN2<br>0Eh<br>(read-only) | 7:0 | CATCODE<br>[7:0] | 15:8               | 00000000 | <b>Category Code</b><br>Refer to S/PDIF specification (IEC 60958-3) for full details.<br>0x00h indicates "general" mode. |

Table 41 S/PDIF Receiver Channel Status Register 2

| REGISTER ADDRESS                     | BIT | LABEL           | CHANNEL STATUS BIT | DEFAULT | DESCRIPTION  |
|--------------------------------------|-----|-----------------|--------------------|---------|--|
| R15<br>RXCHAN3<br>0Fh<br>(read-only) | 3:0 | SRCNUM<br>[3:0] | 19:16              | 0000    | <b>S/PDIF Source Number</b><br>Refer to S/PDIF specification (IEC 60958-3) for full details.   |
|                                      | 5:4 | CHNUM1[1:0]     | 21:20              | 00      | <b>Channel Number for Sub-frame 1</b><br>00 = do not use channel number<br>01 = channel 1 to left channel<br>10 = channel 1 to right channel |
|                                      | 7:6 | CHNUM2[1:0]     | 23:22              | 00      | <b>Channel Number for Sub-frame 2</b><br>00 = do not use channel number<br>01 = channel 2 to left channel<br>10 = channel 2 to right channel |

Table 42 S/PDIF Receiver Channel Status Register 3

| REGISTER ADDRESS                     | BIT | LABEL       | CHANNEL STATUS BIT | DEFAULT | DESCRIPTION  |
|--------------------------------------|-----|-------------|--------------------|---------|--|
| R16<br>RXCHAN4<br>10h<br>(read-only) | 3:0 | FREQ[3:0]   | 27:24              | 0001    | <b>Indicated Sampling Frequency</b><br>Refer to S/PDIF specification (IEC 60958-3) for full details.   |
|                                      | 5:4 | CLKACU[1:0] | 29:28              | 11      | <b>Clock Accuracy of Received Clock</b><br>00 = Level II<br>01 = Level I<br>10 = Level III<br>11 = Interface frame rate not matched to sampling frequency. |

Table 43 S/PDIF Receiver Channel Status Register 4

| REGISTER ADDRESS  | BIT              | LABEL     | CHANNEL STATUS BIT | DEFAULT   | DESCRIPTION   |
|---|------------------|-----------|--------------------|---|---|
| R17<br>RXCHAN5<br>11h<br>(read-only)                                    | 0                | MAXWL     | 32                 | 1   | <b>Maximum Audio Sample Word Length</b><br>0 = 20 bits<br>1 = 24 bits<br>Note: see table in description of bits 3:1 of this register, |
|   | 3:1              | RXWL[2:0] | 35:33              | 000   | <b>Audio Sample Word Length</b><br>000: Word length not indicated   |
|   |                  |           |                    |   | <b>RXWL[2:0]</b> <b>MAXWL==1</b> <b>MAXWL==0</b>  |
|   |                  |           |                    |   | 001            20 bits            16 bits   |
|   |                  |           |                    |   | 010            22 bits            18 bits   |
|   |                  |           |                    |   | 100            23 bits            19 bits   |
|   |                  |           |                    |   | 101            24 bits            20 bits   |
|   |                  |           |                    |   | 110            21 bits            17 bits   |
| All other combinations are reserved and should not be used. See note 1. |                  |           |                    |   |   |
| 7:4   | ORGSAMP<br>[3:0] | 39:36     | 0000               | <b>Original Sampling Frequency</b><br>Refer to S/PDIF specification (IEC 60958-3) for full details. |   |

Table 44 S/PDIF Receiver Channel Status Register 5

**Note 1:** MAXWL and RXWL[2:0] bits in recovered channel status data are used to truncate digital audio interface transmitted data. Truncation replaces the lower data bits with 0. Truncation can be masked using the WL\_MASK control bit. Truncation can be masked by the WL\_MASK Refer to received channel status bit description.

**S/PDIF RECEIVER STATUS FLAGS**

There are several S/PDIF receiver status flags which are recorded by the WM8804. The flags are described in Table 45. These flags are available via GPIO pins or status registers.

| FLAG          | DESCRIPTION   | VISIBILITY   |
|---------------|---|--|
| UNLOCK        | Unlock Flag<br>Indicates that the S/PDIF Rx clock recovery circuit is unlocked.<br>0 = Locked onto incoming S/PDIF stream.<br>1 = Not locked onto the incoming S/PDIF stream.   | S/PDIF Status Register,<br>GPO,<br>CSB –hardware mode      |
| INVALID       | Invalid Flag<br>Indicates that recovered S/PDIF data is marked as invalid.<br>0 = Data marked as valid<br>1 = Data marked as invalid  | Interrupt Status Reg                                       |
| TRANS_ERR     | Transmission Error Flag<br>Indicates that a transmission error has occurred. This signal is asserted when the preamble sequence is incorrectly received or there is a parity error or a bi-phase mark encoding error.<br>0 = No error detected in transmission<br>1 = Error in transmission | Interrupt Status Reg,<br>GPO,<br>SCLK –hardware mode       |
| AUDIO_N       | Audio Status Flag<br>Recovered Channel Status bit 1.<br>0 = Data word represents audio PCM samples.<br>1 = Data word does not represent audio PCM samples.  | Channel Status Register,<br>S/PDIF Status Register         |
| PCM_N         | Non-PCM Flag<br>Indicates that non-audio code (defined in IEC-61937) has been detected.<br>0 = Sync code not detected.<br>1 = Sync code detected – received data is not audio PCM.  | S/PDIF Status Register                                     |
| ZEROFLAG      | Zero Flag<br>Indicates detection of 1024 consecutive all zero frames<br>0 = 1024 consecutive all zero frames not detected<br>1 = 1024 consecutive all zero frames detected  | GPO  |
| CPY_N         | Non-Copyright Flag<br>Recovered Channel Status bit 2.<br>0 = Copyright is asserted for this data.<br>1 = Copyright is not asserted for this data.<br>Note this signal is inverted and will cause an interrupt on logic 0.   | Channel Status Register,<br>S/PDIF Status Register,<br>GPO |
| REC_FREQ[1:0] | Recovered Frequency Flag<br>Indicates recovered S/PDIF clock frequency:<br>00 = 192kHz<br>01 = 96kHz or 88.2kHz<br>10 = 48kHz or 44.1kHz<br>11 = 32kHz  | S/PDIF Status Register                                     |
| INT_N         | Interrupt Signal<br>0 = Interrupt has occurred<br>1 = No interrupt has occurred   | GPO  |
| V             | Recovered validity bit for current sub-frame  | GPO  |
| U             | Recovered user bit for current sub-frame  | GPO  |
| C             | Recovered channel status bit for current sub-frame  | GPO  |
| SFRM_CLK      | Sub-frame clock.<br>1 = Current sub-frame is sub-frame A<br>0 = Current sub-frame is sub-frame B  | GPO  |
| 192BLK        | Start OF 192 Frame Sequence Flag<br>Indicates start of 192 frame block. Asserted duration of frame 0.   | GPO  |
| GEN_FLAG      | General Error Flag<br>Logical OR of TRANS_ERR, NON_AUDIO and UNLOCK. Used only in Hardware Control Mode   | GPO0 - hardware Mode                                       |

|           |   |   |
|-----------|---|---|
| NON_AUDIO | Non-Audio Flag<br>Logical OR of PCM_N and AUDIO_N   | Interrupt status register,<br>GPO,<br>SDOUT - hardware mode |
| CSUD      | Channel Status Update<br>Indicates that channel status registers have updated and may be read back over the serial interface. | Interrupt status register,<br>GPO                           |
| DEEMPH    | De-emphasis Flag<br>0 = Recovered data has no pre-emphasis<br>1 = Recovered data has pre-emphasis                             | S/PDIF Status Register,<br>GPO                              |

Table 45 S/PDIF Receiver Status Flags Description

**'WITH FLAGS' MODE**

The WM8804 features a 'With Flags' mode to enable the user to append status flags to the audio sample streamed transmitted from the digital audio interface. When WITHFLAG is set to 1 'With Flags' mode is enabled and the flags in Table 47 are appended to the LSB of the audio sample. If WITHFLAG is set to 0 'With Flags' mode is disabled and only the audio sample is transmitted from the digital audio interface.

| REGISTER ADDRESS     | BIT | LABEL    | DEFAULT | DESCRIPTION  |
|----------------------|-----|----------|---------|--|
| R29<br>SPDRX1<br>1Dh | 4   | WITHFLAG | 0       | <b>Enable With Flags Mode</b><br>0 = Disabled<br>1 = Enabled |

Table 46 With Flags Mode Control Register

| WITH FLAGS BIT ORDER | FLAG      |
|----------------------|-----------|
| 0                    | V         |
| 1                    | U         |
| 2                    | C         |
| 3                    | 192BLK    |
| 4                    | CSUD      |
| 5                    | TRANS_ERR |
| 6                    | UNLOCK    |
| 7                    | NON_AUDIO |

Table 47 Flags Appended to Audio Sample in 'With Flags' Mode

Diagrams illustrating 'With Flags' mode for each audio data format can be found on page 48 of the data sheet (Figure 23 to Figure 27).

**Note:** 24-bit RJ digital audio interface mode does not support 'With Flags' mode.

**INTERRUPT GENERATION**

The INT\_N flag indicates that a change of status has occurred on one or more of the UNLOCK, INVALID, TRANS\_ERR, CSUD, NON\_AUDIO, CPY\_N, REC\_FREQ or DEEMPH status flags. To identify which flag caused the interrupt, the Interrupt Status Register (INTSTAT) must be read. INVALID and TRANS\_ERR are level sensitive interrupts. When these signals are high an interrupt will be generated. The interrupt can be cleared by reading the interrupt status register, however, the interrupt will re-assert if the signal is still high. CSUD and REC\_FREQ will generate an interrupt on a low to high transition and can be cleared by reading the interrupt status register. Once clear the interrupt will not re-assert until another low to high transition occurs. NON\_AUDIO, CPY\_N, UNLOCK and DEEMPH will generate an update signal on any change in flag status. The interrupt and update signals are latched and will remain asserted until they are cleared by reading the Interrupt Status Register.

| REGISTER ADDRESS                     | BIT | LABEL         | DEFAULT | DESCRIPTION  |
|--------------------------------------|-----|---------------|---------|--|
| R11<br>INTSTAT<br>0Bh<br>(read-only) | 0   | UPD_UNLOCK    | -       | <b>UNLOCK update signal</b><br>0 = INT_N not caused by a toggle of UNLOCK flag<br>1 = INT_N caused by a toggle of UNLOCK flag                          |
|                                      | 1   | INT_INVALID   | -       | <b>INVALID flag interrupt signal</b><br>0 = INT_N not caused by INVALID flag<br>1 = INT_N caused by INVALID flag                                       |
|                                      | 2   | INT_CSUD      | -       | <b>INT_CSUD interrupt signal</b><br>0 = INT_N not caused by CSUD flag<br>1 = INT_N caused by CSUD flag   |
|                                      | 3   | INT_TRANS_ERR | -       | <b>TRANS_ERR flag interrupt signal</b><br>0 = INT_N not caused by TRANS_ERR flag<br>1 = INT_N caused by TRANS_ERR flag                                 |
|                                      | 4   | UPD_NON_AUDIO | -       | <b>NON_AUDIO update signal</b><br>0 = INT_N not caused by a toggle of AUDIO_N or PCM_N flags<br>1 = INT_N caused by a toggle of AUDIO_N or PCM_N flags |
|                                      | 5   | UPD_CPY_N     | -       | <b>CPY_N update signal</b><br>0 = INT_N not caused by assertion of CPY_N flag<br>1 = INT_N caused assertion of CPY_N flag                              |
|                                      | 6   | UPD_DEEMPH    | -       | <b>DEEMPH update signal</b><br>0 = INT_N not caused by a toggle of DEEMPH flag<br>1 = INT_N caused by a toggle of DEEMPH flag                          |
|                                      | 7   | UPD_REC_FREQ  | -       | <b>REC_FREQ update signal</b><br>0 = INT_N not caused by assertion of REC_FREQ flag<br>1 = INT_N caused by assertion of REC_FREQ flag                  |

Table 48 Interrupt Status Register



Where the INT\_N has been asserted by an update signal (UPD\_NON\_AUDIO, UPD\_CPY\_N, UPD\_REC\_FREQ, UPD\_UNLOCK or UPD\_DEEMPH) the S/PDIF Status Register (SPDSTAT) can be interrogated to establish the updated value of the flag.

| REGISTER ADDRESS                     | BIT | LABEL             | DEFAULT | DESCRIPTION   |
|--------------------------------------|-----|-------------------|---------|---|
| R12<br>SPDSTAT<br>0Ch<br>(read-only) | 0   | AUDIO_N           | -       | <b>Audio Status Flag</b><br>Recovered channel status bit-1.<br>0 = Data word represents audio PCM samples.<br>1 = Data word does not represent audio PCM samples.                         |
|                                      | 1   | PCM_N             | -       | <b>Non-PCM Flag</b><br>Indicates that non-audio code (defined in IEC-61937) has been detected.<br>0 = Sync code not detected.<br>1 = Sync code detected – received data is not audio PCM. |
|                                      | 2   | CPY_N             | -       | <b>Non-Copyright Flag</b><br>Recovered Channel Status bit-2.<br>0 = Copyright is asserted for this data.<br>1 = Copyright is not asserted for this data.                                  |
|                                      | 3   | DEEMPH            | -       | <b>De-emphasis Flag</b><br>Recovered Channel Status bit-3.<br>0 = Copyright is asserted for this data.<br>1 = Copyright is not asserted for this data.                                    |
|                                      | 5:4 | REC_FREQ<br>[1:0] | --      | <b>Recovered Frequency Flag</b><br>Indicates recovered S/PDIF clock frequency:<br>00 = 192kHz<br>01 = 96kHz or 88.2kHz<br>10 = 48kHz or 44.1kHz<br>11 = 32kHz                             |
|                                      | 6   | UNLOCK            | -       | <b>Unlock Flag</b><br>Indicates that the S/PDIF Rx clock recovery circuit is unlocked.<br>0 = Locked onto incoming S/PDIF stream.<br>1 = Not locked onto the incoming S/PDIF stream.      |

Table 49 S/PDIF Status Register

The interrupt and update signals used to generate INT\_N can be masked at the users discretion. The MASK register bit (Table 50) prevents flags from asserting INT\_N and from updating the Interrupt Status Register.

| REGISTER ADDRESS      | BIT | LABEL     | DEFAULT  | DESCRIPTION  |
|-----------------------|-----|-----------|----------|--|
| R10<br>INTMASK<br>0Ah | 7:0 | MASK[7:0] | 00000000 | <b>Interrupt Mask Enable</b><br>When a flag is masked, it does not update the Interrupt Status Register or cause an INT_N interrupt to be asserted.<br>0 = unmask, 1 = mask.<br>MASK[0] = mask control for UPD_UNLOCK<br>MASK[1] = mask control for INT_INVALID<br>MASK[2] = mask control for INT_CSUD<br>MASK[3] = mask control for INT_TRANS_ERR<br>MASK[4] = mask control for UPD_NON_AUDIO<br>MASK[5] = mask control for UPD_CPY_N<br>MASK[6] = mask control for UPD_DEEMPH<br>MASK[7] = mask control for UPD_REC_FREQ |

Table 50 Interrupt Mask Control Register

### ERROR HANDLING IN SOFTWARE MODE

When the TRANS\_ERR flag is asserted, it indicates that the recovered Rx S/PDIF sub-frame is corrupted. This corruption can be due to a BI-Phase error, a parity error or a pre-amble error. When the INVALID flag is asserted, it indicates that the recovered Rx S/PDIF sub-frame has been marked as being invalid by the source of the S/PDIF data. Both TRANS\_ERR and INVALID indicate an error.

The S/PDIF receiver has two modes of handling for these errors, manual and automatic. The mechanism for each flag is similar. The mechanisms are described below.

#### MANUAL ERROR HANDLING

This manual handling of errored Rx S/PDIF data can be used when an application processor is being interrupted via the INT\_N signal. Appropriate action should be taken by the application processor to handle the error condition.

If the TRANS\_ERR and INVALID error flags are not masked using the MASK register, the recovered S/PDIF Rx data is passed to the digital audio interface or to the S/PDIF transmitter irrespective of the state of the flag and the data content of the recovered stream. (Also refer to note below). In this case, the application processor will be interrupted via the INT\_N signal.

#### AUTOMATIC ERROR HANDLING

This automatic handling of errored Rx S/PDIF data can be used when an application processor is not being interrupted via the INT\_N signal leaving the WM8804 to handle the error condition.

If the TRANS\_ERR and INVALID error flags are masked using the MASK register, the WM8804 output data from the S/PDIF Rx interface depends on the setting of FILLMODE. If FILLMODE=1, then the incoming data (which is errored) is overwritten with 0's. If FILLMODE=0, then the last valid data sample is repeatedly output.

For the INVALID flag, the automatic error handling can be disabled if ALWAYSVALID =1. If ALWAYSVALID is set, then the recovered Rx S/PDIF data, which is marked as invalid, will be allowed to pass to the digital audio interface or to the S/PDIF transmitter. The data will not be modified in any way.

#### Note:

For the S/PDIF receiver to S/PDIF transmitter data path, only the INVALID flag will cause data to be overwritten, the TRANS\_ERR flag is not used to overwrite data which is passed to the S/PDIF transmitter.

| REGISTER ADDRESS  | BIT | LABEL       | DEFAULT | DESCRIPTION  |
|-------------------|-----|-------------|---------|--|
| R8<br>PLL6<br>08h | 5   | FILLMODE    | 0       | <b>Fill Mode Overwrite Configuration</b><br>Determines S/PDIF receiver action when TRANS_ERR or INVALID flag is masked and error condition sets the flag:<br>0 = Data from S/PDIF receiver is overwritten with last valid data sample when flag is set.<br>1 = Data from S/PDIF receiver is overwritten as all zeros when flag is set. |
|                   | 6   | ALWAYSVALID | 0       | <b>Automatic Error Handling Configuration for INVALID Flag</b><br>0 = INVALID flag automatic error handling enabled.<br>1 = INVALID flag automatic error handling disabled.  |

Table 51 S/PDIF Receiver Automatic Error Handling Configuration Registers

**NON-AUDIO DETECTION**

The SPDIF payload can contain PCM data for audio or non-audio applications. In the case where the payload contains the 96 bit synchronization code defined in IEC61937 then this indicates that the payload contains data which is not suitable for direct playback through an audio codec. This 96 bit code is defined as 4\*16bits of '0'+Pa (16bits)+Pb (16bits)..

If the S/PDIFRx interface decodes this sync code then it sets the PCM\_N bit.

When the PCM\_N =1, then it indicates non-audio data. When the PCM\_N =0, then it indicates that the SPDIF payload does not contain the synch code..

Another status bit, AUDIO\_N status is recovered from the Channel Status block. It is bit 1 of the channel status. When AUDIO\_N =0, then it indicates that the SPDIF payload contains audio PCM encoded data. This is also referred to as linear PCM data. When the AUDIO\_N= 1, then it indicates that the SPDIF payload does not contain audio PCM data.

NON\_AUDIO data is indicated by a logical OR of the AUDIO\_N and PCM\_N flags.

Any change of AUDIO\_N or PCM\_N status will cause an INT\_N interrupt (UPD\_NON\_AUDIO) to be generated. If the MASK register bit for AUDIO\_N or PCM\_N is set, then the associated signal will not generate an interrupt (UPD\_NON\_AUDIO).

**GENERAL PURPOSE OUTPUT (GPO) CONFIGURATION**

The WM8804 has a maximum of three configurable GPO pins depending upon the mode of operation of the device. By default GPO0 is available, however if 2-wire Software Control Mode is selected the CSB pin becomes GPO1 and the SDOOUT pin becomes GPO2.

| REGISTER ADDRESS   | BIT | LABEL     | DEFAULT             | DESCRIPTION  |
|--------------------|-----|-----------|---------------------|--|
| R23<br>GPO0<br>17h | 3:0 | GPO0[3:0] | 0000<br>(INT_N)     | Flags and status bits available on GPO pins<br><br>0000 = INT_N<br>0001 = V<br>0010 = U<br>0011 = C<br>0100 = TRANS_ERR<br>0101 = SFRM_CLK<br>0110 = 192BLK<br>0111 = UNLOCK<br>1000 = NON_AUDIO<br>1001 = CSUD<br>1010 = DEEMPH<br>1011 = CPY_N<br>1100 = ZEROFLAG<br>1101 = 0<br>↓<br>1111 = 0 |
| R24<br>GPO1<br>18h | 3:0 | GPO1[3:0] | 0111<br>(UNLOCK)    |  |
| R26<br>GPO2<br>1Ah | 7:4 | GPO2[3:0] | 0100<br>(TRANS_ERR) |  |

**Note 1:** GPO1 and GPO2 are only available in 2-wire software control mode.  
**Note 2:** Refer to Table 45 for signal descriptions

Table 52 GPO Control Registers

## DIGITAL AUDIO INTERFACE

Audio data is transferred to and from the WM8804 via the digital audio interface. Data from the digital audio interface transmitter may be passed to the S/PDIF transmitter or data from the S/PDIF receiver may be output on the digital audio interface receiver. The digital audio interface can be powered down using the AIFPD register bit described in Table 53.

| REGISTER ADDRESS    | BIT | LABEL | DEFAULT | DESCRIPTION   |
|---------------------|-----|-------|---------|---|
| R30<br>PWRDN<br>1Eh | 5   | AIFPD | 1       | <b>Digital Audio Interface Power Down</b><br>1 = Power down<br>0 = Power up |

**Table 53 Digital Audio Interface Power Down Control**

### MASTER AND SLAVE MODES

The audio interface operates in either slave or master mode, selectable using the AIF\_MS bit (see Table 55). In both master and slave modes DIN is always an input and DOUT is always an output. The default is slave mode.

In slave mode (AIF\_MS=0), LRCLK and BCLK are inputs. DIN and LRCLK are sampled on the rising edge of BCLK. Data output, DOUT, changes on the falling edge of BCLK and the polarity of BCLK may be reversed independently on the transmit and receive sides of the interface using the AIFRX\_BCP and AIFTX\_BCP control bits, see Table 56.

In master mode (AIF\_MS=1), LRCLK and BCLK are generated by the WM8804. As in slave mode, DIN is sampled on the rising edge of BCLK, and DOUT changes on the falling edge of BCLK and the polarity of BCLK may be reversed the transmit and receive sides of the interface with the AIFRX\_BCP and AIFTX\_BCP control bits.

The frequencies of LRCLK are derived from MCLK and are dependant on the MCLKDIV control bit. Table 54 shows the settings for MCLKDIV for common sample rates and MCLK frequencies.

| SAMPLING RATE<br>(LRCLK) | MASTER CLOCK (MCLK) FREQUENCY<br>(MHZ) |             |
|--------------------------|--|-------------|
|                          | 128fs                                  | 256fs       |
|                          | MCLKDIV = 1                            | MCLKDIV = 0 |
| 32kHz                    | 4.096                                  | 8.192       |
| 44.1kHz                  | 5.6448                                 | 11.2896     |
| 48kHz                    | 6.144                                  | 12.288      |
| 96kHz                    | 12.288                                 | 24.576      |
| 192kHz                   | 24.576                                 | Unavailable |

**Table 54 Master Mode LRCLK Frequency Selection**

BCLK is also generated by the WM8804. The frequency of BCLK depends on the mode of operation. In 128fs mode (MCLKDIV = 1) BCLK = MCLK/2. In 256fs mode (MCLKDIV = 0) BCLK = MCLK/4. However if DSP mode is selected as the audio interface mode then BCLK=MCLK. Note that DSP mode cannot be used in 128fs mode for data word lengths greater than 16-bits.

Master/slave mode is selected with the following register:

| REGISTER ADDRESS    | BIT | LABEL    | DEFAULT | DESCRIPTION  |
|---------------------|-----|----------|---------|--|
| R28<br>AIFRX<br>1Ch | 6   | AIF_MS   | 0       | <b>Audio Interface Master/Slave Mode Select</b><br>0 = Slave mode – MCLK, LRCLK and BCLK are inputs<br>1 = Master mode – MCLK, LRCLK and BCLK are outputs  |
|                     | 7   | SYNC_OFF | 0       | <b>Audio Interface Clock Output Enable</b><br>Enables BCLK and LRCLK out when external S/PDIF source has been removed (master mode only)<br>0 = LRCLK, BCLK are not output when S/PDIF source has been removed<br>1 = LRCLK, BCLK output when S/PDIF source has been removed |

**Table 55 Master/Slave Mode Select Register**

When operating in master mode, then the BCLK and LRCLK are derived from the sample rate of the S/PDIF received signal. If the S/PDIF receive data signal is removed (unplugged) then by default the AIF BCLK and LRCLK will not be output. This can be reconfigured to allow these clocks to continue outputting when the source is removed using the SYNC\_OFF bit in register R28.

## AUDIO DATA FORMATS

Five interface formats are supported:

- Left Justified Mode
- Right Justified Mode
- I<sup>2</sup>S Mode
- DSP Mode A
- DSP Mode B

The MSB is sent first in all formats. Word lengths of 16, 20 and 24 bits are supported.

Audio data for each stereo channel is clocked with the BCLK signal. Data is time multiplexed with the LRCLK, indicating whether the left or right channel data is present. The LRCLK is also used as a timing reference to indicate the beginning or end of the data words.

In Left Justified, Right Justified and I<sup>2</sup>S modes the minimum number of BCLKs per LRCLK period is two times the number of bits in the selected word length. LRCLK must be high for a minimum of  $n$  BCLKs and low for a minimum of  $n$  BCLKs, where  $n$  is the number of bits in an audio word. Any mark to space ratio on LRCLK is acceptable provided the above requirements are met.

The data may also be output in DSP Mode A or Mode B, with LRCLK used as a frame sync to identify the MSB of the first word. The minimum number of BCLKs per LRCLK period is two times the number of bits in the word length.

### LEFT JUSTIFIED MODE

In Left Justified mode, the MSB of DIN is sampled by the WM8804 on the first rising edge of BCLK following an LRCLK transition. The MSB of the output data (DOUT) changes on the same falling edge of BCLK as LRCLK and may be sampled on the next rising edge of BCLK. LRCLK is high during the left samples and low during the right samples (Figure 18).

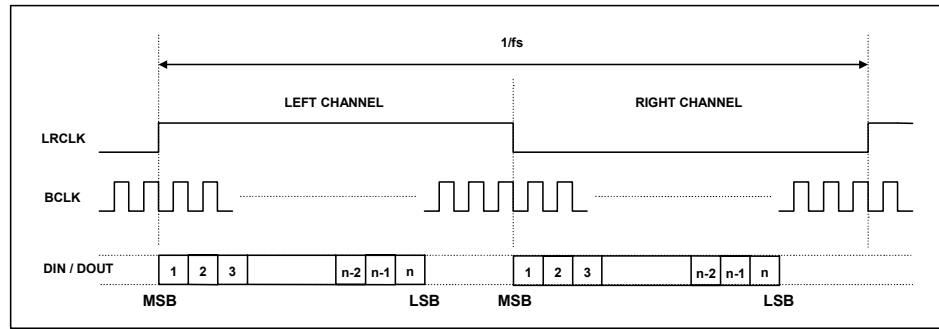


Figure 18 Left Justified Mode

**RIGHT JUSTIFIED MODE**

In Right Justified Mode, the LSB of DIN is sampled by the WM8804 on the rising edge of BCLK preceding an LRCLK transition. The LSB of the output data (DOUT) changes on the falling edge of BCLK preceding an LRCLK transition, and may be sampled on the next rising edge of BCLK. LRCLK is high during the left samples and low during the right samples (Figure 19).

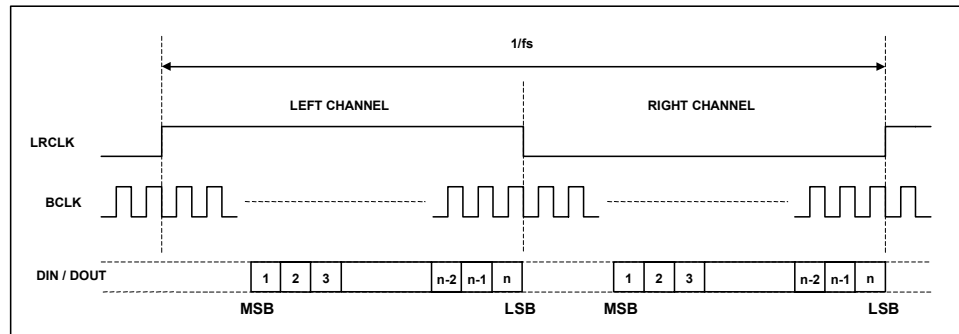


Figure 19 Right Justified Mode

**I<sup>2</sup>S MODE**

In I<sup>2</sup>S Mode, the MSB of DIN is sampled by the WM8804 on the second rising edge of BCLK following an LRCLK transition. The MSB of the output data changes on the first falling edge of BCLK following an LRCLK transition, and may be sampled on the next rising edge of BCLK. LRCLK is low during the left samples and high during the right samples (Figure 20).

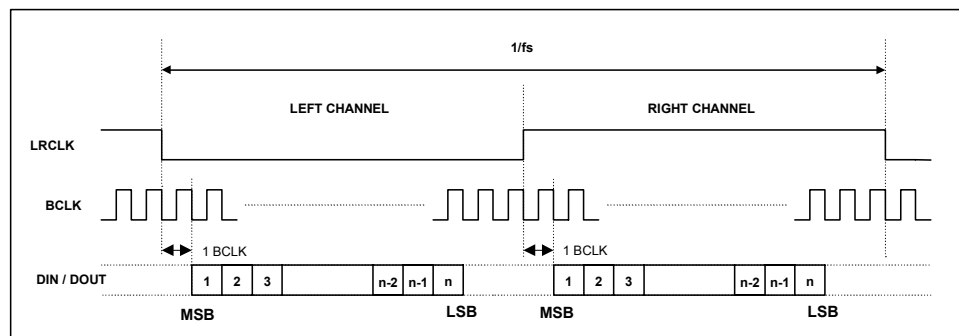
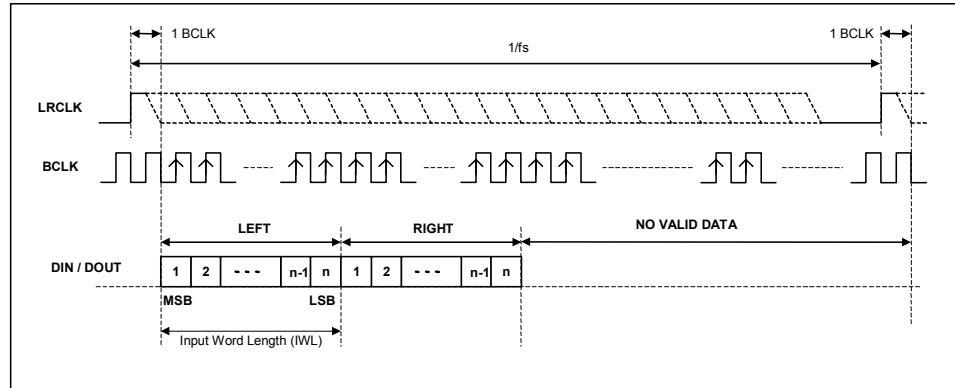


Figure 20 I<sup>2</sup>S Mode

**DSP MODE A**

In DSP Mode A, the MSB of the left channel data is sampled by the WM8804 on the second rising edge of BCLK following an LRCLK rising edge. The right channel data follows the left channel data (Figure 21).

The MSB of the left channel of the output data changes on the first falling edge of BCLK following a low to high LRCLK transition and may be sampled on the rising edge of BCLK. The right channel data is contiguous with the left channel data (Figure 21).

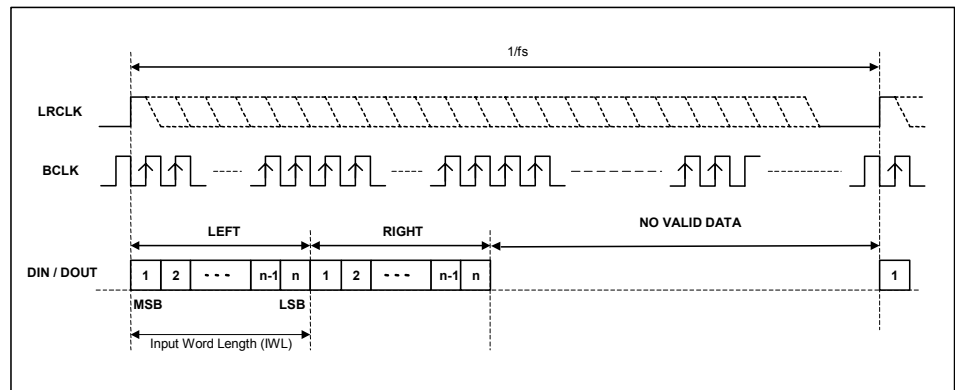


**Figure 21 DSP Mode A**

**DSP MODE B**

In DSP Mode B, the MSB of the left channel data is sampled by the WM8804 on the first BCLK rising edge following an LRCLK rising edge. The right channel data follows the left channel data (Figure 22).

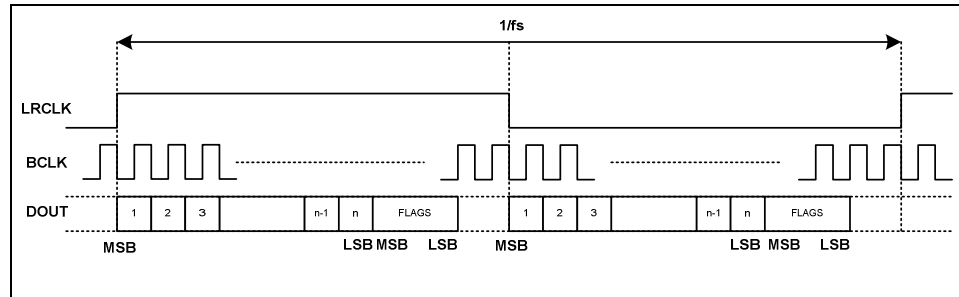
The MSB of the output data changes on the same falling edge of BCLK as the low to high LRCLK transition and may be sampled on the rising edge of BCLK. The right channel data is contiguous with the left channel data (Figure 22).



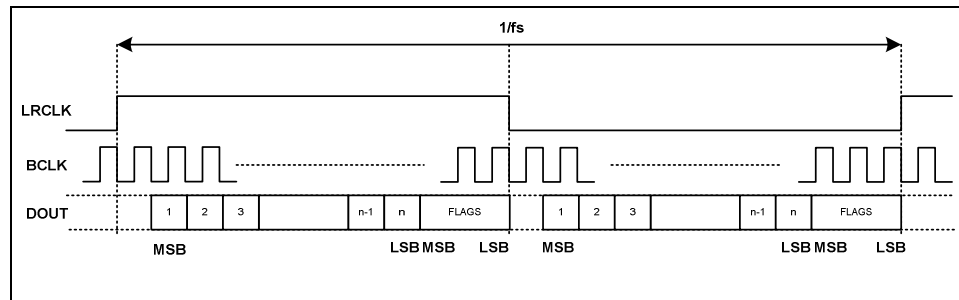
**Figure 22 DSP Mode B**

**'WITH FLAGS' MODE**

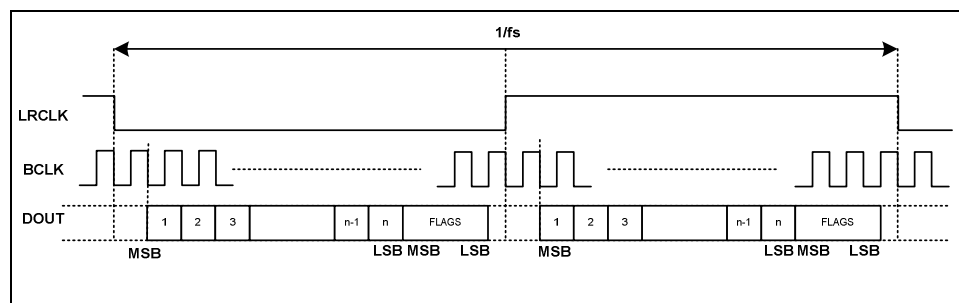
The following diagrams illustrate the position of the status flags within the audio sample for each audio data format when 'With Flags' Mode is enabled. 'With Flags' Mode is only available on pin DOUT. The WM8804 does not support Right Justified 24-Bit 'With Flags' Mode.



**Figure 23 Left Justified 'With Flags' Mode**



**Figure 24 Right Justified 'With Flags' Mode**



**Figure 25 I²S 'With Flags' Mode**



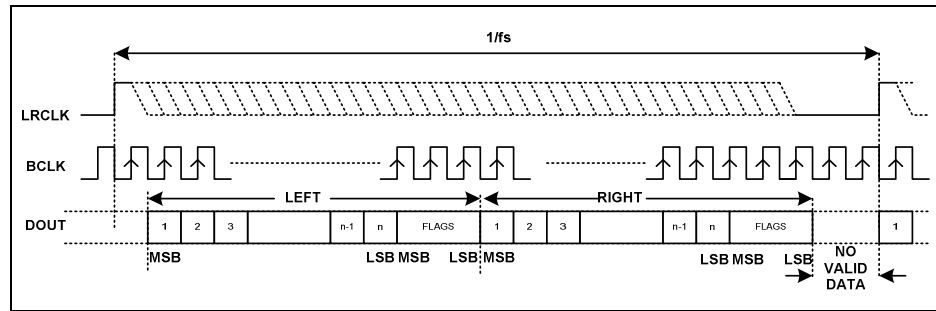


Figure 26 DSP Mode A 'With Flags'

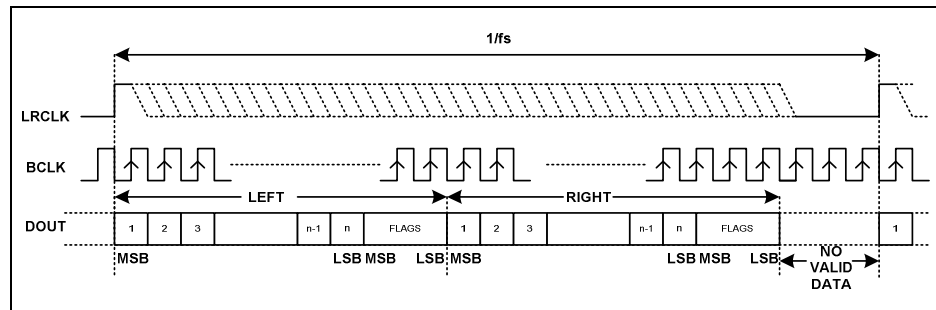


Figure 27 DSP Mode B 'With Flags'

## AUDIO INTERFACE CONTROL

The register bits controlling the audio interface are summarised below. Note that dynamically changing the audio data format may cause erroneous operation, and hence is not recommended.

| REGISTER ADDRESS       | BIT | LABEL          | DEFAULT | DESCRIPTION   |
|------------------------|-----|----------------|---------|---|
| R29<br>SPDIFRX1<br>1Dh | 4   | WITHFLAG       | 0       | 'With Flags' Mode Select<br>0: 'With Flags' Mode disabled (see Note 3)<br>1: 'With Flags' Mode enabled  |
|                        | 6   | WL_MASK        | 0       | <b>S/PDIF Receiver Word Length Truncation Mask</b><br>0 = disabled, data word is truncated as described in Table 44 S/PDIF Receiver Channel Status Register 5<br>1 = enabled, data word is not truncated. |
| R27<br>AIFTX<br>1Bh    | 1:0 | AIFTX_FMT[1:0] | 10      | Audio Data Format Select<br>11: DSP mode<br>10: I <sup>2</sup> S mode<br>01: Left justified mode<br>00: Right justified mode  |
|                        | 3:2 | AIFTX_WL[1:0]  | 01      | Audio Data Word Length<br>11: 24 bits (see notes 1/2/3/6)<br>10: 24 bits (see notes 1/2/3/6)<br>01: 20 bits<br>00: 16 bits  |
|                        | 4   | AIFTX_BCP      | 0       | BCLK invert (for master and slave modes)<br>0 = BCLK not inverted<br>1 = BCLK inverted  |
|                        | 5   | AIFTX_LRP      | 0       | Right, left and I <sup>2</sup> S modes – LRCLK polarity and DSP mode select<br>1 = invert LRCLK polarity / DSP Mode B<br>0 = normal LRCLK polarity / DSP Mode A   |
| R28<br>AIFRX<br>1Ch    | 1:0 | AIFRX_FMT[1:0] | 10      | Audio Data Format Select<br>11: DSP mode<br>10: I <sup>2</sup> S mode<br>01: Left justified mode<br>00: Right justified mode  |
|                        | 3:2 | AIFRX_WL[1:0]  | 01      | Audio Data Word Length<br>11: 24 bits (see note 1/2/3/6)<br>10: 24 bits<br>01: 20 bits<br>00: 16 bits   |
|                        | 4   | AIFRX_BCP      | 0       | BCLK Invert (for master and slave modes)<br>0 = BCLK not inverted<br>1 = BCLK inverted<br>See Note 4  |
|                        | 5   | AIFRX_LRP      | 0       | Right, left and I <sup>2</sup> S modes – LRCLK polarity and DSP mode select<br>1 = invert LRCLK polarity / DSP Mode B<br>0 = normal LRCLK polarity / DSP Mode A<br>See Note 5                             |

Table 56 Audio Interface Control

- Note 1:** S/PDIF data frames contain a maximum of 24-bits of audio data.
- Note 2:** In 24 bit I<sup>2</sup>S mode, any data width of 24 bits or less is supported provided that LRCLK is high for a minimum of 24 BCLK cycles and low for a minimum of 24 BCLK cycles (48 BCLK cycles). If exactly 32 BCLK cycles occur in one LRCLK (16 high, 16 low) the chip will auto detect and operate in 16 bit data word length mode.
- Note 3:** 24 bit Right Justified 'With Flags' Mode is not supported.
- Note 4:** Must be set to the same value as AIFTX\_BCP.
- Note 5:** Must be set to the same value as AIFTX\_LRP.
- Note 6:** MAXWL and RXWL[2:0] bits in recovered channel status data are used to truncate digital audio interface transmitted data. The truncation replaces the lower data bits with 0. Refer to received channel status bit description.

## REGISTER MAP

The complete register map is shown below. The detailed description can be found in the relevant text of the device description. The WM8804 can be configured using the Control Interface. Any unused bits which are not specified should be set to '0'. Not all registers can be read. Only the device ID (registers R0, R1 and R2) and the status registers can be read. These status registers are labelled as "read only".

| REGISTER | NAME        | ADDRESS [0:7] | B7                               | B6          | B5             | B4        | B3            | B2           | B1             | B0          | DEFAULT   |
|----------|-------------|---------------|----------------------------------|-------------|----------------|-----------|---------------|--------------|----------------|-------------|-----------|
| R0       | RST/DEVID 1 | 00            | write: RESET read: DEVICEID[7:0] |             |                |           |               |              |                |             | -         |
| R1       | DEVID2      | 01            | DEVICEID[15:8]                   |             |                |           |               |              |                |             | read only |
| R2       | DEVREV      | 02            | 0                                | 0           | 0              | 0         | DEVREV[3:0]   |              |                |             | read only |
| R3       | PLL1        | 03            | PLL_K[7:0]                       |             |                |           |               |              |                |             | 00100001  |
| R4       | PLL2        | 04            | PLL_K[15:8]                      |             |                |           |               |              |                |             | 11111101  |
| R5       | PLL3        | 05            | 0                                | 0           | PLL_K[21:16]   |           |               |              |                |             | 00110110  |
| R6       | PLL4        | 06            | TXVAL_OVWR                       | TXVAL_SF1   | TXVAL_SF0      | PRESCALE  | PLL_N[3:0]    |              |                |             | 00000111  |
| R7       | PLL5        | 07            | 0                                | 0           | CLKOUTDIV[1:0] |           | MCLKDIV       | FRACEN       | FREQMODE[1:0]  |             | 00010110  |
| R8       | PLL6        | 08            | MCLKSRC                          | ALWAYSVALID | FILLMODE       | CLKOUTDIS | CLKOUTSRC     | 0            | 0              | 0           | 00011000  |
| R9       | SPDMODE     | 09            | 1                                | 1           | 1              | 1         | 1             | 1            | 1              | SPDIFINMODE | 11111111  |
| R10      | INTMASK     | 0A            | MASK[7:0]                        |             |                |           |               |              |                |             | 00000000  |
| R11      | INTSTAT     | 0B            | Interrupt Status                 |             |                |           |               |              |                |             | read only |
| R12      | SPDSTAT     | 0C            | S/PDIF Status                    |             |                |           |               |              |                |             | read only |
| R13      | RXCHAN1     | 0D            | RX Channel Info 1                |             |                |           |               |              |                |             | read only |
| R14      | RXCHAN2     | 0E            | RX Channel Info 2                |             |                |           |               |              |                |             | read only |
| R15      | RXCHAN3     | 0F            | RX Channel Info 3                |             |                |           |               |              |                |             | read only |
| R16      | RXCHAN4     | 10            | RX Channel Info 4                |             |                |           |               |              |                |             | read only |
| R17      | RXCHAN5     | 11            | RX Channel Info 5                |             |                |           |               |              |                |             | read only |
| R18      | SPDXTX1     | 12            | CHSTMODE[1:0]                    |             | DEEMPH[2:0]    |           | CPY_N         | AUDIO_N      | CON/PRO        |             | 00000000  |
| R19      | SPDXTX2     | 13            | CATCODE[7:0]                     |             |                |           |               |              |                |             | 00000000  |
| R20      | SPDXTX3     | 14            | CHNUM2[1:0]                      |             | CHNUM1[1:0]    |           | SRCNUM[3:0]   |              |                | 00000000    |           |
| R21      | SPDXTX4     | 15            | TXSTATSRC                        | TXSRC       | CLKACU[1:0]    |           | FREQ[3:0]     |              |                | 01110001    |           |
| R22      | SPDXTX5     | 16            | ORGSAMP[3:0]                     |             |                |           | TXWL[2:0]     |              | MAXWL          |             | 00001011  |
| R23      | GPO0        | 17            | 0                                | 1           | 1              | 1         | GPO0[3:0]     |              |                |             | 01110000  |
| R24      | GPO1        | 18            | 0                                | 1           | 0              | 1         | GPO1[3:0]     |              |                |             | 01010111  |
| R25      |             | 19            | 0                                | 0           | 1              | 1         | 0             | 1            | 1              | 0           | 00110110  |
| R26      | GPO2        | 1A            | GPO2[3:0]                        |             |                |           | 0             | 0            | 1              | 0           | 01000010  |
| R27      | AIFTX       | 1B            | 0                                | 0           | AIFTX_LRP      | AIFTX_BCP | AIFTX_WL[1:0] |              | AIFTX_FMT[1:0] |             | 00000110  |
| R28      | AIFRX       | 1C            | SYNC_OFF                         | AIF_MS      | AIFRX_LRP      | AIFRX_BCP | AIFRX_WL[1:0] |              | AIFRX_FMT[1:0] |             | 00000110  |
| R29      | SPDRX1      | 1D            | SPD_192K_EN                      | WL_MASK     | 0              | WITHFLAG  | CONT          | READMUX[2:0] |                |             | 10000000  |
| R30      | PWRDN       | 1E            | 0                                | 0           | TRIOP          | AIFPD     | OSCPD         | SPDIFTXPD    | SPDIFRXPD      | PLLPD       | 00000111  |

Table 57 WM8804 Register Map

| REGISTER ADDRESS                    | BIT | LABEL        | DEFAULT  | DESCRIPTION   |
|-------------------------------------|-----|--------------|----------|---|
| R00<br>RST/DEVID1<br>00h            | 7:0 | RESET        | -        | Writing to this register will apply a reset to the device.<br>Reading from this register will return the second part of the device ID<br>00000101 = 05h   |
| R01<br>DEVID2<br>01h<br>(read only) | 7:0 | DEVID2       | 10001000 | Reading from this register will return the first part of the device ID<br>10001000 = 88h  |
| R02<br>DEVREV<br>02h                | 3:0 | DEVREV[3:0]  | -        |   |
| R3<br>PLL1<br>03h                   | 7:0 | PLL_K[7:0]   | 00100001 | Fractional (K) part of PLL frequency ratio (R).<br>Value K is one 22-digit binary number spread over registers R3, R4 and R5 as shown.<br><b>Note: PLL_K must be set to specific values when the S/PDIF receiver is used. Refer to S/PDIF Receiver clocking section for details.</b>  |
| R4<br>PLL2<br>04h                   | 7:0 | PLL_K[15:8]  | 11111101 |   |
| R5<br>PLL3<br>05h                   | 5:0 | PLL_K[21:16] | 00110110 |   |
| R6<br>PLL4<br>06h                   | 3:0 | PLL_N[3:0]   | 0111     | Integer (N) part of PLL frequency ratio (R).<br>Use values in the range $5 \leq \text{PLL\_N} \leq 13$ as close as possible to 8<br><b>Note: PLL_N must be set to specific values when the S/PDIF receiver is used. Refer to S/PDIF Receiver clocking section for details.</b>  |
|                                     | 4   | PRESCALE     | 0        | <b>PLL Pre-scale Divider Select</b><br>0 = Divide by 1 (PLL input clock = oscillator clock)<br>1 = Divide by 2 (PLL input clock = oscillator clock ÷ 2)   |
|                                     | 5   | TXVAL_SF0    | 0        | <b>Overwrite Mode S/PDIF Transmitter Validity Sub-Frame 0</b><br>0 = transmit validity = 0<br>1 = transmit validity = 1   |
|                                     | 6   | TXVAL_SF1    | 0        | <b>Overwrite Mode S/PDIF Transmitter Validity Sub-Frame 1</b><br>0 = transmit validity = 0<br>1 = transmit validity = 1   |
|                                     | 7   | TXVAL_OVWR   | 0        | <b>S/PDIF Transmitter Validity Overwrite Mode Enable</b><br>0 = disabled, validity bit is 0 when the S/PDIF transmitter sources PCM audio interface, or it matches the S/PDIF input validity when the S/PDIF transmitter sources the S/PDIF receiver.<br>1 = enabled, validity bit transmitted for subframe 0 is defined by TXVAL_SF0, validity bit transmitted for subframe 1 is defined by TXVAL_SF1. |

| REGISTER ADDRESS  | BIT | LABEL          | DEFAULT | DESCRIPTION   |
|-------------------|-----|----------------|---------|---|
| R7<br>PLL5<br>07h | 1:0 | FREQMODE[1:0]  | 10      | <b>PLL Post-scale Divider Select</b><br>Selects the PLL output divider value in conjunction with MCLKDIV and CLKOUTDIV. Refer to Table 23 for details of FREQMODE operation.<br><b>Note: FREQMODE[1:0] bits are automatically set in S/PDIF Receive Mode.</b> |
|                   | 2   | FRACEN         | 1       | <b>Integer/Fractional PLL Mode Select</b><br>0 = Integer PLL (PLL_N value used, PLL_K value ignored)<br>1 = Fractional PLL (both PLL_N and PLL_K values used)<br><b>Note: FRACEN must be set to enable the fractional PLL when using S/PDIF Receive Mode.</b> |
|                   | 3   | MCLKDIV        | 0       | <b>MCLK Divider Select</b><br>(Only valid when CLK2 is selected as MCLK output source)<br>See Table 23 for MCLKDIV configuration in PLL user mode.<br>See Table 28 for MCLKDIV configuration in PLL S/PDIF receive mode.                                      |
|                   | 5:4 | CLKOUTDIV[1:0] | 01      | <b>CLKOUT Divider Select</b><br>(Only valid when CLK1 is selected as CLKOUT output source)<br>See Table 23 for CLKOUTDIV[1:0] configuration in PLL user mode.<br>See Table 28 for CLKOUTDIV[1:0] configuration in PLL S/PDIF receive mode.                    |
| R8<br>PLL6<br>08h | 3   | CLKOUTSRC      | 1       | <b>CLKOUT Pin Source Select</b><br>0 = Select CLK1<br>1 = Select OSCCLK   |
|                   | 4   | CLKOUTDIS      | 1       | <b>CLKOUT Pin Disable</b><br>0 = Pin Disabled (Pin tri-stated)<br>1 = Pin Enabled   |
|                   | 5   | FILLMODE       | 0       | <b>Fill Mode Select</b><br>Determines S/PDIF receiver action when corrupt or invalid data is detected:<br>0 = Data from S/PDIF receiver remains static at last valid sample.<br>1 = Data from S/PDIF receiver is output as all zeros.                         |
|                   | 6   | ALWAYSVALID    | 0       | <b>Always Valid Select</b><br>Used to ignore the INVALID flag.<br>0 = Use INVALID flag.<br>1 = Ignore INVALID flag.   |
|                   | 7   | MCLKSRC        | 0       | <b>MCLK Output Source Select</b><br>0 = Select CLK2<br>1 = Select OSCCLK  |

| REGISTER ADDRESS      | BIT | LABEL       | DEFAULT  | DESCRIPTION   |
|-----------------------|-----|-------------|----------|---|
| R9<br>SPDMODE<br>09h  | 0   | SPDIFINMODE | 1        | <p><b>S/PDIF Input Mode Select</b></p> <p>Selects the input circuit type for the receiver input.</p> <p>0 = CMOS input</p> <p>1 = Comparator input. Compatible with 500mVppAC coupled consumer S/PDIF input signals. Refer to S/PDIF specification (IEC 60958-3) for full details.</p>  |
| R10<br>INTMASK<br>0Ah | 7:0 | MASK[7:0]   | 00000000 | <p><b>Interrupt Mask Enable</b></p> <p>When a flag is masked, it does not update the Interrupt Status Register or cause an INT_N interrupt to be asserted.</p> <p>0 = unmask, 1 = mask.</p> <p>MASK[0] = mask control for UPD_UNLOCK</p> <p>MASK[1] = mask control for INT_INVALID</p> <p>MASK[2] = mask control for INT_CSUD</p> <p>MASK[3] = mask control for INT_TRANS_ERR</p> <p>MASK[4] = mask control for UPD_NON_AUDIO</p> <p>MASK[5] = mask control for UPD_CPY_N</p> <p>MASK[6] = mask control for UPD_DEEMPH</p> <p>MASK[7] = mask control for UPD_REC_FREQ</p> |

| REGISTER ADDRESS                     | BIT | LABEL         | DEFAULT | DESCRIPTION   |
|--------------------------------------|-----|---------------|---------|---|
| R11<br>INTSTAT<br>0Bh<br>(read-only) | 0   | UPD_UNLOCK    | -       | <b>UNLOCK Update Signal</b><br>0 = INT_N not caused by a toggle of UNLOCK flag<br>1 = INT_N caused by a toggle of UNLOCK flag   |
|                                      | 1   | INT_INVALID   | -       | <b>INVALID Flag Interrupt Signal</b><br>0 = INT_N not caused by INVALID flag<br>1 = INT_N caused by INVALID flag  |
|                                      | 2   | INT_CSUD      | -       | <b>INT_CSUD Interrupt Signal</b><br>0 = INT_N not caused by CSUD flag<br>1 = INT_N caused by CSUD flag  |
|                                      | 3   | INT_TRANS_ERR | -       | <b>TRANS_ERR Flag Interrupt Signal</b><br>0 = INT_N not caused by TRANS_ERR flag<br>1 = INT_N caused by TRANS_ERR flag  |
|                                      | 4   | UPD_NON_AUDIO | -       | <b>NON_AUDIO Update Signal</b><br>0 = INT_N not caused by a toggle of AUDIO_N or PCM_N flags<br>1 = INT_N caused by a toggle of AUDIO_N or PCM_N flags                                    |
|                                      | 5   | UPD_CPY_N     | -       | <b>CPY_N Update Signal</b><br>0 = INT_N not caused by a toggle of CPY_N flag<br>1 = INT_N caused a toggle of CPY_N flag   |
|                                      | 6   | UPD_DEEMPH    | -       | <b>DEEMPH Update Signal</b><br>0 = INT_N not caused by a toggle of DEEMPH flag<br>1 = INT_N caused by a toggle of DEEMPH flag   |
|                                      | 7   | UPD_REC_FREQ  | -       | <b>REC_FREQ Update Signal</b><br>0 = INT_N not caused by a toggle of REC_FREQ flag<br>1 = INT_N caused by a toggle of REC_FREQ flag   |
| R12<br>SPDSTAT<br>0Ch<br>(read-only) | 0   | AUDIO_N       | -       | <b>Audio Status Flag</b><br>Recovered channel status bit-1.<br>0 = Data word represents audio PCM samples.<br>1 = Data word does not represent audio PCM samples.                         |
|                                      | 1   | PCM_N         | -       | <b>Non-PCM Flag</b><br>Indicates that non-audio code (defined in IEC-61937) has been detected.<br>0 = Sync code not detected.<br>1 = Sync code detected – received data is not audio PCM. |
|                                      | 2   | CPY_N         | -       | <b>Non-Copyright Flag</b><br>Recovered Channel Status bit-2.<br>0 = Copyright is asserted for this data.<br>1 = Copyright is not asserted for this data.                                  |
|                                      | 3   | DEEMPH        | -       | <b>De-emphasis Flag</b><br>Recovered Channel Status bit-3.<br>0 = Copyright is asserted for this data.<br>1 = Copyright is not asserted for this data.                                    |



| REGISTER ADDRESS                     | BIT | LABEL             | DEFAULT  | DESCRIPTION  |
|--------------------------------------|-----|-------------------|----------|--|
|                                      | 5:4 | REC_FREQ<br>[1:0] | --       | <b>Recovered Frequency Flag</b><br>Indicates recovered S/PDIF clock frequency:<br>00 = 192kHz<br>01 = 96kHz or 88.2kHz<br>10 = 48kHz or 44.1kHz<br>11 = 32kHz                          |
|                                      | 6   | UNLOCK            | -        | <b>Unlock Flag</b><br>Indicates that the S/PDIF Rx clock recovery circuit is unlocked.<br>0 = Locked onto incoming S/PDIF stream.<br>1 = Not locked onto the incoming S/PDIF stream.   |
| R13<br>RXCHAN1<br>0Dh<br>(read-only) | 0   | CON/PRO           | 0        | <b>Use Of Channel Status Block</b><br>0 = Consumer Mode<br>1 = Professional Mode<br>The WM8804 is a consumer mode device. Detection of professional mode may give erroneous behaviour. |
|                                      | 1   | AUDIO_N           | 0        | <b>Linear PCM Identification</b><br>0 = Data word represents audio PCM samples.<br>1 = Data word does not represent audio PCM samples.   |
|                                      | 2   | CPY_N             | 0        | <b>Copyright Information</b><br>0 = Copyright is asserted for Rx data.<br>1 = Copyright is not asserted for Rx data.   |
|                                      | 3   | DEEMPH            | 0        | <b>Additional Format Information</b><br>0 = Recovered S/PDIF data has no pre-emphasis.<br>1 = Recovered S/PDIF data has pre-emphasis.  |
|                                      | 5:4 | Reserved          | 00       | Reserved for additional de-emphasis modes.   |
|                                      | 7:6 | CHSTMODE<br>[1:0] | 00       | <b>Channel Status Mode</b><br>00 = Only valid mode for consumer applications.  |
| R14<br>RXCHAN2<br>0Eh<br>(read-only) | 7:0 | CATCODE<br>[7:0]  | 00000000 | <b>Category Code</b><br>Refer to S/PDIF specification (IEC 60958-3) for full details.<br>0x00h indicates "general" mode.   |
| R15<br>RXCHAN3<br>0Fh<br>(read-only) | 3:0 | SRCNUM<br>[3:0]   | 0000     | <b>S/PDIF Source Number</b><br>Refer to S/PDIF specification (IEC 60958-3) for full details.   |
|                                      | 5:4 | CHNUM1[1:0]       | 00       | <b>Channel Number For Sub-frame 1</b><br>00 = do not use channel number<br>01 = channel 1 to left channel<br>10 = channel 1 to right channel   |
|                                      | 7:6 | CHNUM2[1:0]       | 00       | <b>Channel Number For Sub-frame 2</b><br>00 = do not use channel number<br>01 = channel 2 to left channel<br>10 = channel 2 to right channel   |
| R16<br>RXCHAN4                       | 3:0 | FREQ[3:0]         | 0001     | <b>Indicated Sampling Frequency</b><br>Refer to S/PDIF specification (IEC 60958-3) for full details.   |

| REGISTER ADDRESS                     | BIT              | LABEL             | DEFAULT   | DESCRIPTION   |
|--------------------------------------|------------------|-------------------|---|---|
| 10h<br>(read-only)                   | 5:4              | CLKACU[1:0]       | 11  | <b>Clock Accuracy of Received Clock</b><br>00 = Level II<br>01 = Level I<br>10 = Level III<br>11 = Interface frame rate not matched to sampling frequency.  |
| R17<br>RXCHAN5<br>11h<br>(read-only) | 0                | MAXWL             | 1   | <b>Maximum Audio Sample Word Length</b><br>0 = 20 bits<br>1 = 24 bits<br>Note: see table in description of bits 3:1 of this register.   |
|                                      | 3:1              | RXWL[2:0]         | 000   | <b>Audio Sample Word Length</b><br>000: Word length not indicated   |
|                                      |                  |                   |   | <b>RXWL[2:0]</b>   <b>MAXWL==1</b>   <b>MAXWL==0</b>  |
|                                      |                  |                   |   | 001   20 bits   16 bits   |
|                                      |                  |                   |   | 010   22 bits   18 bits   |
|                                      |                  |                   |   | 100   23 bits   19 bits   |
|                                      |                  |                   |   | 101   24 bits   20 bits   |
| 110   21 bits   17 bits              |                  |                   |   |   |
|                                      |                  |                   |   | All other combinations are reserved and should not be used.   |
| 7:4                                  | ORGSAMP<br>[3:0] | 0000              | <b>Original Sampling Frequency</b><br>Refer to S/PDIF specification (IEC 60958-3) for full details. |   |
| R18<br>SPD TX1<br>12h                | 0                | CON/PRO           | 0   | <b>Use Of Channel Status Block</b><br>0 = Consumer Mode<br>1 = Professional Mode (not supported by WM8804).   |
|                                      | 1                | AUDIO_N           | 0   | <b>Linear PCM Identification</b><br>0 = S/PDIF transmitted data is audio PCM.<br>1 = S/PDIF transmitted data is not audio PCM.  |
|                                      | 2                | CPY_N             | 0   | <b>Copyright Information</b><br>0 = Transmitted data has copyright asserted.<br>1 = Transmitted data has no copyright assertion.  |
|                                      | 5:3              | DEEMPH[2:0]       | 000   | <b>Additional Format Information</b><br>000 = Data from Audio interface has no pre-emphasis.<br>001 = Data from Audio interface has pre-emphasis.<br>All other modes are reserved and should not be used. |
|                                      | 7:6              | CHSTMODE<br>[1:0] | 00  | <b>Channel Status Mode</b><br>00 = Only valid mode for consumer applications.   |
| R19<br>SPD TX2<br>13h                | 7:0              | CATCODE<br>[7:0]  | 00000000  | <b>Category Code</b><br>Refer to S/PDIF specification (IEC 60958-3) for full details.<br>00h indicates "general" mode.  |

| REGISTER ADDRESS     | BIT              | LABEL           | DEFAULT   | DESCRIPTION  |  |                 |
|----------------------|------------------|-----------------|---|--|--|-----------------|
| R20<br>SPDIX3<br>14h | 3:0              | SRCNUM<br>[3:0] | 0000  | <b>Source Number</b><br>Refer to S/PDIF specification (IEC 60958-3) for full details.  |  |                 |
|                      | 5:4              | CHNUM1[1:0]     | 00  | <b>Channel Number for Subframe 1</b>   |  |                 |
|                      |                  |                 |   | <b>CHNUM1</b>  | <b>Channel Status Bits[21:20]<br/>Function</b> |                 |
|                      |                  |                 |   | 00   | Do not use channel number                      |                 |
|                      |                  |                 |   | 01   | Send to Left Channel                           |                 |
|                      |                  |                 |   | 10   | Send to Right Channel                          |                 |
|                      | 7:6              | CHNUM2[1:0]     | 00  | <b>Channel Number for Subframe 2</b>   |  |                 |
|                      |                  |                 |   | <b>CHNUM2</b>  | <b>Channel Status Bits[23:22]<br/>Function</b> |                 |
|                      |                  |                 |   | 00   | Do not use channel number                      |                 |
|                      |                  |                 |   | 01   | Send to Left Channel                           |                 |
| 10                   |                  |                 |   | Send to Right Channel  |  |                 |
| R21<br>SPDIX4<br>15h | 3:0              | FREQ[3:0]       | 0001  | <b>Indicated Sampling Frequency</b><br>Refer to S/PDIF specification (IEC 60958-3) for full details.<br>0001 = Sampling Frequency not indicated.   |  |                 |
|                      | 5:4              | CLKACU[1:0]     | 11  | <b>Clock Accuracy of Transmitted Clock</b><br>00 = Level II<br>01 = Level I<br>10 = Level III<br>11 = Interface frame rate not matched to sampling frequency.  |  |                 |
|                      | 6                | TXSRC           | 1   | <b>S/PDIF Transmitter Data Source</b><br>0 = S/PDIF Received Data – SPDIFTXCLK Source = CLK2<br>1 = Digital Audio Interface Received Data – SPDIFTXCLK Source = MCLK Input/Output Signal at MCLK Pin |  |                 |
|                      | 7                | TXSTATSRC       | 0   | <b>S/PDIF Transmitter Channel Status Data Source</b><br>0 = Received channel status data<br>1 = Transmit channel status registers<br>Note : Only used if TXSRC=0                                     |  |                 |
| R22<br>SPDIX5<br>16h | 0                | MAXWL           | 1   | <b>Maximum Audio Sample Word Length</b><br>0 = 20 bits<br>1 = 24 bits  |  |                 |
|                      | 3:1              | TXWL[2:0]       | 101   | <b>Audio Sample Word Length</b><br>Used with MAXWL to indicate Tx word length<br>000 = Word length not indicated   |  |                 |
|                      |                  |                 |   | <b>TXWL[2:0]</b>   | <b>MAXWL==1</b>                                | <b>MAXWL==0</b> |
|                      |                  |                 |   | 001  | 20 bits  | 16 bits         |
|                      |                  |                 |   | 010  | 22 bits  | 18 bits         |
|                      |                  |                 |   | 100  | 23 bits  | 19 bits         |
|                      |                  |                 |   | 101  | 24 bits  | 20 bits         |
| 110                  | 21 bits          | 17 bits         |   |  |  |                 |
| 7:4                  | ORGSAMP<br>[3:0] | 0000            | <b>Original Sampling Frequency</b><br>Refer to S/PDIF specification (IEC 60958-3) for full details. |  |  |                 |

| REGISTER ADDRESS    | BIT | LABEL          | DEFAULT | DESCRIPTION  |
|---------------------|-----|----------------|---------|--|
| R23<br>GPO0<br>17h  | 3:0 | GPO0[3:0]      | 0000    | Flags and Status bits available on GPO pins<br><br>0000 = INT_N<br>0001 = V<br>0010 = U<br>0011 = C<br>0100 = TRANS_ERR<br>0101 = SFRM_CLK<br>0110 = 192BLK<br>0111 = UNLOCK<br>1000 = NON_AUDIO<br>1001 = CSUD<br>1010 = DEEMPH<br>1011 = CPY_N<br>1100 = ZEROFLAG<br>1101 = 0<br>↓<br>1111 = 0 |
| R24<br>GPO1<br>18h  | 3:0 | GPO1[3:0]      | 0111    |  |
| R26<br>GPO2<br>1Ah  | 7:4 | GPO2[3:0]      | 0100    | <b>Note:</b> GPO1 and GPO2 is only available in 2-wire software control mode.  |
| R27<br>AIFTX<br>1Bh | 1:0 | AIFTX_FMT[1:0] | 10      | <b>Audio Data Format Select</b><br>11: DSP mode<br>10: I <sup>2</sup> S mode<br>01: Left justified mode<br>00: Right justified mode  |
|                     | 3:2 | AIFTX_WL[1:0]  | 01      | <b>Audio Data Word Length Select</b><br>11: 24 bits<br>10: 24 bits<br>01: 20 bits<br>00: 16 bits   |
|                     | 4   | AIFTX_BCP      | 0       | <b>BCLK Invert</b> (for master and slave modes)<br>0 = BCLK not inverted<br>1 = BCLK inverted  |
|                     | 5   | AIFTX_LRP      | 0       | Right, left and I <sup>2</sup> S modes – LRCLK polarity and DSP mode select<br>1 = invert LRCLK polarity / DSP Mode B<br>0 = normal LRCLK polarity / DSP Mode A  |
| R28<br>AIFRX<br>1Ch | 1:0 | AIFRX_FMT[1:0] | 10      | <b>Audio Data Format Select</b><br>11: DSP mode<br>10: I <sup>2</sup> S mode<br>01: Left justified mode<br>00: Right justified mode  |
|                     | 3:2 | AIFRX_WL[1:0]  | 01      | <b>Audio Data Word Length Select</b><br>11: 24 bits<br>10: 24 bits<br>01: 20 bits<br>00: 16 bits   |
|                     | 4   | AIFRX_BCP      | 0       | <b>BCLK Invert</b> (for master and slave modes)<br>0 = BCLK not inverted<br>1 = BCLK inverted  |

| REGISTER ADDRESS     | BIT | LABEL            | DEFAULT | DESCRIPTION   |
|----------------------|-----|------------------|---------|---|
|                      | 5   | AIFRX_LRP        | 0       | Right, left and I <sup>2</sup> S modes – LRCLK polarity and DSP mode select<br>1 = invert LRCLK polarity / DSP Mode B<br>0 = normal LRCLK polarity / DSP Mode A   |
|                      | 6   | AIF_MS           | 0       | <b>Audio Interface Master/Slave Interface Select</b><br>0 = Slave Mode – LRCLK, BCLK are inputs<br>1= Master Mode – LRCLK and BCLK are outputs  |
|                      | 7   | SYNC_OFF         | 0       | <b>Audio Interface Clock Output Enable</b><br>Enables BCLK and LRCLK out when external S/PDIF source has been removed (master mode only)<br>0 = LRCLK, BCLK are not output when S/PDIF source has been removed<br>1= LRCLK, BCLK output when S/PDIF source has been removed   |
| R29<br>SPDRX1<br>1Dh | 2:0 | READMUX<br>[2:0] | 000     | <b>Status Register Select</b><br>Determines which status register is to be read back:<br>000 = Interrupt Status Register<br>001 = Channel Status Register 1<br>010 = Channel Status Register 2<br>011 = Channel Status Register 3<br>100 = Channel Status Register 4<br>101 = Channel Status Register 5<br>110 = S/PDIF Status Register |
|                      | 3   | CONT             | 0       | <b>Continuous Read Enable</b><br>0 = Continuous read-back mode disabled<br>1 = Continuous read-back mode enabled  |
|                      | 4   | WITHFLAG         | 0       | <b>'With Flags' Mode Select</b><br>0: 'With Flags' Mode disabled<br>1: 'With Flags' Mode enabled  |
|                      | 6   | WL_MASK          | 0       | <b>S/PDIF Receiver Word Length Truncation Mask</b><br>0 = disabled, data word is truncated as described in Table 44 S/PDIF Receiver Channel Status Register 5<br>1 = enabled, data word is not truncated.   |
|                      | 7   | SPD_192K_EN      | 1       | <b>S/PDIF Receiver 192kHz Support Enable</b><br>0 = disabled, S/PDIF receiver maximum supported sampling frequency is 96kHz<br>1 = enabled, S/PDIF receiver maximum supported sampling frequency is 192kHz  |

| REGISTER ADDRESS    | BIT | LABEL     | DEFAULT | DESCRIPTION  |
|---------------------|-----|-----------|---------|--|
| R30<br>PWRDN<br>1Eh | 0   | PLLPD     | 1       | <b>PLL Powerdown</b><br>0 = PLL enabled<br>1 = PLL disabled  |
|                     | 1   | SPDIFRXP  | 1       | <b>S/PDIF Receiver Powerdown</b><br>0 = S/PDIF receiver enabled<br>1 = S/PDIF receiver disabled          |
|                     | 2   | SPDIFTXPD | 1       | <b>S/PDIF Transmitter Powerdown</b><br>0 = S/PDIF transmitter enabled<br>1 = S/PDIF transmitter disabled |
|                     | 3   | OSCPD     | 0       | <b>Oscillator Power down</b><br>0 = Power Up<br>1 = Power Down   |
|                     | 4   | AIFPD     | 0       | <b>Digital Audio Interface Power down</b><br>0 = Power Up<br>1 = Power Down                              |
|                     | 5   | TRIOP     | 0       | <b>Tri-state all Outputs</b><br>0 = Outputs not tri-stated<br>1 = Outputs tri-stated                     |

## APPLICATIONS INFORMATION

### RECOMMENDED EXTERNAL COMPONENTS

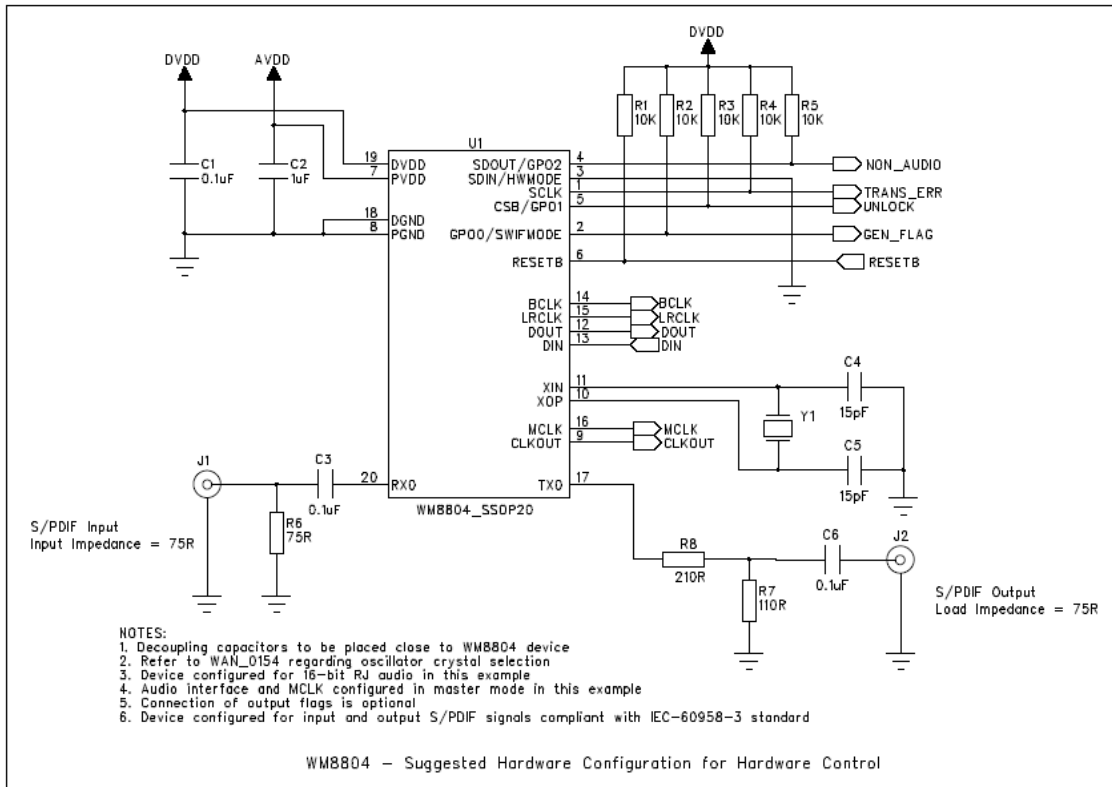


Figure 28 Recommended External Components for Hardware Control Mode

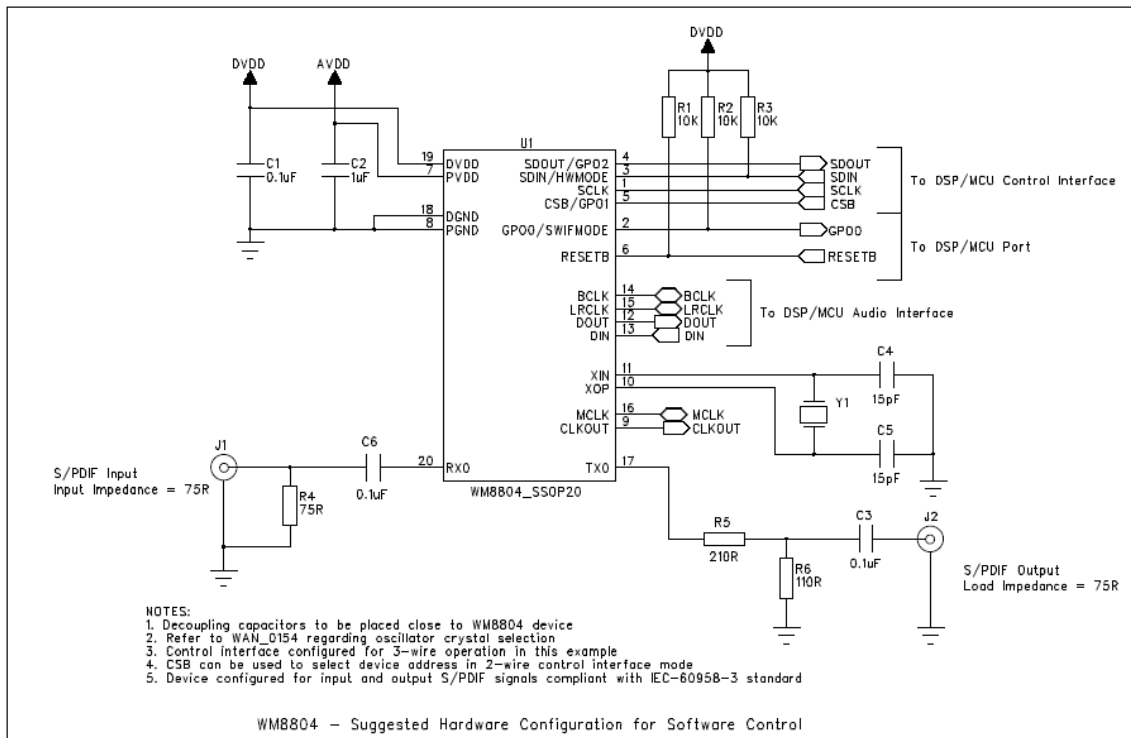
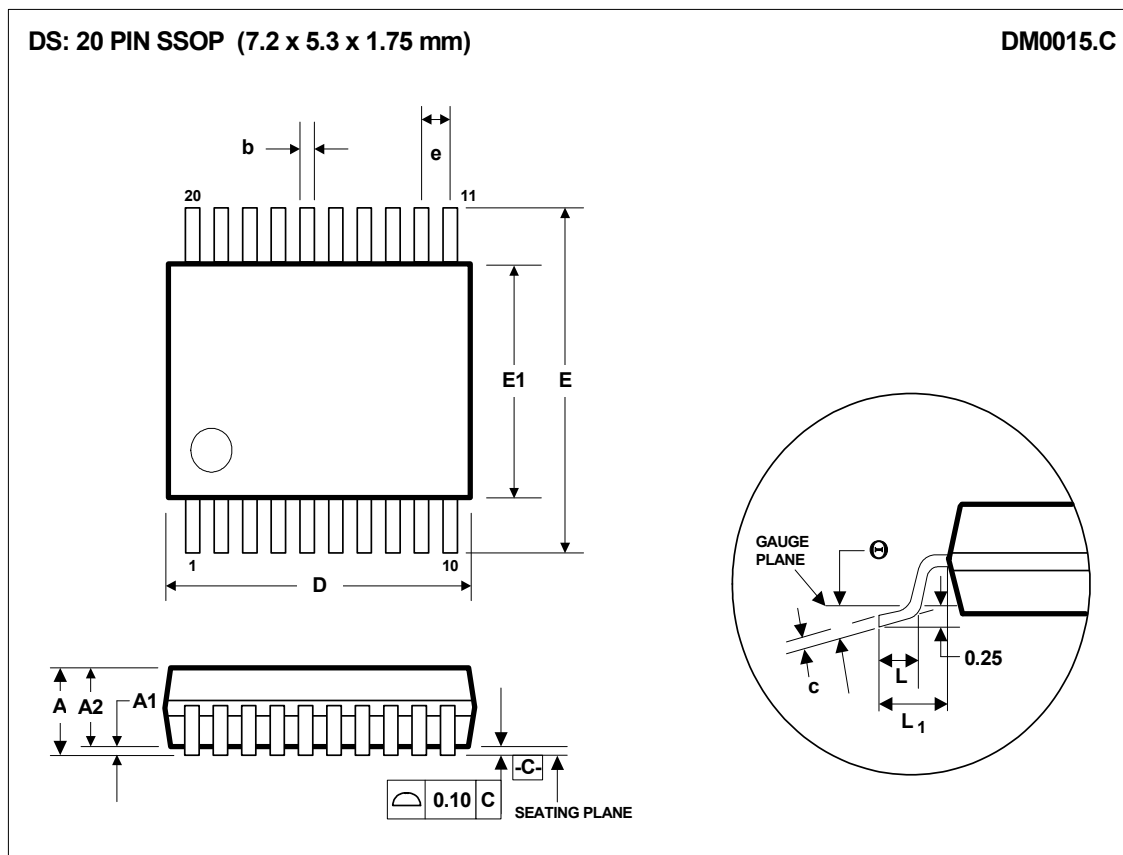


Figure 29 Recommended External Components for Software Control Mode



**PACKAGE DIMENSIONS**



| Symbols              | Dimensions (mm)  |      |      |
|----------------------|------------------|------|------|
|                      | MIN              | NOM  | MAX  |
| <b>A</b>             | ----             | ---- | 2.0  |
| <b>A<sub>1</sub></b> | 0.05             | ---- | ---- |
| <b>A<sub>2</sub></b> | 1.65             | 1.75 | 1.85 |
| <b>b</b>             | 0.22             | 0.30 | 0.38 |
| <b>c</b>             | 0.09             | ---- | 0.25 |
| <b>D</b>             | 6.90             | 7.20 | 7.50 |
| <b>e</b>             | 0.65 BSC         |      |      |
| <b>E</b>             | 7.40             | 7.80 | 8.20 |
| <b>E<sub>1</sub></b> | 5.00             | 5.30 | 5.60 |
| <b>L</b>             | 0.55             | 0.75 | 0.95 |
| <b>L<sub>1</sub></b> | 1.25 REF         |      |      |
| <b>θ</b>             | 0°               | 4°   | 8°   |
| <b>REF:</b>          | JEDEC.95, MO-150 |      |      |

- NOTES:  
 A. ALL LINEAR DIMENSIONS ARE IN MILLIMETERS.  
 B. THIS DRAWING IS SUBJECT TO CHANGE WITHOUT NOTICE.  
 C. BODY DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSION, NOT TO EXCEED 0.20MM.  
 D. MEETS JEDEC.95 MO-150, VARIATION = AE. REFER TO THIS SPECIFICATION FOR FURTHER DETAILS.

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