ANALOG DEVICES

AN-654 APPLICATION NOTE

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Optical Module Development Platform 2.5 Gbps Transmitter with Digital Diagnostics

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FEATURES
Development Platform for SFF-8472
Digital Diagnostics and Control (ADuC832/ADuC842*)
3.2 Gbps Laser Diode Driver (ADN2847)
1310 nm FP Laser LC TOSA
Triple Digitally Controlled Potentiometer (ADN2860)
Flexible Control Loop Options
Interface Software
Dual/Triple I^{2}C® Address Support
64 kB Program Flash, 4 kB Data Flash, 256 Byte EEPROM
3.3 V Single-Supply Operation
Schematics and BOM
Layout with Gerber Files Available

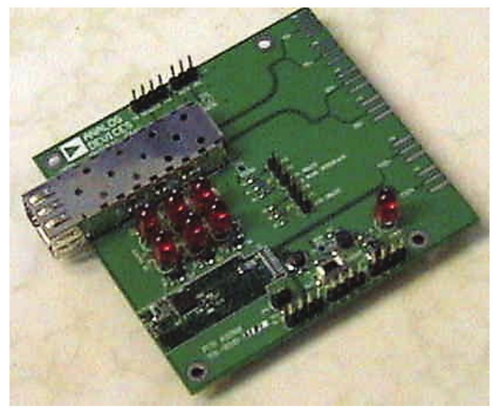
APPLICATIONS
OC3–OC48, FC, GBE Optical Transmitters
GBIC, SFP and SFF Transmitter Evaluation
Digital Diagnostics Development Platform

GENERAL DESCRIPTION
The SFP Digital Diagnostics Development Board is a platform designed to enable optical module designers to develop SFP and SFF compliant transceivers with digital diagnostics. The same platform can be used to develop the digital diagnostics section for other 2-wire based ID and diagnostics functions, such as the ones found in GBIC, 300 pin MSA, XFP, and other optical MSAs.

The development platform includes a development board with an SFP-like layout, an auxiliary SFP cage and connector for final module evaluation, source code to communicate to the I^{2}C interface through an extension board, schematics, bill of material, and layout recommendations.

The ADN2847 dual loop laser diode driver (LDD) drives an ac-coupled laser diode assembled in a low cost TOSA can. The ADN2860 digital potentiometer is used to independently control the extinction ratio and average power set points. The ADN2860 also includes EEPROM compliant with the extension to the GBIC serial ID specifications. These two devices allow the development of basic optical GBIC modules.

The ADuC832/ADuC842 MicroConverters® add a number of functionalities to the system, such as SFF-8472 compliant enhanced digital diagnostics and alternative control loop algorithms, and can be used to support feature-rich modules.



SFP Development Board

INCLUDES
Schematics and Layout of SFP Development Board
Software for ADuC832
Supporting Documents
  ADN2847 Data Sheet
  ADN2860 Data Sheet
  ADuC832/ADuC842 Data Sheet
  TN012: ADN2847 32L Optical AC Evaluation Board
  TN017: ADN2841 Burst Mode Application
  SFP MSA Agreement
  SFF-8472 Draft Rev x.x

DESIGN REVIEW
This section describes the basic operation of each IC on the board and discusses optional functions that can be supported. The design is primarily targeted for SFF-8472 implementation. Reference to the digital diagnostics will be consistent with this particular MSA, but its implementation can be applicable to other 2-wire based digital diagnostics implementations. For more information on the specific registers of the MSAs, refer to the published document.

*ADuC842 pin/code compatible future product

The system as shown in Figure 1 is designed around a MicroConverter that handles both the digital interface and the analog parameters monitoring. Although a set of codes is available with this board, the design is set up to allow the user to develop their own codes and download it into the MicroConverter through either the UART or the emulator port. The design is focused on the transmitter side as most of the diagnostics is performed on or around the laser.

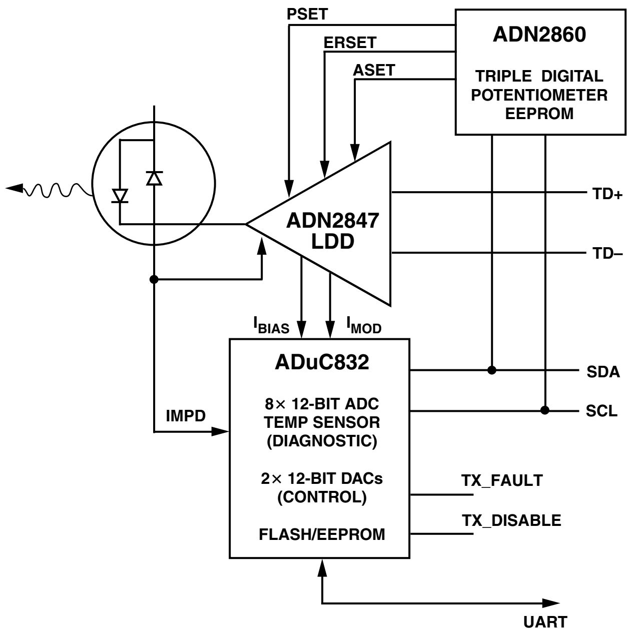


Figure 1. Block Diagram

ADN2860

The ADN2860 is a low tempco 3-channel digital potentiometer (2 × 512 + 1 × 128 positions) with 256 bytes of user EEPROM. This device is hardwired to respond to addresses A0h and 58h. Address A0h contains the serial ID information and other static information regarding the module that the vendor specifies (Table I). This is used to support the basic GBIC requirements and the extended SFF-8472 requirements at the first 2-wire address (by default address A2 is handled by the ADuC832).

The digital potentiometer controls the extinction ratio, average power set points, and end-of-life thresholds for the laser driver (ADN2847). The potentiometer responds to I^2C address 58h and is typically programmed at manufacturing to set the desired laser operating point. The RDAC values can be overwritten to RAM to adjust the laser driver settings, but typically these settings are write protected. By default, to allow the user to experiment, the ADN2860 is NOT write protected, so if these values are overwritten on the RDAC EEPROM, the original data will be lost. The code on the ADuC832 can be modified to enable this protection.

Channel 0 controls the laser bias current threshold (failure or end-of-life indication), Channel 1 controls the average output power set point, and Channel 2 controls the extinction ratio set point.

For more information on register configuration for the ADN2860, refer to the device's data sheet. The appendix lists the most useful commands. For information on the SFF-8472 register configuration, refer to the MSA document.

Table I. SFF-8472 Digital Diagnostics Memory Map

Address	2-Wire Address1010000X (A0h)	Address	2-Wire Address1010001X (A2h)
0–95	SERIAL ID DEFINED BY SFP MSA (96 BYTES)	0–55	ALARM AND WARNING THRESHOLDS (56 BYTES)
		55–95	CAL CONSTANTS (40 BYTES)
95–127	VENDOR SPECIFIC (32 BYTES)	95–119	REAL TIME DIAGNOSTIC INTERFACE (24 BYTES)
		119–127	VENDOR SPECIFIC (8 BYTES)
127–255	RESERVED IN SFP MSA (128 BYTES)	127–247	USER WRITABLE EEPROM (120 BYTES)
		247–255	VENDOR SPECIFIC (8 BYTES)

ADuC832/ADuC842

The MicroConverter is used to perform the monitoring and control of the key parameters in the module. The device includes an 8-channel 12-bit A/D converter, a temperature sensor, two 12-bit voltage output DACs, and an 8052 core that can operate without an external XTAL.

Memory space is divided into 62K of flash program space, 4K of flash data space and 2K + 256 bytes of RAM. The MicroConverter responds to the I^2C address A2h corresponding to the SFF-8472 digital diagnostics EEPROM space (Table I). The software included with the device enables an external master to read the EEPROM through the I^2C interface and retrieve the relevant diagnostics information, module status, and perform software enabled functions such as software shutdown or software monitored LOS.

The monitored parameters are: VCCT, VCCR, I_{BIAS}, I_{MOD}, TX power, temperature, and a provision to monitor the RSSI from the receiver side of the module. They can be read through the 2-wire interface at location 96d (60h) to 119d (77h) of the A2h table. The associated alarms and warning thresholds are programmable at location 0 to 55d (37h). The flexible MicroConverter based design permits the implementation of an internally calibrated diagnostics system and does not require calibration constant to be used. The temperature sensor can also be used to perform temperature dependent compensation of the LDD settings or alarms.

The design using the ADuC842 enables both I^2C addresses to be covered by the MicroConverter and in most cases eliminates the need for the ADN2860.

Another advantage of using a MicroConverter based design is the ability to add additional features such as control loop and monitoring functions for APD receivers and cooled or wavelength controlled lasers. The ADuC842 is a single-cycle per instruction core and is ideal for these expanded features.

ADN2847

The ADN2847 is a multirate (up to 3.2 Gbps) dual loop laser driver. It is used to directly drive an ac-coupled FP laser. The laser driver controls both the average output power and the extinction ratio over temperature and over the lifetime of the laser. This active control of both extension ratio and output power enables the module designer to cut down the time spent characterizing the laser, as the driver will maintain control of ER over varying slope efficiency of the laser due to either temperature or aging effects.

The driver also monitors the bias current and detects failure conditions. The control loop set points are programmed on the ADN2860, while the ADuC832 reads the monitored parameters.

The driver can supply up to 100 mA of bias current and 80 mA of modulation current. For more information on the ADN2847 and other parts in this family, refer to the respective data sheets and published technical notes.

SOFTWARE

Part of the software for the ADuC832 has been developed and is available from the authors upon request. The main functions performed by the MicroConverter are to enable the LDD, monitor the laser parameters, and communicate with an external master through the I^2C. The software also includes a routine that allows the display of the requested parameter values on a PC through the RS-232 port.

Following are examples of the main routines necessary to perform these tasks.

Accessing the ADC and Storing Data into Memory

The digital diagnostics portion of the code uses the on-board ADC to measure the module's supply voltage, its temperature, and the LD bias current (voltage across the monitoring resistor). Output power and modulation current can also be measured but the code has not been added yet. As these values are measured they are saved into data memory space. To avoid too many memory writes, these values are stored/updated only as the request for these values is issued through the I^2C. The smallest memory page size is four words. However, the software is able to update one word at a time through a software mask.

Accessing the Memory Locations Through the I^2C

The MicroConverter is configured as a slave on the I^2C bus with address A2h, as per the GBIC requirements. Data can be read from a specific address by first performing a write command to that address with no data. Next, when a read is performed, data is read from the previously set address location.

The appendix shows the most useful commands to access the I^2C interface from the external master.

SCHEMATICS AND BOM

Schematics and BOM are available at the end of this document. Figure 1 shows a block diagram of the SFP TX section, while the schematics (Figures 2, 3, and 4) enable the user to develop the board.

A few stuffing options are available for the user to experiment. Here is a summary of these options (Option 1 is preferred):

1. LDD set by digital potentiometer, classic configuration:

   Uses ADuC832, ADN2847, and ADN2860. ADN2860 controls PSET, ERSET, and ASET through R34, R35, and R36. R54 and R55 are not stuffed. R58 and R59 are not stuffed. Both ADN2860 and ADuC832 handle the I^2C communication.

2. LDD set by MicroConverter:

   Uses ADuC842, ADN2847. ADN2860 not used. ADuC842 controls PSET and ERSET through R34 and R35. R54 and R55 are 0 Ω. R36 connected to ASET and GND. R58 and R59 are not stuffed. ADuC842 handles both I^2C addresses.

3. MicroConverter forces LDD in open loop. MicroConverter handles control loop:

   Uses ADuC842, ADN2847. ADN2860 not used. ADuC842 controls PAVCAP and ERCAP through R58 and R59. R54 and R55 not stuffed. R34 and R35 0 Ω to GND, R36 connected to ASET and GND. ADuC842 sets PAV and ER based on reading of I_{MOD} and I_{BIAS}. These two parameters are both monitored and controlled at the same time. The dual loop functionality of the ADN2847 is disabled. ADuC842 handles both I^2C addresses.

QUICK START INSTRUCTIONS

A limited number of evaluation systems is available to selected customers. The schematics offered in this application note allow the user to design the board (schematics, layout, and gerber files are available upon request). Once the board is manufactured, follow these instructions:

Start with a factory preprogrammed configuration. On a blank board, download the code to the ADuC832/ADuC842. To modify the ADuC8xx code, a software update through the UART or emulator interface is necessary; QuickStart development tools for the MicroConverter are available at www.analog.com/microconverters.

The EEPROMs should contain a sample of data according to the SFF-8472 standard; when the MicroConverter is enabled, it performs the digital diagnostics and other monitoring functions. The LDD performs a dual loop control function so that the board can be powered and used without downloading codes every time. Following these instructions will allow the user to transmit optical data in addition to read and write to the I^2C accessible registers.

Before starting, make sure you have all necessary components and equipments.

1. SFP Digital Diagnostics Development Board
2. 3.3 V regulated power source
3. I^2C-to-PC interface board (WIN-I2CNT) available at www.demoboard.com
4. PC with WIN-I2CNT board software installed. Alternatively, other I^2C utilities can be used.
5. Differential signal generator (data source) set to 500 mV p-p single-ended or 1 V p-p differential
6. Optical data analyzer (optional)

Then proceed with the following steps:

1. Connect the WIN-I2CNT board to the PC
2. Install the I^2C support software
3. With the SFP development board set to disable (JP2 and JP8 Pins 3 and 4 connected through jumper or floating), connect the 3.3 V and GND power to the SFP board (JP1) and the WIN-I2CNT board (any of the JP3, JP4, or JP5)
4. Connect the I^2C interface of the development board (labeled SDA and SCL on WINI2C and SFP board)
5. Connect the data source to the development board
6. Enable TX (JP2 Pins 2 and 3 connected through jumper)
7. Run the I^2C communication software to read and write into the EEPROM locations. See the appendix for useful commands.

The board contains data on I^2C addresses A2h, A0h (SFF standard registers), and 58h (ADN2860 digital potentiometer settings). For details about these registers, see the Design Review section.

APPENDIX

Most Useful ADN2860 Commands

Extinction Ratio (RDAC2)

	I²C Address	W	Data	I²C Address	R	Data
Increase Resistance 2×	58	W	9C			
Decrease Resistance 2×	58	W	C4			
Increase One Step	58	W	AC			
Decrease One Step	58	W	D4			
Save Settings	58	W	94	58	R	7 BITS
Read DAC Settings	58	W	04			

Average Power (RDAC1)

	I²C Address	W	Data	I²C Address	R	Data
Increase Resistance 2×	58	W	9A			
Decrease Resistance 2×	58	W	C2			
Increase One Step	58	W	AA			
Decrease One Step	58	W	D2			
Save Settings MSB	58	W	92			
Save Settings LSB	58	W	93			
Read DAC Settings	58	W	02	58	R	8 LSB +1 MSB
Read all RDAC Settings	58	W	00	58	R	RDAC0L RDAC0M RDAC1L RDAC1M RDAC2

End of Life Bias Current Threshold (RDAC0)

	I²C Address	W	Data	I²C Address	R	Data
Increase Resistance 2×	58	W	98			
Decrease Resistance 2×	58	W	C0			
Increase One Step	58	W	A8			
Decrease One Step	58	W	D0			
Save Settings MSB	58	W	90			
Save Settings LSB	58	W	91			
Read DAC Settings	58	W	00	58	R	8 LSB +1 MSB

Most Useful Digital Diagnostic Commands

	I²C Address	W	Field	I²C Address	R	Data
Read Temperature	A2	W	60	A2	R	MSB
	A2	W	61	A2	R	LSB
Read VCC	A2	W	62	A2	R	MSB
	A2	W	63	A2	R	LSB
Read TX Bias	A2	W	64	A2	R	MSB
	A2	W	65	A2	R	LSB
Read TX Power	A2	W	66	A2	R	MSB
	A2	W	67	A2	R	LSB
Read RX Power	A2	W	68	A2	R	MSB
	A2	W	69	A2	R	LSB

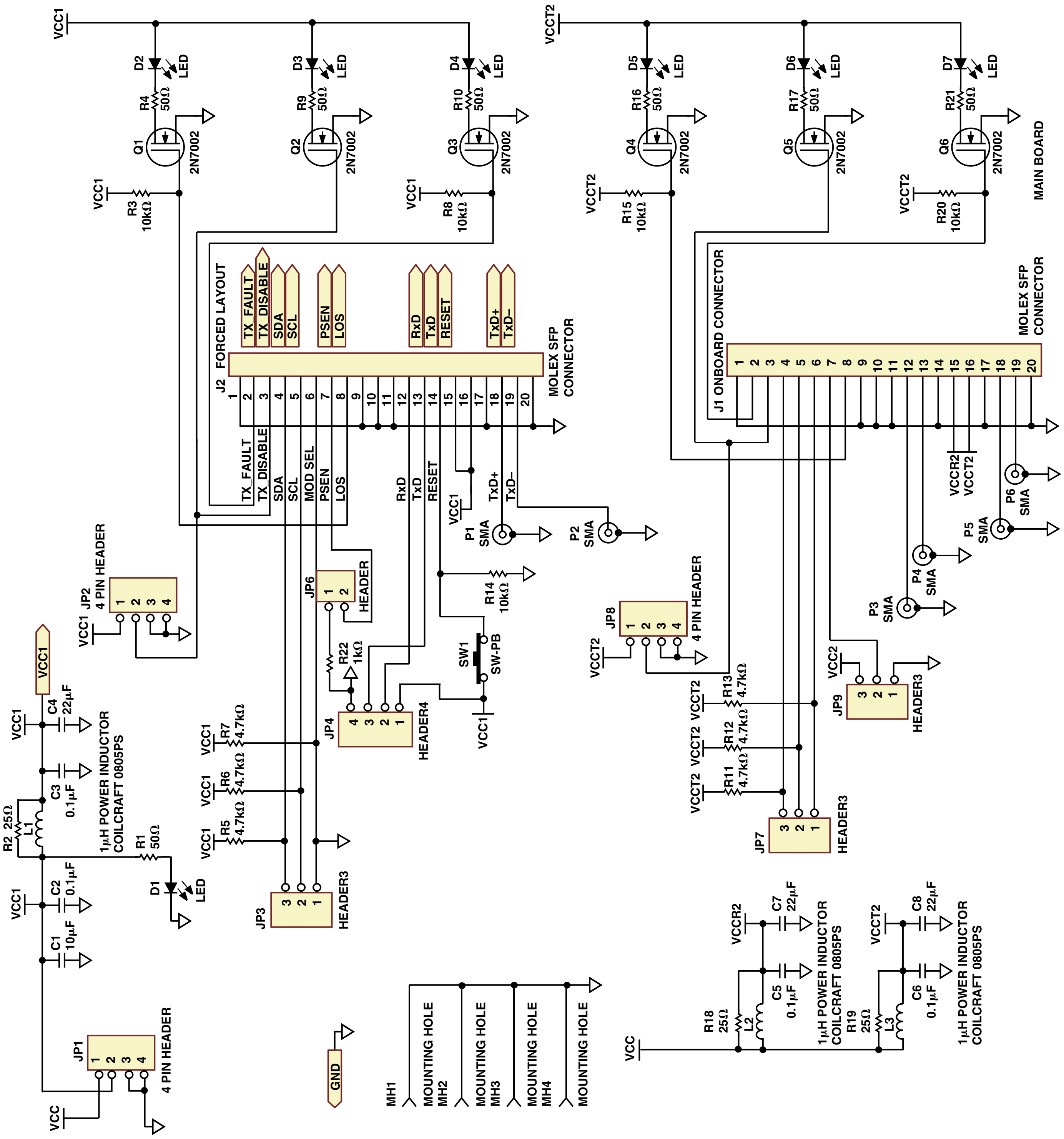


Figure 2. Main Board

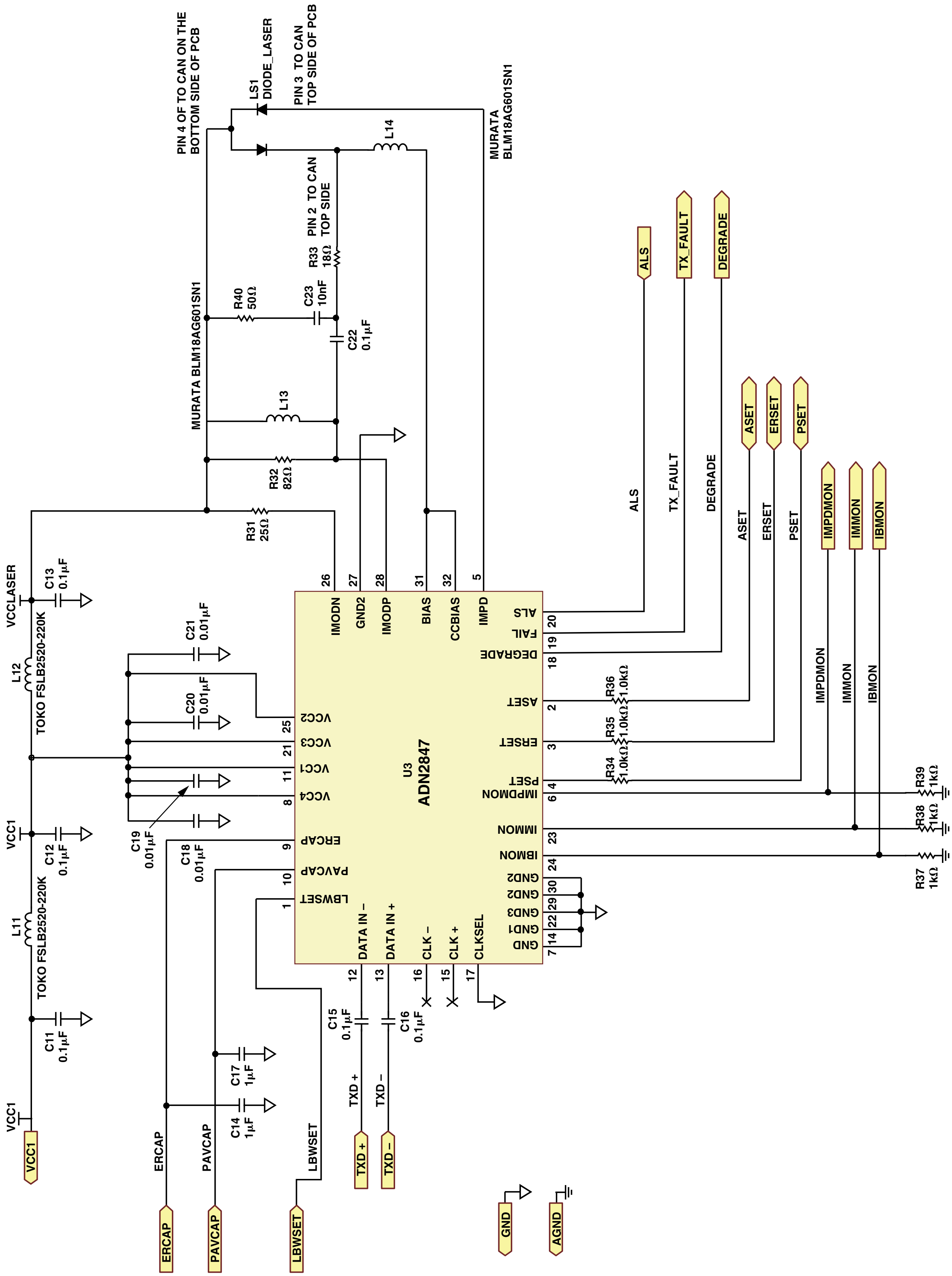


Figure 3. High Speed Section

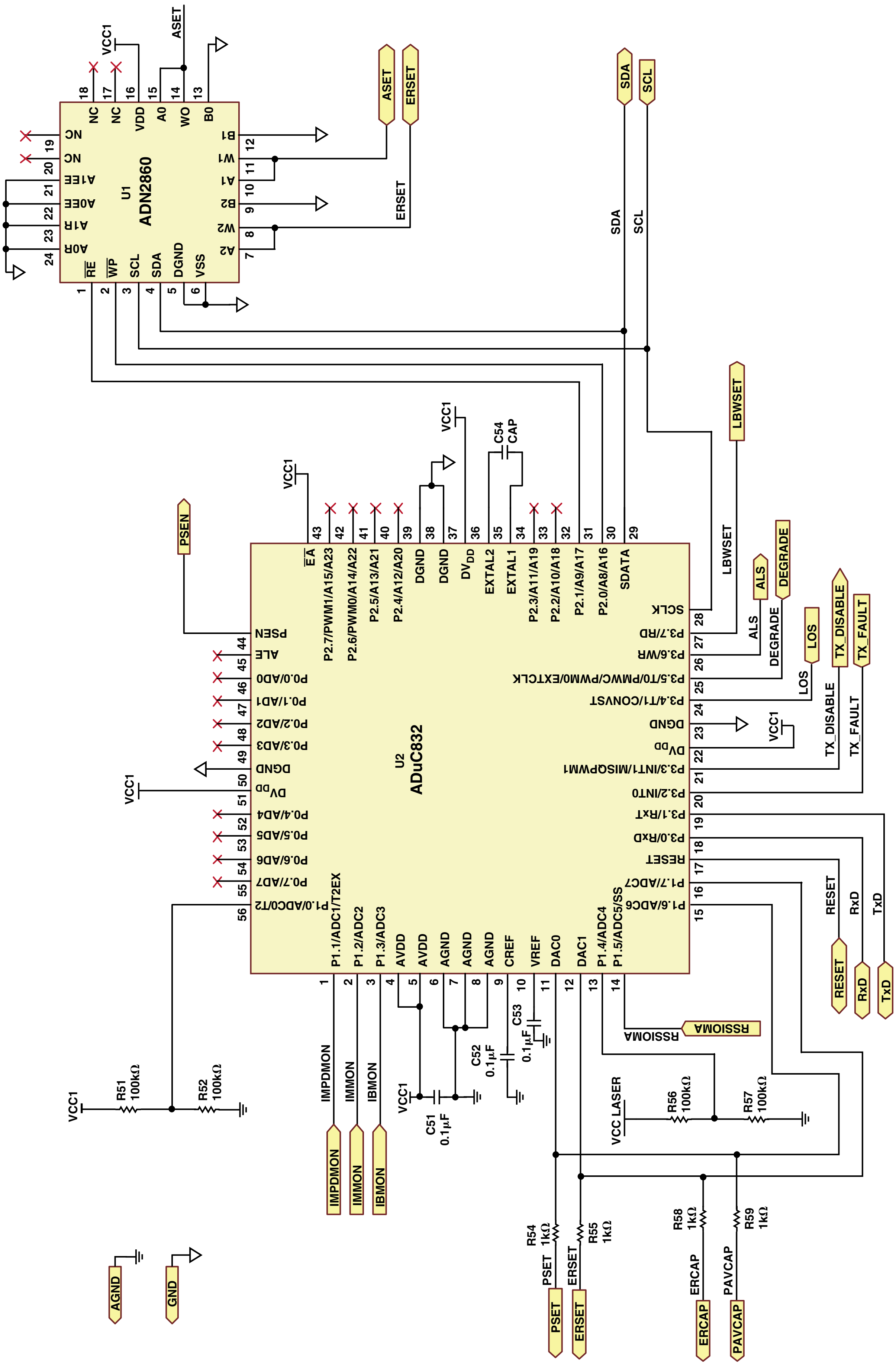


Figure 4. Control and Diagnostics

Table II. Bill of Materials

Item	Qty.	Reference	Description	Manufacturer	Mfgr P/N	Stuffing
1	1	C1	CAP TANT CASE-B 10 μF 6.3 V 10%	KEMET	T491B106K006AST	
2	4	C2, C3, C5, C6	CAP 0603 CERM 0.1 μF Z5U 16 V +80/–20%	KEMET	C0603C104Z4VACTU	
3	3	C4, C7, C8	CAP TANT CASE-B 22 μF 6.3 V 10%	KEMET	T491B226K006AS	
4	4	C18, C19, C20, C21	CAP 0201 CERM 0.01 μF X5R 6.3 V 10%	Panasonic	ECJ-ZEB0J103K	
5	8	C11, C13, C15, C16, C22, C51, C52, C53	CAP 0402 CERM 0.1 μF Y5V 16 V +80/–20%	BC Components	0402F104Z160BT	
6	3	C12, C14, C17	CAP 0603 CERM 1 μF 6.3 V X5R 10%	Panasonic	ECJ-1VB0J105K	
7	7	D1, D2, D3, D4, D5, D6, D7	LED T.H.	Lite-On Electronics	S270CKT	
8	1	J1	CONN SMT SFP Connector	Molex	74441-0010	
9	1	J2	IDC20 Forced Layout SFP Electrical Connector1			Onboard
10	1	JP6	CONN T.H. HEADER 2 × 1 Male 0.1″ SP STR	Sullins Electronics	PZC36DAAN	
11	3	JP3, JP7, JP9	CONN T.H. HEADER 3 × 1 Male 0.1″ SP STR	Sullins Electronics	PZC36DAAN	
12	4	JP1, JP2, JP4, JP8	CONN T.H. HEADER 4 × 1 Male 0.1″ SP STR	Sullins Electronics	PZC36DAAN	
13	3	L1, L2, L3	IND 1608 1 μH Power Inductor	Coilcraft	DS1608C-102	
14	2	L11, L12	IND 1210	TOKO	FSLB2520-220K	
15	2	L13, L14	IND 0603 EMIFIL for DC 600 Ω	Murata	BLM18AG601SN1	
16	1	LS1	Laserdiode T.H. 3 PINS	INFOMAX	LD1310-134-4-2-C0110	
				Sumitomo	SLT2276-LN	
				Excelight	SLT2276-LN	
17	6	P1, P2, P3, P4, P5, P6	CONN T.H. SMA BNC Connector 5 PINS	Lighthorse	SASF55ZGT-6	
18	6	Q1, Q2, Q3, Q4, Q5, Q6	MOSFET SOT-23 N-CH 60 V 7.5 Ω	Fairchild	2N7002	
19	3	R37, R38, R39	RES 0201 1 kΩ 1/20W 5%	Panasonic	ERJ-1GEJ103C	
20	3	R34, R35, R36	RES 0201 1 kΩ 1/20W 5%	Panasonic	ERJ-1GEJ152C	
21	1	R33	RES 0402 18 Ω 1/16W 5%	Panasonic	ERJ-2GEJ180X	

Table II. Bill of Materials (continued)

Item	Qty.	Reference	Description	Manufacturer	Mfgr P/N	Stuffing
22	1	R32	RES 0603 82 Ω 1/16W 5%	Yageo America	9C06031A82ROJLHFT	
23	4	R2, R18, R19, R31	RES 0603 25.5 Ω 1/16W 1%	Yageo America	9C06031A25R5FKHFT	
24	4	R51, R52, R56, R57	RES 0201 100 kΩ 1/20W 5%	Panasonic	ERJ-1GEJ104C	
25	7	R1, R4, R9, R10, R16, R17, R21	RES 0603 56 Ω 1/16W 5%	Panasonic	ERJ-3GEYJ560V	
26	5	R3, R8, R14 R15, R20	RES 0603 10 kΩ 1/16W 1%	Panasonic	ERA-3YEB103V	
27	6	R5, R6, R7, R11, R12, R13	RES 0603 4.7 kΩ 1/16W 5%	Yageo America	9C06031A4701JLHFT	
28	1	R22	RES 0603 1.1 kΩ 1/16W 5%	Yageo America	9C06031A1101JLHFT	
29	1	SW1	SWITCH TACT 6 × 3.5 MM H = 4.3 MM 130GF	E-Switch	TL1107AF130W	
30	1	U1	IC SMT LFCSP24 NV Triple Digital Potentiometer with EEPROM I^2C	ADI	ADN2860	
31	1	U2	IC SMT LFCSP56 Micro-Converter with 62 kB MCU	ADI	ADUC832	
32	1	U3	IC SMT LFCSP32 2.5 G Dual Loop Laser Driver	ADI	ADN2847	
33	1	C54	32 kHz Watch Crystal			NI
34	1	C23	CAP 0201 10 nF		ECJ-ZEB0J103K	NI
35	1	R40	RES 0201 50 Ω			NI
36	4	R54, R55, R58, R59	RES 0201 1 kΩ			NI

NI = Not Installed

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