1. FEATURES

- Highly integrated System-on-Module (SoM)
  20mm x 20mm, PCB thickness of 0.8mm only
- ESP32-PICO-D4 based design (240 MHz, dual core)
- Wi-Fi (2.4 GHz) and Bluetooth LE support
- High performance stereo audio codec
- Hardware audio mixing and pre-processing
- Integrated 800mA Li-Po cell charger
- Integrated 1A, 3.0V buck regulator
- Capacitor-less headphone driver
- Microphone input, stereo line-out and line-in
- IPEX connector for 50 ohm Wi-Fi/BT antenna
- Open-Source codec driver
- Customization services available on request

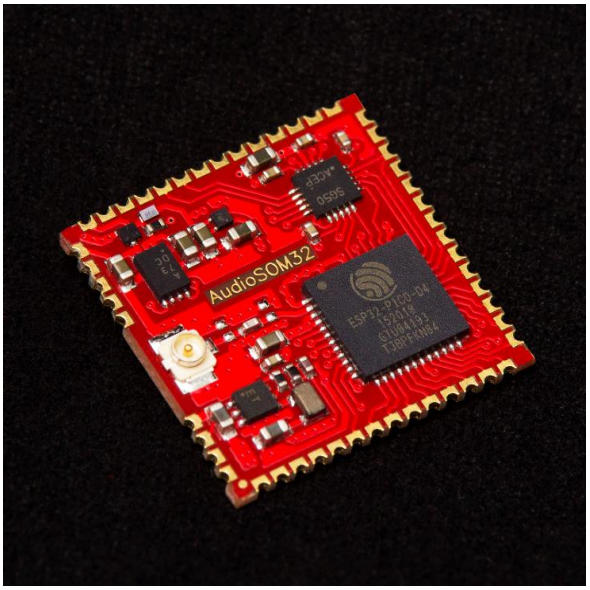

FIGURE 1: AUDIOSOM32 MODULE

2. APPLICATIONS

- Web Radio
- Audio recorders
- Internet connected toys
- Interactive home automation

3. DESCRIPTION

The AudioSOM32 features Espressif System's most integrated SIP, the ESP32-PICO-D4. It provides Wi-Fi and Bluetooth communication, in addition to dual 240MHz CPU cores for computation intensive applications like audio encoding/decoding or processing.

Using just 3 external discrete components, the AudioSOM32 is capable of working as a full featured audio recorder and player with built-in Li-Po cell charge management. The u.FL antenna connector allows for flexibility in antenna selection and is tuned to accommodate any 50 ohm (2.4GHz) antenna. IoTBits provides u.FL PCB antennas for the AudioSOM32.

The integrated audio codec features true stereo ADCs/DACs, supporting direct headphone drive, Line in, Line out, and condenser microphone interface with digital bias. The AudioSOM32 integrates a dedicated 1.8V low-noise LDO to power the audio codec with clean power derived directly from the Li-Po cell or 5V input.

IoTBits provides customization and design services to assist customers with integrating the AudioSOM32 into their product design.

4. FUNCTIONAL BLOCK DIAGRAM

Figure 1 shows the functional block diagram of the AudioSOM32 module. The module includes:

- ESP32 PICO-D4 SIP from Espressif Systems
- SGTL5000 audio codec from NXP
- Li-Po charger (1 cell, 4.2V, adjustable charge current)
- 3.0V, 1 Amp output buck regulator for external electronics
- Dedicated analog LDO for superior audio performance

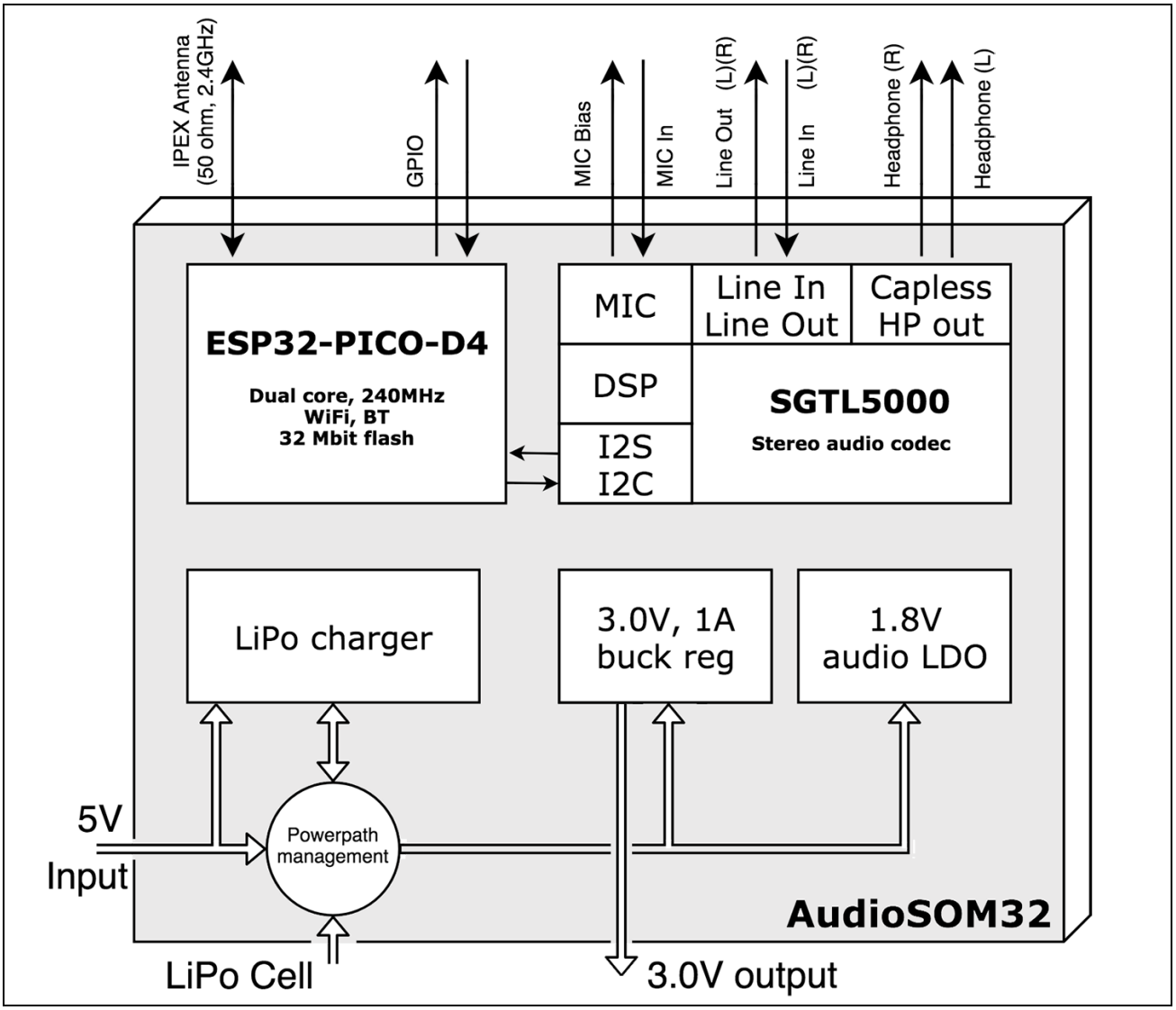

FIGURE 2: FUNCTIONAL BLOCK DIAGRAM

5. IN ASSIGNMENT

The AudioSOM32 module extends out all the GPIOs of ESP32-PICO-D4. The I^2S bus pins that are internally used for interfacing with the audio codec are not exposed to preserve signal integrity.

5.1. PIN OUT

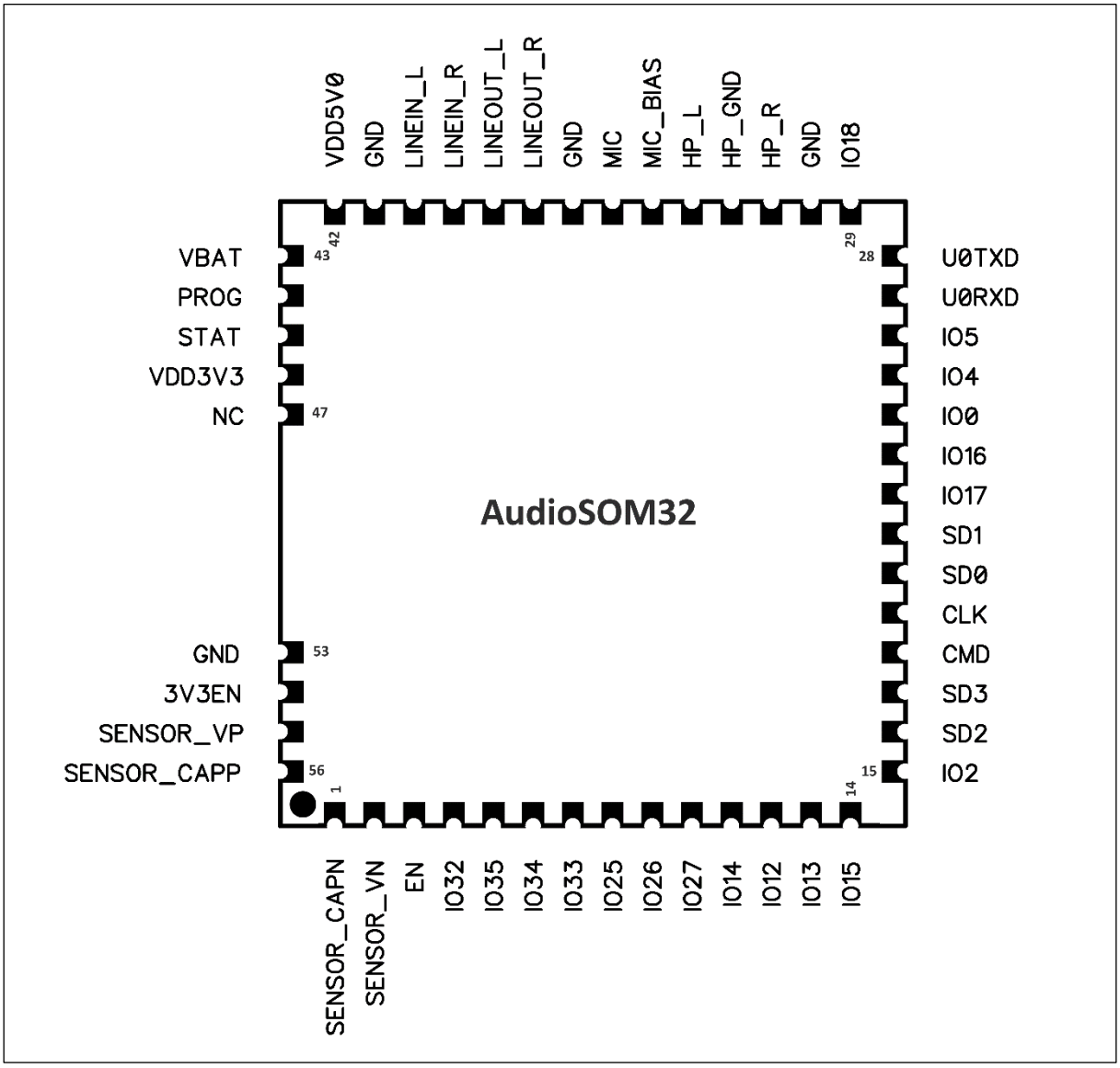

FIGURE 3: AUDIOSOM32 PIN DIAGRAM (TOP VIEW)

5.2. PIN DESCRIPTIONS

Table 1: AudioSOM32 Pin Descriptions

Pin Number	Name	Internal Function	Power Domain	Description
1	SENSOR_CAPN	-	VDD3V0	GPIO38 ADC1_CH2 ADC_PRE_AMP RTC_GPIO2
2	SENSOR_VN	-	VDD3V0	GPIO39 ADC1_CH3 ADC_PRE_AMP RTC_GPIO3
3	EN	-	VDD3V0	ESP32-PICO-D4 enable pin (active high)
4	IO32	-	VDD3V0	32K_XP ADC1_CH4 TOUCH9 RTC_GPIO9
5	IO35	-	VDD3V0	ADC1_CH7 RTC_GPIO5
6	IO34	-	VDD3V0	ADC1_CH6 RTC_GPIO4
7	IO33	-	VDD3V0	32K_XN ADC1_CH5 TOUCH8 RTC_GPIO8
8	IO25	-	VDD3V0	GPIO25 DAC_1 ADC2_CH8 RTC_GPIO6 EMAC_RXD0
9	IO26	-	VDD3V0	GPIO26 DAC_2 ADC2_CH9 RTC_GPIO7 EMAC_RXD1
10	IO27	-	VDD3V0	GPIO27 ADC2_CH7 TOUCH7 RTC_GPIO17 EMAC_RX_DV
11	IO14	-	VDD3V0	ADC2_CH6 TOUCH6 RTC_GPIO16 SD_CLK EMAC_TXD2
12	IO12	-	VDD3V0	ADC2_CH5 TOUCH5 RTC_GPIO15 SD_DATA2 EMAC_TXD3
13	IO13	-	VDD3V0	ADC2_CH4 TOUCH4 RTC_GPIO14 SD_DATA3 EMAC_RX_ER
14	IO15	-	VDD3V0	ADC2_CH3 TOUCH3 RTC_GPIO13 SD_CMD EMAC_RXD3
15	IO2	-	VDD3V0	ADC2_CH2 TOUCH2 RTC_GPIO12 SD_DATA0

16	SD2	-	VDD3V0	GPIO9 SD_DATA2 U1RXD
17	SD3	-	VDD3V0	GPIO10 SD_DATA3 U1TXD
18	CMD	-	VDD3V0	GPIO11 SD_CMD U1RTS
19	CLK	-	VDD3V0	GPIO6 SD_CLK U1CTS
20	SD0	-	VDD3V0	GPIO7 SD_DATA0 U2RTS
21	SD1	-	VDD3V0	GPIO8 SD_DATA1 U2CTS
22	IO17	-	VDD3V0	GPIO17 U2TXD EMAC_CLK_OUT_180
23	IO16	-	VDD3V0	GPIO16 U2RXD EMAC_CLK_OUT
24	IO0	Codec MCLK	VDD3V0	ADC2_CH1 TOUCH1 RTC_GPIO11 CLK_OUT1 EMAC_TX_CLK
25	IO4	-	VDD3V0	ADC2_CH0 TOUCH0 RTC_GPIO10 SD_DATA1 EMAC_TX_ER
26	IO5	Codec I2C SCL	VDD3V0	May be used with external I2C hardware Must not be pulled low externally
27	U0RXD	-	VDD3V0	GPIO3 CLK_OUT2
28	U0TXD	-	VDD3V0	GPIO1 CLK_OUT3
29	IO18	Codec I2C SDA	VDD3V0	May be used with external I2C hardware Must not be pulled low externally
30	GND	-	-	Module or system ground
31	HP_RIGHT	-	-	Cap-less headphone output (right channel)
32	HP_COM	-	-	Headphone ground (**NOTE:** Do NOT connect to circuit ground)
33	HP_LEFT	-	-	Cap-less headphone output (left channel)
34	MIC_BIAS	-	VDD1V8	Microphone bias voltage output (0V to 1.6V)
35	MIC	-	VDD1V8	Microphone input
36	GND	-	-	Module or system ground
37	LINEOUT_RIGHT	-	VDD1V8	Line out (right channel)
38	LINEOUT_LEFT	-	VDD1V8	Line out (left channel)
39	LINEIN_RIGHT	-	VDD1V8	Line in (right channel), 1.6V V_{pp}
40	LINEIN_LEFT	-	VDD1V8	Line in (left channel), 1.6V V_{pp}
41	GND	-	-	Module ground
42	VDD5V0	-	-	Li-Po charger supply and system power
43	VBAT	-	-	Connect to positive terminal of Li-Po cell
44	VDD3V0	-	-	3V output from internal buck converter

45	PROG	-	VDD5V0	Li-Po charge current setting
46	STAT	-	VDD5V0	Li-Po charging status
47	RESERVED	-	-	*Leave floating, do NOT connect*
48…52	*NC*	-	-	*These pads do not exist in the module footprint*
53	GND	-	-	Module ground
54	3V3_EN	-	VBAT	Module buck converter enable (active high)
55	SENSOR_VP	-	VDD3V0	ADC1_CH0 GPIO36, input only RTC_GPIO0
56	SENSOR_CAPP	-	VDD3V0	ADC1_CH1 GPIO37, input only RTC_GPIO1

6. ELECTRICAL CHARACTERISTICS

The electrical characteristics of the AudioSOM32 module may be derived from the datasheets of components used in the SoM (in accordance to the schematic). However, because the characteristics of the system as a whole deviates from the characteristics of the individual components, a collective list of parameters is listed here for quick reference when designing systems built around the AudioSOM32.

6.1. ABSOLUTE MAXIMUM RATINGS

Exceeding the maximum ratings specified in the following table could cause permanent damage to the part and is not recommended. Normal operation is not guaranteed at or beyond the absolute maximum ratings. Extended exposure to these conditions could affect long term reliability of the module.

Table 2: Electrical Ratings

Parameter	Conditions	Value	Unit
Charger supply voltage (VDD5V0)	-	6.0 V	V
Buck converter enable (3V0_EN)	-	-0.3V to VBAT	V
Battery voltage	-	0V to 4.3V	V
VDD3V0 output current	AudioSOM32 fully functional	600mA	mA
Digital input voltage range	-	(GND-0.3V) to (VDD3V0+0.3V)	V

Table 3: Thermal Ratings

Parameter	Conditions	Value	Unit
Storage Temperature	-	-55 to +125	^{O}C
Operating Temperature (ambient)	-	-20 to + 85	^{O}C

6.2. RECOMMENDED OPERATING CONDITIONS

The recommended operating conditions for reliable operation of the module are listed in the following table.

Table 4: Recommended Operating Conditions

Parameter	Conditions	Value	Unit
Charger supply voltage (VDD5V0)	-	5.0	V
Battery voltage range (Lithium Ion Polymer cell)	-	3.3 ~ 4.2	V
Battery charging current	-	200 – 800	mA
VDD3V0 output current	Current drawn by external load	0 – 500	mA

6.3. INPUT/OUTPUT ELECTRICAL CHARACTERISTICS

Test conditions unless otherwise specified:
VDD_{5V0} = 5.0V, V_{BAT} = 3.7V, T_A = 25 ^{O}C
ESP32 PICO-D4 active at 160MHz (both cores), running FreeRTOS idle task, I2S output via DMA ring buffer
SGTL5000 is slave mode, f_s = 48 kHz, MCLK = 256 f_s, 24 bits per sample (stereo), 1 kHz sine wave input
LINEOUT load = 10 kΩ

Table 5: Input and Output Specifications

Characteristic	Minimum	Typical	Maximum	Unit
LINEIN input level	-	1.60	-	V_{pp}
MIC input level	-	1.60	-	V_{pp}
LINEOUT output level	1.46	1.52	1.68	V_{pp}
LINEIN input impedance	-	29	-	kΩ
MIC input impedance	-	2.9	-	kΩ
LINEOUT output impedance	-	320	-	Ω
LINEOUT load	10	-	-	kΩ
HP load	16	-	-	Ω

6.4. AUDIO PERFORMANCE

Test conditions unless otherwise specified:
VDD_{5V0} = 5.0V, V_{BAT} = 3.7V, T_A = 25 ^{O}C
ESP32 PICO-D4 active at 160MHz (both cores), running FreeRTOS idle task, I2S output via DMA ring buffer
SGTL5000 is slave mode, f_s = 48 kHz, MCLK = 256 f_s, 24 bits per sample (stereo), 1 kHz sine wave input
LINEOUT load = 10 kΩ

Table 6: Audio Performance and Characteristics

Characteristic	Minimum	Typical	Maximum	Unit
LINEIN > ADC > I2S				
SNR	-	82	-	dB
THD + N	-	-70	-	dB
Channel Separation	-	75	-	dB
I2S > DAC > LINEOUT				
Output level	-	0.6	-	V_{RMS}
SNR	-	92	-	dB
THD + N	-	-85	-	dB
I2S > DAC > HP OUT				
Output power	-	10	-	mW
SNR	-	92	-	dB
THD + N	-	-85	-	dB

7. ORDERING INFORMATION

For bulk orders of more than 500 pieces, please reach us at hello@iot-bits.com for lead times and availability.

8. CUSTOMIZATION SERVICES

IoTBits provides consulting plans for integration of audio codec functionality into product design.

9. RESOURCES

We are in the process of developing an ESP-ADF port for the AudioSOM32 and will be updating this documentation in October 2018.
A set of application notes and examples, along with detailed driver API documentation will also be published soon.

The module can be programmed using ESP-IDF (by Espressif Systems):
https://docs.espressif.com/projects/esp-idf/en/latest/