ESP32-S3 Power Consumption Reference Guide –from Espressif “ESP32S3 Technical Manual”

“Test Conditions

- **Supply Voltage:** 3.3V ± 5%
- **Ambient Temperature:** 25°C
- **RF Measurements:** At antenna port with 100% duty cycle

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1. Active Mode - RF Working

Wi-Fi Transmission (TX)

Protocol	Data Rate	Power Level	Peak Current
802.11b	1 Mbps	@21 dBm	**340 mA**
802.11g	54 Mbps	@19 dBm	**291 mA**
802.11n HT20	MCS7	@18.5 dBm	**283 mA**
802.11n HT40	MCS7	@18 dBm	**286 mA**

Wi-Fi Reception (RX)

Protocol	Current
802.11b/g/n HT20	**88 mA**
802.11n HT40	**91 mA**

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2. Modem-Sleep Mode

Wi-Fi is clock-gated, CPU remains active

CPU Frequency	CPU Configuration	Peripherals OFF	Peripherals ON

40 MHz	Dual core idle (WAITI)	13.2 mA	18.8 mA
	Single core 32-bit, other idle	16.2 mA	21.8 mA
	Dual core 32-bit	18.7 mA	24.4 mA
	Single core 128-bit, other idle	19.9 mA	25.4 mA
	Dual core 128-bit	23.0 mA	28.8 mA
80 MHz	Dual core idle (WAITI)	22.0 mA	36.1 mA
	Single core 32-bit, other idle	28.4 mA	42.6 mA
	Dual core 32-bit	33.1 mA	47.3 mA
	Single core 128-bit, other idle	35.1 mA	49.6 mA
	Dual core 128-bit	41.8 mA	56.3 mA
160 MHz	Dual core idle (WAITI)	27.6 mA	42.3 mA
	Single core 32-bit, other idle	39.9 mA	54.6 mA
	Dual core 32-bit	49.6 mA	64.1 mA
	Single core 128-bit, other idle	54.4 mA	69.2 mA
	Dual core 128-bit	66.7 mA	81.1 mA
240 MHz	Dual core idle (WAITI)	32.9 mA	47.6 mA
	Single core 32-bit, other idle	51.2 mA	65.9 mA
	Dual core 32-bit	66.2 mA	81.3 mA
	Single core 128-bit, other idle	72.4 mA	87.9 mA
	Dual core 128-bit	91.7 mA	107.9 mA

Additional Notes for Modem-Sleep:

- Flash access adds ~10 mA (80 Mbit/s flash in SPI 2-line mode)
- PSRAM variants may consume more power

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3. Low-Power Modes

Mode	Description	Typical Current
Light-Sleep	VDD_SPI and Wi-Fi powered down, GPIOs high-impedance	**240 µA**
Deep-Sleep	RTC memory + RTC peripherals powered	**8 µA**
Deep-Sleep	RTC memory only (peripherals powered down)	**7 µA**
Power Off	CHIP_PU set low, chip shut down	**1 µA**

PSRAM Power Additions (Light-Sleep Mode):

- **8MB Octal PSRAM (3.3V):** +140 µA
- **8MB Octal PSRAM (1.8V):** +200 µA
- **2MB Quad PSRAM (3.3V):** +40 µA

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4. Power Mode Characteristics

Mode	CPU Status	Wi-Fi Status	Wake-up Sources	Use Cases
Active	Running	Active TX/RX	N/A	Data transmission, processing
Modem-Sleep	Running	Clock-gated	N/A	Local processing, periodic Wi-Fi
Light-Sleep	Stopped	Powered down	Timer, GPIO, RTC	Sensor monitoring
Deep-Sleep	Stopped	Powered down	Timer, GPIO, RTC, Touch	Long-term standby

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5. Battery Life Estimation Examples

Scenario 1: IoT Sensor (Mostly Deep-Sleep)

- Deep-sleep 99.9% of time: 8 µA
- Active 0.1% for data transmission: ~100 mA average
- **Average current ≈ 8.1 µA**
- **1000 mAh battery ≈ 14 years**

Scenario 2: Periodic Wi-Fi Data Logger

- Deep-sleep 95%: 8 µA
- Light-sleep 4%: 240 µA
- Active Wi-Fi 1%: 150 mA average
- **Average current ≈ 1.5 mA**
- **1000 mAh battery ≈ 28 days**

Scenario 3: Always-Connected Device

- Modem-sleep 80 MHz: ~30 mA average
- Periodic transmission: +20 mA average
- **Average current ≈ 50 mA**
- **1000 mAh battery ≈ 20 hours**

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6. Power Optimization Tips

1. **Use appropriate sleep modes** based on wake-up requirements
2. **Lower CPU frequency** when high performance isn't needed
3. **Disable unused peripherals** to reduce base consumption
4. **Optimize Wi-Fi duty cycle** - use modem-sleep between transmissions
5. **Consider PSRAM power overhead** when choosing chip variant
6. **Use RTC GPIO and peripherals** for ultra-low power wake-up scenarios

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Data source: ESP32-S3 Series Datasheet v2.0