



# YC1166



**Bluetooth 5.0 BR/EDR/BLE**

## **Datasheet**

Yichip Microelectronics

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## Revision History

| Version     | Date       | Author | Description     |
|-------------|------------|--------|-----------------|
| preliminary | 2020-02-26 | Rake   | Initial version |
|             |            |        |                 |
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## General Description

The YC1166 is a very low power, high performance and highly integrated Bluetooth 5.0 BR/EDR/BLE solution with Audio Codec, designed for operation over the 2400MHz to 2483.5Mhz ISM frequency band.

YC1166 is manufactured using advanced 55nm CMOS low leakage process, which offers highest integration, lowest power consumption, lowest leakage current and reduced BOM cost while simplifying the overall system design. Rich peripherals including an 8-channel general purpose ADC, power-on-reset (POR), Arithmetic Accelerators, 3axis Q-decoder, ISO7816, UART/SPI/I2C and 8 GPIOs, which further reduce overall system cost and size.

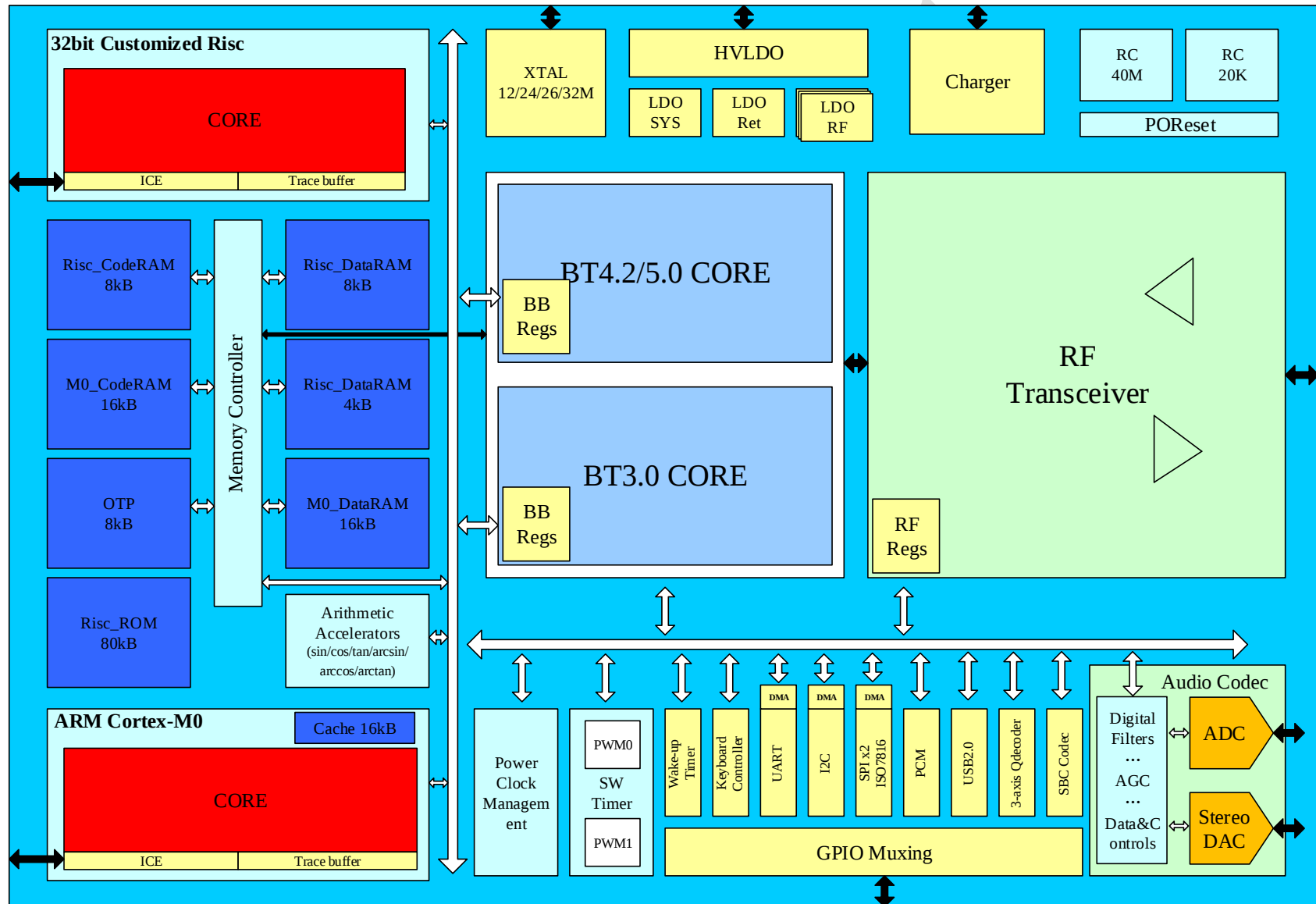
YC1166 operates with a power supply range from 1.8 to 5.5V and has very low power consumption in both Tx and Rx modes, enabling long lifetimes in battery-operated systems while maintaining excellent RF performance. The device can enter an ultra-low power sleep mode in which the registers and retention memory content are retained while low power Oscillator and sleep timer is ON.

Confidential

## Key Features

- Bluetooth 5.0 BR/EDR/BLE Proprietary double-mode RF SOC
- Very Low Power Consumption
  - 10nA shut down mode (external interrupts)
  - 800nA sleep mode (32kHz RC OSC, sleep timer and register ON)
  - 2.1uA retention mode (32kHz RC OSC, sleep timer, 2k retention memory and register ON)
  - Rx peak current w/o DCDC
    - 16mA in BLE/2.4G mode
    - 17mA in EDR mode
  - Tx peak current w/o DCDC @ -2dBm
    - 22mA in BLE/2.4G mode
    - 23mA in EDR mode
  - Rx peak current with DCDC
    - 6.75mA in BLE/2.4G mode
    - 7.25mA in EDR mode
  - Tx peak current with DCDC @ -2dBm
    - 16.5mA in BLE/2.4G mode
    - 17mA in EDR mode
  - <25uA avg, 500ms sniff hold connection
- 2.4GHz Transceiver
  - Single-end RFIO
  - -95dBm in BLE mode
  - support 250kbps, 1/2/3Mbps data rates
  - Tx Power upto +9dBm
- Audio Function
  - Mic PGA 0-18dB, 3dB per step
  - 16-bits ADC
  - 2x16Bit DAC, Stereo
  - Audio SNR: ADC 88dB; DAC 92dB
- Oscillators
  - 16M/24M/32M XTAL supported (default 24M)
  - 40M RC oscillator
  - Low Jitter 20K RC oscillator
- Dual Core Digital Architecture
  - ARM Cortex-M0 Core for application
    - DataRAM 16kB+Cache 16kB
    - CPU clock speed 48Mhz
  - 32bit-Risc Core for link management
    - 80kB code ROM and 64Kbit OTP
    - 8kB patch RAM and 8kB dataRAM
    - All RAMs can be set to retention mode
- Arithmetic Accelerators [*Accuracy : (sign, 15b.16b)*]
  - sin/cos/tan/sin<sup>-1</sup>/cos<sup>-1</sup>/tan<sup>-1</sup>/ multi/div/sqrt
- Analog Peripherals
  - 8 channel ADC with 10 bit accuracy/3Msps
- Digital Peripherals
  - Two-wire Master (I2C compatible), upto 400kbps; UART(RTS/CTS) with HCI-H5 protocol, upto 3.25Mbps; SPI Master, upto 24Mbps and internal QSPI connected 2Mbit Flash
  - ISO7816
  - AES256 HW encryption
  - LED drive capability
  - PWM
  - 20x8 key scan
  - 3 axis Q-decoder
  - USB2.0 fullspeed, 4Eps

Block Diagram



## Electrical Specifications

| Name                | Parameter (Condition)                                                                                                   | Min     | Typ | Max     | Unit | Comment |
|---------------------|-------------------------------------------------------------------------------------------------------------------------|---------|-----|---------|------|---------|
| Power Supplies      |                                                                                                                         |         |     |         |      |         |
| HVIN                | Voltage Input, typically 1uF decouple cap                                                                               | 3.1     | 4.2 | 5.5     | V    | (1)     |
| HVOUT               | Voltage Output, typically 1uF decouple cap, maximum 150mA load capability                                               | 3.1     | 3.3 | 3.4     | V    |         |
| CHARGE_VAD          | Voltage Input, typically 4.7uF decouple cap                                                                             | 4.8     | 5   | 5.5     | V    |         |
| CHARGE_VBAT         | Voltage Input, typically 4.7uF decouple cap                                                                             | 4.0     | 4.2 | 4.6     | V    |         |
| IQ_HV               | Quiescent Current of high voltage LDO                                                                                   |         | 750 |         | nA   |         |
| VIN                 | Voltage Input, typically 1uF decouple cap                                                                               | 1.5     |     | 3.6     | V    |         |
| VINPA               | Voltage Input, typically 5pF decouple cap                                                                               | 1.5     |     | 3.6     | V    | (2)     |
| VINLPM              | Voltage Input                                                                                                           | 1.8     |     | 3.6     | V    | (3)     |
| VIO                 | Voltage Input                                                                                                           | 1.7     |     | 3.6     | V    | (4)     |
| DVDD                | Voltage Output, typically 1uF decouple cap                                                                              | 1.1     | 1.2 | 1.3     | V    |         |
| VDDLPM              | Voltage Output, typically 100nF decouple cap                                                                            | 1.1     | 1.2 | 1.3     | V    |         |
| Temperature         |                                                                                                                         |         |     |         |      |         |
| TEMP                | Temperature                                                                                                             | -20     |     | +85     | ℃    |         |
| Digital Input Pin   |                                                                                                                         |         |     |         |      |         |
| VIH                 | High Level                                                                                                              | VIO-0.3 |     | VIO+0.3 | V    |         |
| VIL                 | Low Level                                                                                                               | VSS     |     | VSS+0.3 | V    |         |
| Digital Onput Pin   |                                                                                                                         |         |     |         |      |         |
| VOH                 | High Level                                                                                                              | VIO-0.3 |     | VIO+0.3 | V    | (5)     |
| VOL                 | Low Level                                                                                                               | VSS     |     | VSS+0.3 | V    |         |
| Current Consumption |                                                                                                                         |         |     |         |      |         |
| IVDD                | Shut down mode, can only be waked up by wake-up pin.                                                                    |         | 10  |         | nA   |         |
| IVDD                | Retention mode (LPO, no retention RAM, POR, sleep timer, I/O interrupts ON), can be waked up by sleep timer & any GPIO  |         | 0.8 |         | uA   | (6)     |
| IVDD                | Retention mode (LPO, 2kB retention RAM, POR, sleep timer, I/O interrupts ON), can be waked up by sleep timer & any GPIO |         | 2.1 |         | uA   |         |
| IVDD                | RX mode, BLE & 2.4G mode, 100% ON (w/o DCDC)                                                                            |         | 16  |         | mA   | (7)     |
| IVDD                | RX mode, EDR mode, 100% ON (w/o DCDC)                                                                                   |         | 17  |         | mA   |         |
| IVDD                | TX mode, BLE & 2.4G mode, 100% ON (w/o DCDC)                                                                            |         | 22  |         | mA   | (8)     |
| IVDD                | TX mode, EDR mode, 100% ON (w/o                                                                                         |         | 23  |         | mA   |         |

|      |                                                         |  |      |    |    |     |
|------|---------------------------------------------------------|--|------|----|----|-----|
|      | DCDC)                                                   |  |      |    |    |     |
| IVDD | RX mode, BLE & 2.4G mode, 100% ON (with ideal DCDC @3V) |  | 6.75 |    | mA | (7) |
| IVDD | RX mode, EDR mode, 100% ON (with ideal DCDC @3V)        |  | 7.25 |    | mA |     |
| IVDD | TX mode, BLE & 2.4G mode, 100% ON (with ideal DCDC @3V) |  | 16.5 |    | mA | (8) |
| IVDD | TX mode, EDR mode, 100% ON (with ideal DCDC @3V)        |  | 17   |    | mA |     |
| IVDD | Average Current, 500ms sniff, hold connection           |  |      | 25 | uA |     |

#### Normal RF Condition

|       |                     |      |    |      |     |     |
|-------|---------------------|------|----|------|-----|-----|
| FOP   | Operating Frequency | 2400 |    | 2480 | MHz |     |
| FXTAL | Crystal Frequency   | 12   | 24 | 32   |     | (9) |

#### Transmitter Characteristics

|      |                                                        |     |     |     |           |  |
|------|--------------------------------------------------------|-----|-----|-----|-----------|--|
| PRF  | RF output power                                        | -20 | 0   | 9   | dBm       |  |
| CD   | Carrier Drift Rate                                     |     | 5   |     | kHz/50 us |  |
| PRF1 | Out of band emission 2 MHz (GFSK)                      |     | -40 |     | dBm       |  |
| PRF2 | Out of band emission 3 MHz (GFSK)                      |     | -48 |     | dBm       |  |
| BW   | 20dB bandwidth                                         |     | 0.9 |     | MHz       |  |
| EVM  | Modulation Accuracy, RMS DEVM ( $\pi/4$ DQPSK)         |     | 7   | 20  | %         |  |
|      | Modulation Accuracy, RMS DEVM (8PSK)                   |     | 7   | 13  | %         |  |
|      | Modulation Accuracy, 99% DEVM ( $\pi/4$ DQPSK)         |     | 14  | 30  | %         |  |
|      | Modulation Accuracy, 99% DEVM (8PSK)                   |     | 14  | 20  | %         |  |
|      | Modulation Accuracy, Peak DEVM ( $\pi/4$ DQPSK & 8PSK) |     | 18  | 35  | %         |  |
|      | Modulation Accuracy, Peak DEVM (8PSK)                  |     | 18  | 25  | %         |  |
| PRF1 | Out of band emission 2 MHz ( $\pi/4$ DQPSK & 8PSK)     |     | -30 | -20 |           |  |
| PRF2 | Out of band emission 3 MHz ( $\pi/4$ DQPSK & 8PSK)     |     | -42 | -40 |           |  |

#### Receiver Characteristics

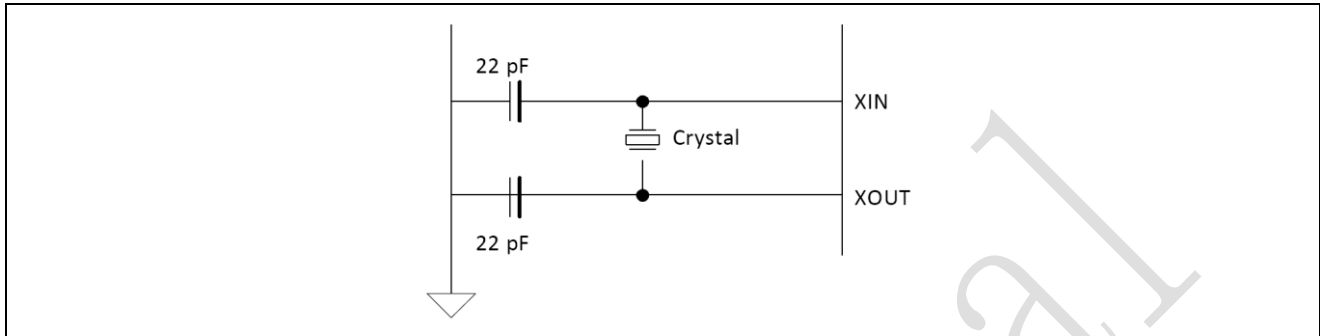
|        |                                       |  |     |     |     |  |
|--------|---------------------------------------|--|-----|-----|-----|--|
|        | <b>BLE</b>                            |  |     |     |     |  |
| SEN    | High Gain mode, Sensitivity @0.1%     |  | -95 |     | dBm |  |
| SEN    | Standard Gain mode, Sensitivity @0.1% |  | -92 |     | dBm |  |
| MaxIn  | Maximum Input Power                   |  | 0   |     | dBm |  |
| C/ICO  | Co-channel C/I, Basic Rate, GFSK      |  | 7   |     | dB  |  |
| C/I1ST | ACS C/I 1MHz, Basic Rate, GFSK        |  | 5.5 | 7   | dB  |  |
| C/I2ND | ACS C/I 2MHz, Basic Rate, GFSK        |  | -36 | -34 | dB  |  |
| C/I3RD | ACS C/I 3MHz, Basic Rate, GFSK        |  | -43 |     | dB  |  |

|                     |                                                         |  |      |  |     |  |
|---------------------|---------------------------------------------------------|--|------|--|-----|--|
| C/I1STI             | ACS C/I Image channel, Basic Rate, GFSK                 |  | -34  |  | dB  |  |
| C/I2NDI             | C/I 1 MHz adjacent to image channel, Basic Rate, GFSK   |  | -28  |  | dB  |  |
| <b>BR &amp; EDR</b> |                                                         |  |      |  |     |  |
| SEN                 | Basic Rate, GFSK, BER<0.1%, Dirty Tx on                 |  | -92  |  | dBm |  |
| SEN                 | EDR, $\pi/4$ DQPSK, BER<0.01%, Dirty Tx on              |  | -93  |  | dBm |  |
| SEN                 | EDR, 8PSK, BER<0.01%, Dirty Tx on                       |  | -83  |  | dBm |  |
| MaxIn               | Maximum Input Power                                     |  | 0    |  | dBm |  |
| C/ICO               | Co-channel C/I, EDR, $\pi/4$ DQPSK                      |  | 10.5 |  | dB  |  |
| C/I1ST              | ACS C/I 1MHz, EDR, $\pi/4$ DQPSK                        |  | -8   |  | dB  |  |
| C/I2ND              | ACS C/I 2MHz, EDR, $\pi/4$ DQPSK                        |  |      |  | dB  |  |
| C/I3RD              | ACS C/I 3MHz, EDR, $\pi/4$ DQPSK                        |  | -54  |  | dB  |  |
| C/I1STI             | ACS C/I Image channel, EDR, $\pi/4$ DQPSK               |  | -27  |  | dB  |  |
| C/I2NDI             | C/I 1 MHz adjacent to image channel, EDR, $\pi/4$ DQPSK |  | -43  |  | dB  |  |
| C/ICO               | Co-channel C/I, EDR, 8PSK                               |  | 20   |  | dB  |  |
| C/I1ST              | ACS C/I 1MHz, EDR, 8PSK                                 |  | 0    |  | dB  |  |
| C/I2ND              | ACS C/I 2MHz, EDR, 8PSK                                 |  | -20  |  | dB  |  |
| C/I3RD              | ACS C/I 3MHz, EDR, 8PSK                                 |  | -45  |  | dB  |  |
| C/I1STI             | ACS C/I Image channel, EDR, 8PSK                        |  | -18  |  | dB  |  |
| C/I2NDI             | C/I 1 MHz adjacent to image channel, EDR, 8PSK          |  | -33  |  | dB  |  |

- (1) HVIN & HVOUT are input & output of a high voltage LDO which is integrated in YC1166, input voltage range from 3.1~5.5V, and maximum load capability upto 150mA. Typically used in Li\_BAT (3.2~4.2V) or USB\_Power(4.5~5.5V) applications. If input voltage is lower than 3.6V, HVIN & HVOUT should be left unconnected and YC1166 should be powered by VIN/VINLPM/VINPA directly.
- (2) If RF output power should be larger than -4dBm, VINPA should be larger than 2.5V.
- (3) VINLPM should always be powered ON in all working cycles.
- (4) VIO should always be powered ON in all working cycles.
- (5) Drive capability of GPIO[20:30] is up to 100mA, other GPIO's drive capability is 10mA
- (6) By default, 2kB retention memory is ON in retention mode. Up to 4kB retentionable X\_memory available at the cost of extra 600nA retention mode current. Besides, 16kB 51-code memory is also retentionable at the cost of extra 1.6uA retention mode current.
- (7) Result based on standard gain mode
- (8) Result based on -2dBm Pout
- (9) 16M, 24M, 26M, 32M crystal supported, 24M by default

## Crystal Oscillator

The crystal oscillator requires a crystal with an accuracy of  $\pm 30$  ppm as defined by the Bluetooth specification. Two external load capacitors in the range of 5 pF to 30 pF are required to work with the crystal oscillator. The selection of the load capacitors is crystal dependent. The recommended crystal specification shows below.



Recommended Oscillator Configuration — 20 pF Load Crystal

Reference Crystal Electrical Specifications

| Name                          | Parameter<br>(Condition) | Min | Typ         | Max      | Unit   | Comment |
|-------------------------------|--------------------------|-----|-------------|----------|--------|---------|
| Frequency                     |                          |     | 24          |          | MHz    |         |
| Oscillation mode              |                          |     | Fundamental |          |        |         |
| Frequency tolerance           | @25 °C                   |     | $\pm 10$    | $\pm 30$ | ppm    |         |
| Tolerance stability over temp | @0 °C to +70 °C          |     | $\pm 10$    | $\pm 30$ | ppm    |         |
| Load capacitance              |                          |     | 20          |          | pF     |         |
| Operating temperature range   |                          | -20 |             | +70      | degree |         |
| Drive Level                   |                          |     | 100         |          | uW     |         |

## Audio DAC

| Parameter          | Min | Typ | Max | Unit | Test condition                                  |
|--------------------|-----|-----|-----|------|-------------------------------------------------|
| Frequency Response | 20  |     | 20k | Hz   | 1kHz & 10kohm loading<br>With A-Weighted Filter |
| Dynamic Range      |     | 90  |     | dB   |                                                 |
| SNR                |     | 92  |     | dB   |                                                 |
| THD+N              |     | -75 |     | dB   |                                                 |
| Output Swing       |     | 1   |     | Vrms |                                                 |
| DAC Output Power   | 12  |     |     | mV   | 32ohm loading                                   |

## Audio ADC

| Parameter     | Min | Typ | Max | Unit | Test condition                                  |
|---------------|-----|-----|-----|------|-------------------------------------------------|
| Dynamic Range |     | 86  |     | dB   | 1kHz & 10kohm loading<br>With A-Weighted filter |
| SNR           |     | 88  |     | dB   |                                                 |
| THD+N         |     | -75 |     | dB   |                                                 |

## Power consumption

| W/O DC-DC    | Parameter                                                            | Average Current | Unit |
|--------------|----------------------------------------------------------------------|-----------------|------|
| Sleep        | /                                                                    | 800             | nA   |
| Sniff        | 500ms interval                                                       | 22              | uA   |
| Discoverable | ADV interval: 640ms<br>Scan interval: 1280ms<br>Scan window: 11.25ms | 139             | uA   |

| With DC-DC   | Parameter                                                            | Average Current | Unit |
|--------------|----------------------------------------------------------------------|-----------------|------|
| Sleep        | /                                                                    | 800             | nA   |
| Sniff        | Sniff Interval: 500ms                                                | 18              | uA   |
| Discoverable | ADV interval: 640ms<br>Scan interval: 1280ms<br>Scan window: 11.25ms | 90              | uA   |

## Bluetooth Security

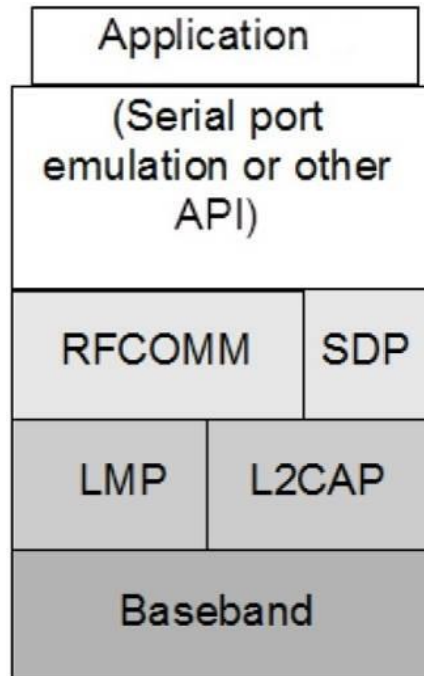
- Pairing
  - Pin Code
- Security Simple Pairing
  - Just Work(No input)
  - Keyboard
  - DisplayYesNo

## MFi

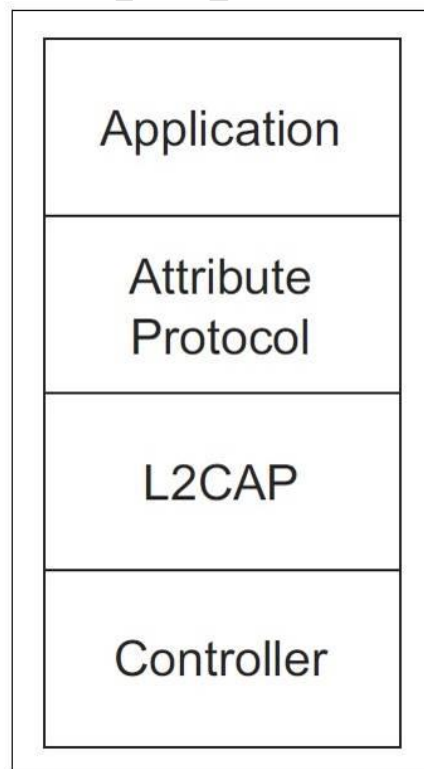
Support Apple's MFi authentication and iAP1/iAP2 protocols.

## Bluetooth Stack

### 1. Serial Port Profile

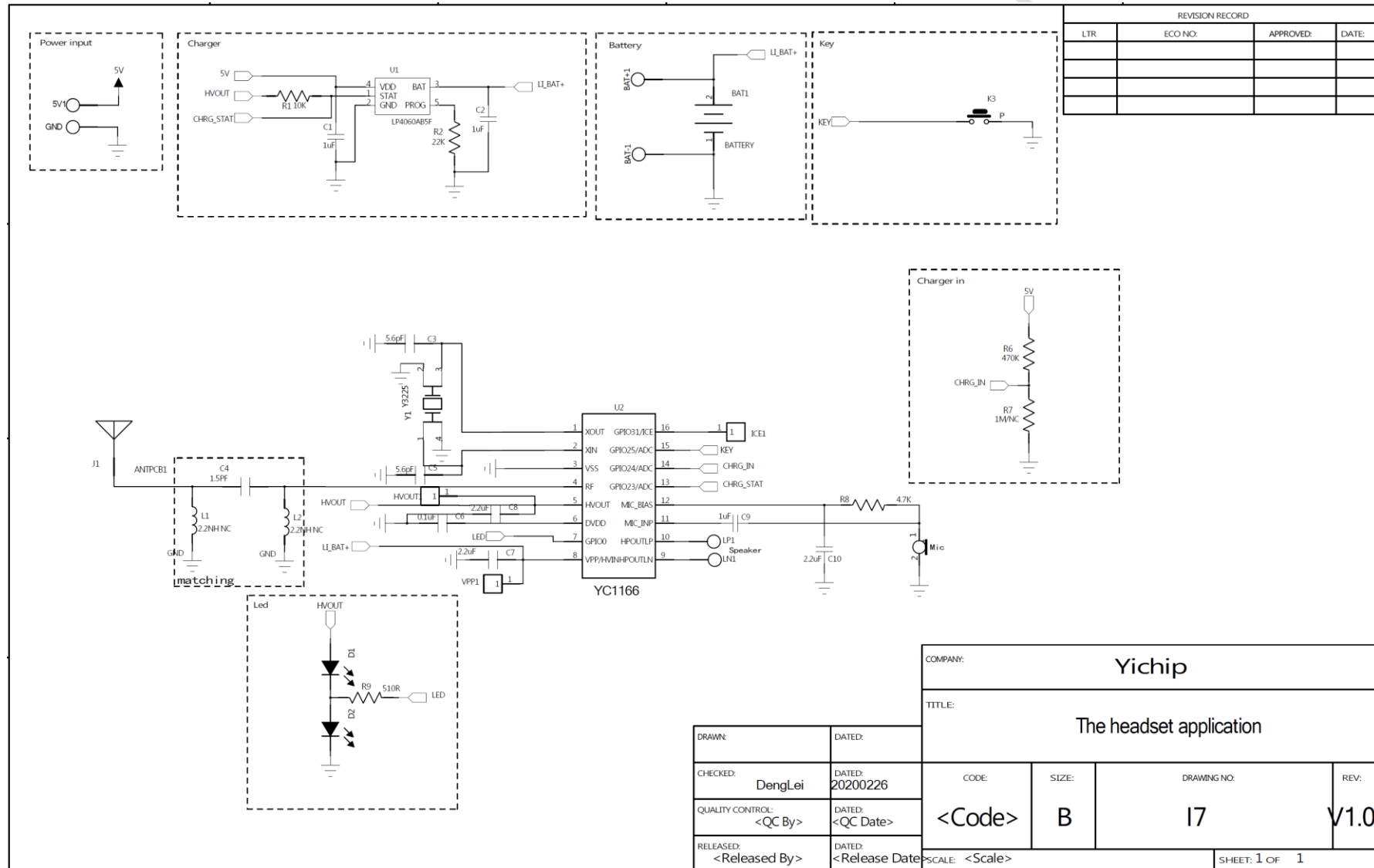


### 2. Generic Attribute Profile

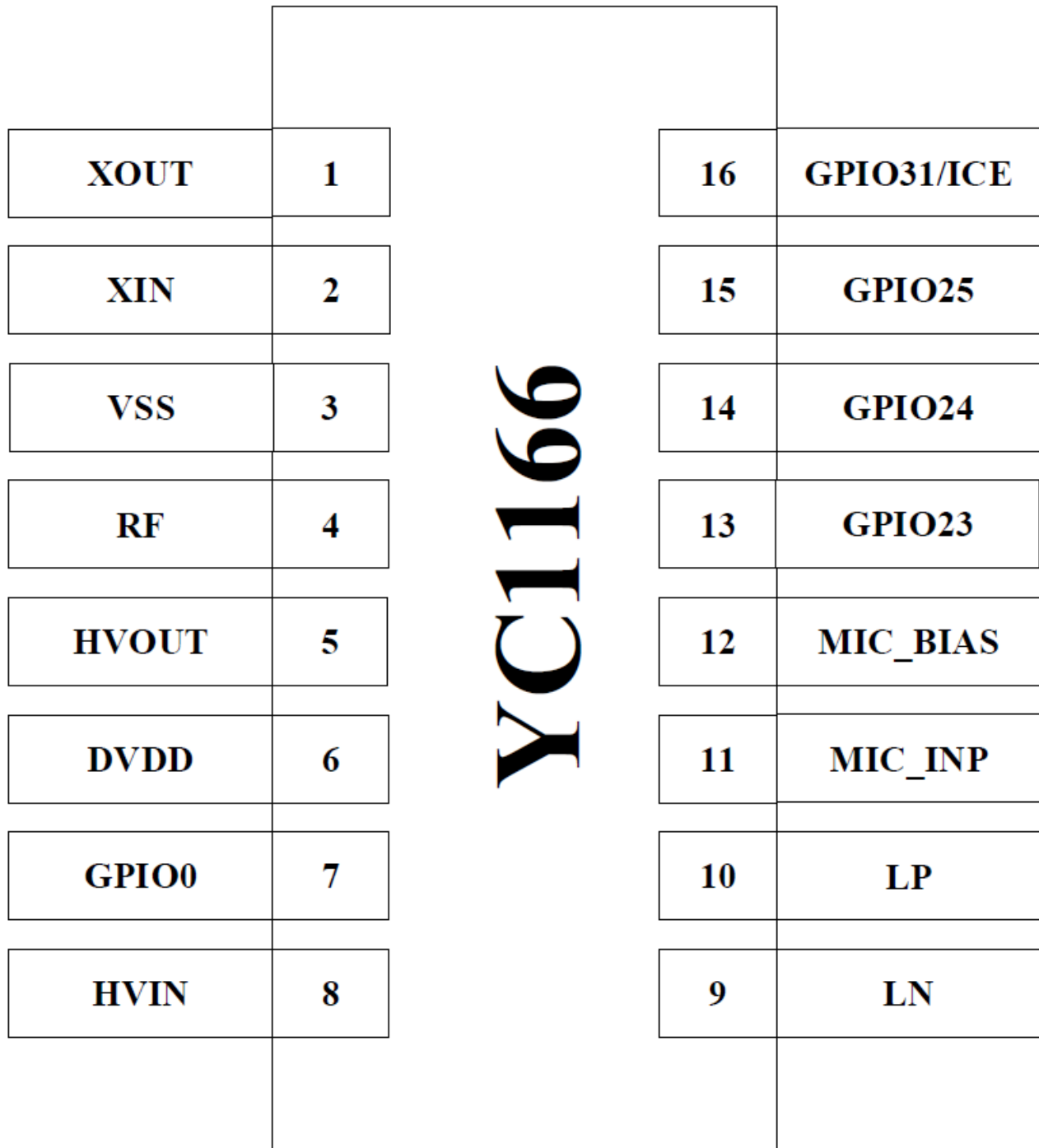


# Application Schematic

The headset application



## Package Information



| sop16 | Pin Name   | Type    | Function Description                                                            |
|-------|------------|---------|---------------------------------------------------------------------------------|
| 1     | XTALOUT    | Ana_O   | XTAL port.                                                                      |
| 2     | XTALIN     | Ana_I   | XTAL port, or external CLK in.                                                  |
| 3     | VSS        | GND     | GND                                                                             |
| 4     | RFIO       | RF Port | ANT port.                                                                       |
| 5     | HVOUT      | Power_O | HV LDO output, 3.3V. Bypass cap need here, 1uF. Max output current, 150mA@3.3V. |
| 6     | DVDD       | Power_O | Internal LDO output, 1.2V. Need an external bypass cap here, 0. 1uF.            |
| 7     | GPIO0      | Dig_IO  | Pls check "sheet: GPIO_Muxing"                                                  |
| 8     | VPP/HVIN   | Power_I | OTP Program Power, 6.5V./HVLDO input, 3.5~5.5V, 4.7uF bypass cap.               |
| 9     | HPOUTLN    | Ana_O   | DAC left channel negative output.                                               |
| 10    | HPOUTLP    | Ana_O   | DAC left channel positive output.                                               |
| 11    | MIC_INP    | Ana_I   | ADC positive input.                                                             |
| 12    | MIC_BIAS   | Ana_O   | Power output for mic.                                                           |
| 13    | GPIO23     | Dig_IO  | Pls check "sheet: GPIO_Muxing"                                                  |
| 14    | GPIO24     | Dig_IO  | Pls check "sheet: GPIO_Muxing"                                                  |
| 15    | GPIO25     | Dig_IO  | Pls check "sheet: GPIO_Muxing"                                                  |
| 16    | GPIO31/ICE | Dig_IO  | Pls check "sheet: GPIO_Muxing"/Debug port, Tx & Rx.                             |

**Note:** Most GPIOs are by default configured to input status after power-on reset, except for GPIO2 & GPIO24/25/26 (if applicable) which are in output status. If a GPIO is not used as well as it is not configured to output, it can be connected to GND. But GPIO2 & GPIO24/25/26 MUST NOT be connect to GND at any time.

PWM, UART, SPI and other digital peripherals can be flexibly configured to any GPIO port.

## GPIO Muxing Table

| GPIOs   | Function1 | Function2 |
|---------|-----------|-----------|
| GPIO[0] |           |           |

|          |         |              |
|----------|---------|--------------|
| GPIO[1]  | SPI-NCS |              |
| GPIO[2]  | SPI-IO1 |              |
| GPIO[3]  | SPI-IO2 |              |
| GPIO[4]  |         |              |
| GPIO[5]  |         |              |
| GPIO[6]  |         |              |
| GPIO[7]  |         |              |
| GPIO[8]  |         |              |
| GPIO[9]  | SPI-IO3 |              |
| GPIO[10] | SPI-SCK |              |
| GPIO[11] | SPI-IO0 |              |
| GPIO[12] |         |              |
| GPIO[13] |         |              |
| GPIO[14] |         |              |
| GPIO[15] |         |              |
| GPIO[16] |         |              |
| GPIO[17] |         | adc_channel1 |
| GPIO[18] |         | adc_channel2 |
| GPIO[19] |         |              |
| GPIO[20] |         | adc_channel3 |
| GPIO[21] | SDA     | adc_channel4 |
| GPIO[22] | SCL     | adc_channel5 |
| GPIO[23] |         | adc_channel6 |
| GPIO[24] |         | adc_channel7 |
| GPIO[25] |         | adc_channel8 |
| GPIO[26] |         |              |
| GPIO[27] |         | wakeup       |
| GPIO[28] |         | wakeup       |
| GPIO[29] |         |              |
| GPIO[30] |         |              |

Note: Drive capability of GPIO[20:30] is up to 20mA, other GPIO's drive capability is 10mA; Micbias output 1.5-2.8V@3mA.

Package Physical Dimension

