Operational Description
Microfence BLE Beacon
FCC ID: 2A2BS-PMF-002
IC ID: 29128-PMF002
Model: PMF-002NP (normal power)
Model: PMF002LP (low power)

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Revision 10

1 Operational Description

The PMF-002NP and PMF-002LP Microfence BLE Beacons is a family of Bluetooth Low-Energy (BLE) beacons used for geolocation of employees when clocking-in/out of or time management system. The beacons advertise a rolling code every 500 ms that is received by employee's cell phone. The rolling code is used to authenticate time clock punches.

The beacons use the Texas Instruments' ultra-low power, multi-protocol, wireless MCU, CC2640R2F. The beacons contains a single internal PCB containing all required passive components, including a 32.768 kHz crystal, a 24 MHz crystal and an on-board 2.4-GHz Inverted F patch antenna integral to the PCB.

The CC2640R2F within the beacon contains an integrated ARM processor that uses TI's Bluetooth® low energy stack running GFSK modulation at 1 Mbps data rate.

The actual frequency range of the beacon is 2.402 to 2.480 Ghz.

The CC2640R2F radio includes a 4.8 GHz PLL running off the 24 MHz crystal oscillator. The PLL outputs the 2.4 GHz digitally modulated RF signal which is amplified in the IC-internal PA and then output on the ICs differential RF pins. The PA can be controlled from -21 dBm to 5 dBm output power.

On the beacon PCB the differential RF output is transformed to a single ended 50 ohm signal through a passive component (capacitor / inductor) balun. The output of the balun is passed through a T-filter to reduce harmonic emission and then connected to the PCB patch antenna. These components are not individually hand-selected and their values are subject to variation due to manufacturing tolerances. Engineering analysis has determined that the best case (highest power to antenna) is 2.925 db path loss. When the transmitter PA is set to 5 dBm (maximum) the input to the antenna will be 2.075 dBm in this optimal case. Actual performance will typically be less than optimal and can be significantly lower, depending on actual values of components. The antenna has 3.3 dBi gain so EIRP can never exceed 5.375 dBm. This EIRP is more than 30 db below regulatory limit of 36 dBm per FCC 15.247:2022 and RSS-247 Issue 2:2017.

The 2.4-GHz Inverted F patch antenna on the module is an exact copy of Texas Instruments reference design[1]. All antenna dimensions are identical to the reference design. The antenna is integral to the PCB and as such not replaceable by the end user.

The beacon is manufactured in two variants: a normal-power variant and a low-power variant. The low power variant has a shorter range than the normal power variant. An impedance-matched attenuator between the transmitter and the inverted F patch antenna is the sole difference. The low-power variant has 10 db attenuator in the RF

[1] Texas Instruments Application Report SWRU120D, "2.4-GHz Inverted F Antenna", April 2007, Revised January 2019.

path, which correspondingly reduces transmit power and range. The normal-power variant is populated with a 0 db attenuator in the RF path.

The beacon PA (on the TI CC2640 chip) transmits at 0 dBm power by default. Beacon testing was conducted at 5 dBm (maximum) power and -21 dBm (minimum) power.

The attenuator used to differentiate the normal and low power product variants is comprised of a network of resistive lumped elements operating only inside their linear frequency ranges with respect to their third order parasitic effects on the PCB. In light of this, the EMC wireless performance should remain linear between PMF-002NP and PMF-002LP's through their highest and lowest software settings minus the 10dB hardware attenuation. Thus, testing the highest power level setting of both variants while testing the lowest power setting on just one variant should prove out compliance.

Beacon PA power is controlled by processor firmware and is selectable only by the manufacturer. Transmit power is typically set to 0 dBm but may be as low as -21 dBm to reduce transmission range. **No radio settings** are controllable by the end user.

The unit was tested with firmware version 2021.06.27, which has frequency hopping disabled (CW) and maximum transmit power. The production firmware version is 2022.08.04.

The manufacturing tolerance in transmit output power (in dB) is determined by the Texas Instruments CC2640R2F chip set. Please refer to the data sheet for the part.

The duty cycle of the radio transmitter is fixed at 0.0496%. The duty cycle is brief as is typical of all Bluetooth Low-Energy devices. An advertisement message is transmitted every 500 ms. The advertisement is 31 bytes (248 bits) long, resulting in a on-time of 248 μs for the transmitter every 500 ms.

2 Revision History

Rev.	Date	Originator	Description
0	August 22, 2022	Chuck Ferguson	Initial release
1	September 2, 2022	Chuck Ferguson	Revised “clone” of antenna to “exact copy” per Element request.
2	September 27, 2002	Chuck Ferguson	Added IC ID to cover page. Added separate model numbers for normal power and low power. Corrected ’10 ohm’ with ’10 db’. Added description of use.
3	September 29, 2022	Chuck Ferguson	Firmware disables changing transmitter settings, such as power & frequency.
4	October 24, 2022	Chuck Ferguson	Added footnote for antenna spec. Added note about firmware versions.
5	November 4, 2022	Chuck Ferguson	Revised transmitter power during test to 3 dbm.
6	November 11, 2022	Chuck Ferguson	Transmit power selectable by users.
7	November 11, 2022	Chuck Ferguson	Explicitly stated that users have no control of any radio parameters other than transmit power.
8	November 16, 2022	Chuck Ferguson	Revised per actions from teleconference with Element.
9	November 18, 2022	Chuck Ferguson	
10	November 27, 2022	Chuck Ferguson	