Guidelines for Incorporating EverSet® In a Clock Radio

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Scope

The reception of the WWVB broadcast in a clock-radio may be hindered in various ways by different factors, which may be either passive (e.g., shielding losses, proximity to metallic/magnetic parts) or active (i.e. interference sources within the device). This document provides design guidelines targeted at minimizing the potential for performance degradation that could be experienced in an EverSet® receiver in such environment.

Passive Interference

1. Metallic/Magnetic objects: The placement of the 60kHz antenna in proximity to a metallic/magnetic object (e.g., large speaker) may cause a shift in the inductance of the antenna and consequently also a loss in its gain at 60kHz. It may also cause a shift it its directionality. It should be noted that while the antenna may have been properly tuned outside of the radio clock's housing, it may need to be retested in its actual environment.
2. Wires: Wiring in proximity to the antenna, even if inactive during reception, should be avoided, unless it is confirmed through measurements that no intolerable effects result from such proximity.

Active Interference

Since the WWVB reception is based on magnetic pickup, magnetic fields, caused by variable currents in PCB routes and in wires, represent potential aggressors.
To minimize the potential for electromagnetic interference (EMI), the design of the clock radio's internals, including all printed circuit boards and the wiring around them, must consider the following general guidelines:

1. If wires are used to carry power from a battery pack or from whatever other source, they should be twisted to minimize the potential for EMI created by loops in the wiring.
2. If power is fed through PCB routing, the power and ground leading to a particular load should be placed tightly together, to minimize the area of potential loops. Note that the characteristics of the current consumed by many loads, such as digital and audio circuitry, and even the ES100 IC itself, may contain noise that could potentially create harmful EMI, depending on the wiring/routing and filtering used.
3. The use of wire-wound inductors (such as dc-filtering chokes), through which time-varying currents may flow, should be avoided.
4. Avoid any clock frequencies or periodic operations that could generate a harmonic at 60 kHz, the center frequency of the receiver. For example, an operation that is performed at a rate of 1kHz could create interference at 60kHz, since this is the 60th harmonic of the 1kHz fundamental frequency.
5. Place antennas as far as possible from sources of interference that may be active during reception.

Specific guidelines for coexisting with other functions in the clock-radio:

6. Display: LED based displays typically employ multiplexing, which involves the use of relatively strong pulses having a specific frequency and duration. The rate of these pulses should avoid any integer divisor of 60kHz, such that they will not have a harmonic at 60kHz. Additionally, if such interference is strong enough and close enough in frequency, it could cause saturation in the receiver's front end. It is therefore preferable to employ scanning at a very high rate or to disable it altogether.

7. Speakers and audio: The magnetics in the speaker often create non-linearity, particularly when the signal level is high. Such non-linearity can result in emissions at harmonics of the audible frequencies. For example, a 12kHz tone has a 5th harmonic at 60kHz. It is advisable to disable the audio, or limit it to low levels, during the initial acquisition and possibly also during subsequent tracking receptions. Measurements would have to be made to confirm that whatever level of audio is allowed to remain on does not intolerably degrade the reception.

8. Wireless charger: Although the wireless charging is based on a higher frequency, it could emit wideband energy that could interfere with the reception at 60kHz. It is best to completely disable this function during reception, which should not even be noticeable for this multi-hour operation.

9. FM radio: the FM radio may involve digital circuitry that could potentially create interference. Such interference could be characterized through measurement. It may be inconvenient and not necessary to have to shut down the radio during EverSet® reception. It can also be conditional (i.e. perform first reception attempt without shutting off potential interferes, and if it fails, a second attempt can be made with the potential interferers turned off).

10. Bluetooth: As with the FM radio above, while the frequency of the Bluetooth band (2.4GHz) is much higher and does not pose a threat at 60kHz, digital/power activity associated with the Bluetooth module may cause EMI. That too can be tested.

11. Main controller: Various functions in the main controller can cause interference, and it is therefore preferable for it to minimize activity during reception. It should be further noted that having a single controller serve as the main controller, having the ability to control/disable all other functions in the clock-radio, could serve to simplify the debugging and development of the product, allowing interference problems to be addressed through simple software modifications.

12. Power supply: If an external switched power supply is to be used, it must be tested to confirm that it does not create intolerable EMI at 60kHz. The use of a transformer based power supply could be considered, if not too bulky/costly.