This document summarizes the strategies employed to

* remove noise and deconflict captures when the adversarial coil is utilize
* Segment and detect each unique Qi packet
* Demodulate the qi packet data bits from the carrier signal

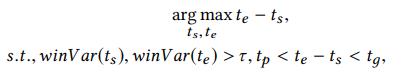
**Voltage Denoising & Filtering**

In order to isolate Qi-message-relevant signals from the adversarial coil voltage, we apply a moving-average filter and a low-pass filter to smooth the signal and eliminate irrelevant frequency components, respectively.

* To extract the modulated data bits, we first apply a moving-average filter which only keeps the average value within a sliding window. We set the window length as ⌈fs /fc ⌉, where fs and fc are the sampling rate of our logging backend (i.e.,Oscilloscope at 312 kHz) and the measured carrier frequency (around 4 kHz), respectively. We then apply a third-order low-pass Butterworth filter with a cut-off frequency at 2 kHz (modulation frequency) to further eliminate irrelevant frequency components,
* After filtering, only the packet segments carrying the data bits are preserved. Qi message data can then be detected and decoded according to the modulating frequency (i.e., ZERO is 1kHz, ONE is 2kHz).

**4.2 Packet Detection & Segmentation**

After filtering, the carrier signal can be filtered out and the signal that does not contain Qi packets would approximately become a constant DC wave.

* To detect and separate each Qi packet segment, we apply a sliding window on the filtered signal and calculate the variance of each sliding window centered at time t, which is represented as winV ar(t). The length of the sliding window is set to ⌈fs /2000⌉ to ensure the difference is sufficiently distinct. Therefore, by setting a threshold τ , we can easily determine whether t is in a packet segment or not. As the duration of a single packet transmission (i.e.,~30 ms) is significantly shorter than the gap between two adjacent packets (i.e.,~150 ms), we can detect the start time ts and end time te of each segment by solving the following objective function:
* 
* here tp is the minimum length of a Qi packet (i.e., 22 ms as shown in Figure 3)2 , and tд represents the maximum length of a Qi packet which is empirically set to 70 ms to detect and segment ID & C packets containing relatively more data bits than Control Error packets. The argmax function is used to ensure the completeness of a single packet segment.

**4.3 Data Bits Demodulation**

ZERO bits and ONE bits in a message segment can be identified leveraging their different modulating frequency. In order to derive the bi-phase encoded data bits, we further leverage the zero-crossing points in the filtered signal to decode the bi-phase bits.

* To detect these zero-crossing points, we first calculate the mean value m and the max value M of all the digital samples in the packet segment and then find out all the digital samples that are within a distance ζ = M 100 to m. Given that each bi-phase bit has a period of 0.5 ms according to the Qi standard [44], the possible distance between two adjacent zero-crossing points should be 0.25 ms or 0.5 ms.
* We thus adopt a minimum acceptable interval σ = 0.2 ms to remove the detected zero-crossing points that are too close to each other. After detecting all the zero-crossing points on the filtered coil voltage signal, we can follow the bi-phase decoding mechanism to derive the bi-phase data bits according to the distance between two adjacent points. Specifically two zero-crossing points with a 0.5 ms distance (1T ) indicates a ZERO bit, while three zero-crossing points with a 0.25 ms distance (0.5T ) between each adjacent pair represents a ONE bit. Following this rule, the data bits sequence could be obtained. In the practical implementation, we increase the distance threshold to 1.5T and 0.75T respectively, in case of the inevitable biases and time delay caused by the manufacturing imperfection.