Figure S1  Orthogonality of $\{k_{\text{inst}}, k_{\text{delay}}\}$ and linearity of $k_{\text{delay_total}}$ in the K-method. Changing $\tau$-setting, the inner product $<k_{\text{inst}}, k_{\text{delay_total}}>$ remains zero; hence, $\{k_{\text{inst}}, k_{\text{delay_total}}\}$ is an orthogonal set. Since $k_{\text{delay}}$ is a linear combination of $k_{\text{delay_total}}$ at different $\tau$-settings, $k_{\text{inst}}$ and $k_{\text{delay}}$ are orthogonal. In addition, the maximum and minimum values of $k_{\text{delay_total}}$ showed good linearity (Pearson’s $r >0.99$) with $\tau$ from 0.5 to 8.0 $\mu$s.

Figure S2  Error induced by linear approximation of the nonlinear $k_{\text{CFComp}}$. The error induced by linearization of $k_{\text{CFComp}}$ is denoted by $\text{error}_{\text{linearization}}$. (a) Expressing $\text{error}_{\text{linearization}}$ in terms of kernel yields $k_{\text{error_linearization}} = k_{\text{delay_total}} - \text{step} \cdot k_{\text{delay}}$. The 16 traces in light gray represent $k_{\text{error_linearization}}$ corresponding to the 16 discrete $\tau$-settings. The linearization errors over the full range of available $\tau$-setting (0.5-8.0 $\mu$s) were 5.16% ± 4.29% (ratio of negative peak values) compared with $k_{\text{delay_total}}$ ($\tau=8.0$ $\mu$s) and were 6.17% ± 3.21% compared with $k_{\text{inst_total}}$ (ratio of positive peak values). (b) Integrating the averaged $k_{\text{error_linearization}}$ yielded $\text{error}_{\text{linearization}}$ in terms of normalized square-wave response. The transient error was 3.77% relative to the CFast transient change due to 8.0 $\mu$s change in $\tau$ and was 0.85% relative to the $8C_{\text{inj}}$ CFast transient.
Figure S3  Comparison of compensation performance under different bandwidth settings. The test was conducted on the same HEK293 cell when changing the bandwidth setting. The compensation performance was indicated by both the residual square-wave response and the CFast estimates. The trace “F2 out” was recorded at the output of the Filter2, i.e., Imon2 in the PC3. In this case, the cutoff frequency of Filter1 was set to 10 kHz, and that of Filter2 was 3 kHz. The corresponding CFast estimates was 4.80 pF (Amp-setting), 6.0 µs (τ-setting), and 50% (%-setting). The traces “10 kHz”, “30 kHz” and “100 kHz” were recorded at Imon1 in the PC3 when Filter1 was set to corresponding bandwidth. Filter2 had no effect on traces recorded at Imon1. For the three settings, the CFast estimates were similar (“10 kHz”: 4.83 pF, 6.0 µs, 50%; “30 kHz”: 4.82 pF, 6.5 µs, 50%; “100 kHz”: 4.80 pF, 6.0 µs, 50%). Therefore, the analog filter bandwidth did not influence the K-method’s performance.