This paper describes a novel virtual signal injection-based direct flux vector control for the maximum torque per ampere (MTPA) operation of the interior permanent magnet synchronous motor (IPMSM) in the constant torque region. The proposed method virtually injects a small high-frequency current angle signal for tracking the optimal flux amplitude of the MTPA operation. This control scheme is not affected by the accuracy of the flux observer and is independent of machine parameters in tracking the MTPA points and will not cause additional iron loss, copper loss, and torque ripple as a result of real signal injection. Moreover, by employing a bandpass filter with a narrow frequency range the proposed control scheme is also robust to current and voltage harmonics, and load torque disturbances. The proposed method is verified by simulations and experiments under various operating conditions on a prototype IPMSM drive system.