Sign reversal of ac Josephson current in a ferromagnetic Josephson junction

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It is known that in a superconductor/insulator/superconductor (SIS) junction, when a finite voltage is applied, the Josephson current shows a logarithmic divergence, i.e., the so-called Riedel peak (RP) at the gap voltage, $V=2\Delta/e$, ($\Delta$ is a superconducting gap). In a double barrier Josephson junction such as SXS junction, on the other hand, the voltage dependence of $I_c$ has not been investigated so far, where X is a normal metal (N) or a ferromagnet (F). We study the voltage dependence of Josephson critical current ($I_c$) in a variety of SXS junctions. In a SNS junction, $I_c$ shows the RP at the gap voltage similar to a SIS junction. On the other hand, in a SFS junction, $I_c$ shows a damped oscillation with the alternation of sign as a function of thickness ($d$) of F due to 0-$\pi$ transition. The RP exhibits a strong dependence on $d$, and changes its sign. It is predicted that the RP disappears at the 0-$\pi$ transition in the SFS junction.