Diagnosis and Explanation of Longitudinal Sextupole-Mode Instability in the CERN PS Booster, A. BLAS, F. PEDERSEN, CERN; S. KOSCIELNIAK, TRIUMF - Dual harmonic RF systems have been discussed for many years, either as an instrument to promote Landau damping, or to improve the bunching factor so as to reduce transverse space-charge. Since its introduction into the CPS Booster in 1982, the dual harmonic acceleration process suffered from an unexplained longitudinal instability occurring when the 2nd harmonic cavity is anti-phased and controlled by the 1st harmonic gap signal. The instability does not occur when the beam fundamental is used as reference, nor when the RF harmonics are in-phase. The impetus for the present study arises from the conversion form harmonic numbers h = 5 & 10 to h = 1 & 2 for LHC operation. The instability has recently been diagnosed as a sextupole mode, and its explanation comprises two unusual ingredients. (i) The large gain of the beam transfer function when the bunch length is sufficiently long that the derivative of synchrotron frequency with respect to action is zero. (ii) The large phase-shifts that are contributed by the long delays in the beam phase loop and second harmonic corrector loop. In this paper, we present experimental results from machine development periods, and a detailed theoretical explanation for the instability that considers feedback from the beam versus the cavity fundamental.