Title: An extension of the sine addition formula on groups and semigroups

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The functional equation \( f(xy) = f(x)g(y) + g(x)f(y) \) is called the sine addition formula, and in a very general setting it is known that \( g \) must be the average of two multiplicative functions. Here we consider the case in which the two multiplicative functions coincide, but we generalize that case to a functional equation with four unknown functions. That is, assuming that \( M \) is a nonzero multiplicative function, we solve \( f(xy) = k(x)M(y) + g(x)h(y) \) for the four unknown functions \( f, g, h, k \) on groups and certain semigroups under the additional assumption that the unknown functions are at least central.

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