Barkhausen stability criterion

For the noise in the output of a ferromagnet upon a change in the magnetizing force, see Barkhausen effect.

Block diagram of a feedback oscillator circuit to which the Barkhausen criterion applies. It consists of an amplifying element $A$ whose output $v_o$ is fed back into its input $v_f$ through a feedback network $\beta(j\omega)$.

To find the loop gain, the feedback loop is considered broken at some point and the output $v_o$ for a given input $v_i$ is calculated:

$$G = \frac{v_o}{v_i} = \frac{v_f}{v_i} \frac{v_o}{v_f} = \beta A(j\omega)$$

In electronics, the Barkhausen stability criterion is a mathematical condition to determine when a linear electronic circuit will oscillate. It was put forth in 1921 by German physicist Heinrich
Georg Barkhausen (1881–1956). It is widely used in the design of electronic oscillators, and also in the design of general negative feedback circuits such as op amps, to prevent them from oscillating.

Limitations[edit]

Barkhausen's criterion applies to linear circuits with a feedback loop. Therefore it cannot be applied to one port negative resistance active elements like tunnel diode oscillators.

Criterion[edit]

It states that if $A$ is the gain of the amplifying element in the circuit and $\beta(j\omega)$ is the transfer function of the feedback path, so $\beta A$ is the loop gain around the feedback loop of the circuit, the circuit will sustain steady-state oscillations only at frequencies for which:

1. The loop gain is equal to unity in absolute magnitude, that is, $|\beta A| = 1$ and
2. The phase shift around the loop is zero or an integer multiple of $2\pi$: $\angle \beta A = 2\pi n$, $n \in 0, 1, 2, \ldots$.

Barkhausen's criterion is a necessary condition for oscillation but not a sufficient condition: some circuits satisfy the criterion but do not oscillate. Similarly, the Nyquist stability criterion also indicates instability but is silent about oscillation. Apparently there is not a compact formulation of an oscillation criterion that is both necessary and sufficient.