Analysis and Design of Operational Amplifier Stability Based on Routh-Hurwitz Method

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**Electronic Circuit Design Field**
- Bode plot (>90% frequently used)
- Nyquist plot (源代裕治、電子回路研究会 2015年7月)

**Control Theory Field**
- Bode plot
- Nyquist plot
- Nicholas plot
- Routh-Hurwitz stability criterion
  - Very popular in control theory field
  - but rarely seen in electronic circuit books/papers
- Lyapunov function method

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We were NOT able to find out any electronic circuit text book which describes Routh-Hurwitz method for operational amplifier stability analysis and design!

None of the above describes Routh-Hurwitz. Only Bode plot is used.
Most of control theory text books describe Routh-Hurwitz method for system stability analysis and design!
Contents

- Stability Criteria
  - Nyquist Criterion and Bode Plot

Harry Nyquist 1889-1976 (Sweden)

Hendrik Wade Bode 1905-1982 (蘭)
Transfer Function and Stability

- Transfer function of closed-loop system
  \[ G(s) = \frac{A(s)}{1 + fA(s)} = \frac{N(s)}{D(s)} \]

- Suppose
  \[ N(s) = b_m s^m + b_{m-1} s^{m-1} + \ldots + b_1 s + b_0 \]
  \[ D(s) = a_n s^n + a_{n-1} s^{n-1} + \ldots + a_1 s + a_0 \]

- System is stable if and only if
  Maxwell and Stodola found out !!
  real parts of all the roots \( S_p \) of the following are negative:
  \[ D(s) = a_n s^n + a_{n-1} s^{n-1} + \ldots + a_1 s + a_0 = 0 \]

- To satisfy this, what are the conditions for \( a_n, a_{n-1}, \ldots, a_1, a_0 \) ?
  Routh and Hurwitz solved this problem independently !!
Very different algorithms, but later it was proved that both are the same results.

Discover Truth
Control theory is the theoretical basis of analog circuit design.

“Feedback” is the most important concept there.

James Watt 1736 - 1819
Nobert Wiener 1894 - 1964
Harold Black 1898-1983
John Ragazzini 1912-1988