
Reference Information

DIFFERENTIAL MODE AND COMMON MODE

Differential amplifiers amplify the voltage difference which appears between the + input and – input. This voltage is referred to as the Differential Mode or Normal Mode voltage. The voltage component which is referenced to earth and is identical on both inputs is rejected by the amplifier. This voltage is referred to as the Common Mode voltage and can be expressed as:

$$V_{CM} = \frac{V_{+ \text{ Input}} + V_{- \text{ Input}}}{2}$$

DIFFERENTIAL MODE RANGE AND COMMON MODE RANGE

Differential Mode range is the maximum signal which can be applied between the + and – inputs without overloading the amplifier, which otherwise would result in clipping or distorting the waveform measured by the oscilloscope.

The Common Mode Range is the maximum voltage with respect to earth ground which can be applied to either input. Exceeding the common mode range can result in unpredictable measurements. Because the Common Mode signal is normally rejected and not displayed on the oscilloscope, the user needs to be careful to avoid accidentally exceeding the common mode range.

COMMON MODE REJECTION RATIO

The ideal differential amplifier would amplify only the differential mode voltage component and reject all of the common mode voltage component. Real differential amplifiers are not perfect and a small portion of the common mode voltage component appears at the output. Common Mode Rejection Ratio (CMRR) is the measure of how much the amplifier rejects the common mode voltage component. CMRR is equal to the differential mode gain (or normal gain) divided by the common mode gain. Common mode gain is equal to the output voltage divided by the input voltage when both inputs are driven by only the common mode signal. CMRR can be expressed as a ratio (e.g. 10000:1) or

DA1855A Differential Amplifier

implicitly in dB (e.g. 80 dB). Higher numbers indicate greater rejection (better performance).

The first order term which determines the CMRR is the relative gain matching between the + and – input paths. To obtain high CMRR values, the input attenuators in a differential amplifier are precisely matched to each other. The matching includes the DC attenuation as well as the capacitance which determines the AC attenuation. As the frequency of the common mode component increases, the effects of stray parasitic capacitance and inductance in determining the AC component becomes more pronounced. The CMRR becomes smaller as the frequency increases. Hence the CMRR is usually specified in a graph of CMRR versus common mode frequency.

The common mode frequency in these graphs is assumed to be sinusoidal. In real life applications, the common mode signal is seldom a pure sine wave. Signals with pulse wave shapes contain frequency components much higher than the repetition rate may suggest. As such, it is very difficult to predict actual performance in the application for CMRR versus frequency graphs. The practical application of these graphs is to compare the relative common mode rejection performance between different amplifiers.

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