Reference Information

DIFFERENTIAL MODE AND COMMON MODE

Differential probes amplify the voltage difference that appears between the **+** and **–** inputs. This voltage is referred to as the Differential Mode or Normal Mode voltage. The voltage component that is referenced to earth ground, and is identical on both inputs, is rejected by the amplifier. This voltage is referred to as the Common Mode voltage, because it is common to both inputs. The common mode voltage can be expressed as:

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

DIFFERENTIAL MODE RANGE AND COMMON MODE RANGE

The Differential Mode Range is the maximum signal that can be applied between the **+** and **–** inputs without overloading the probe amplifier, resulting in "clipping" or distortion of the waveform measured by the oscilloscope.

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

Common Mode Range   Differential Mode Range

Maximum voltage from   Maximum voltage
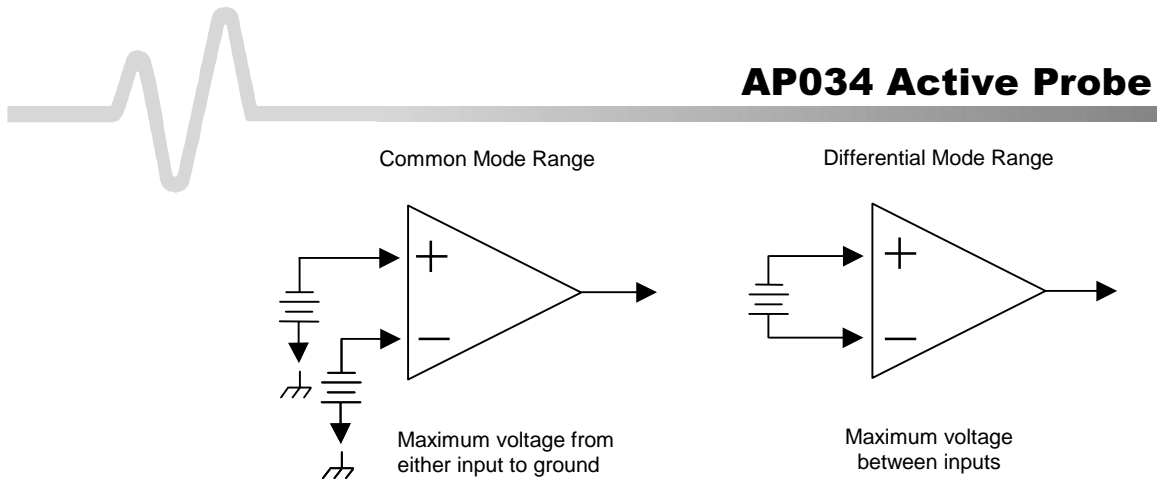either input to ground   between inputs

Figure 6. Common Mode and Differential Mode Range

COMMON MODE REJECTION RATIO

The ideal differential probe or differential amplifier would amplify only the differential mode voltage component and reject all of the common mode voltage component. Real differential probes and amplifiers are not perfect, and a small portion of the common mode voltage component does appear in the output. Common Mode Rejection Ratio (CMRR) is the measure of how much the probe or 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 (for example, 10 000:1) or implicitly in dB (for example, 80 dB). Higher numbers indicate greater rejection (better performance).

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

The common mode frequency in these plots 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 probes or amplifiers.

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