

Level and Reflection Measurement Errors

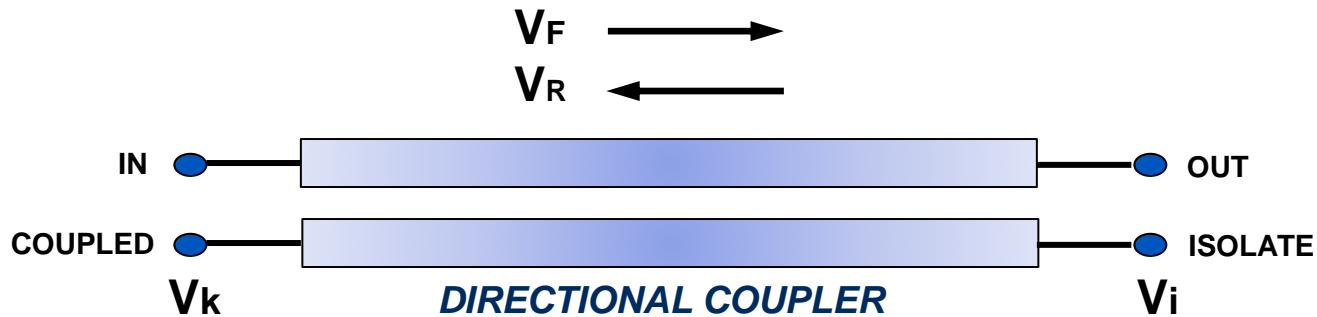


K5TRA

MEASUREMENT ISSUES

- RF forward and reflected power measurements are made with a directional coupler.
- The directivity of the coupler is a measure of leakage between forward and reflected levels in measurements.
- A load mismatch introduces error in level measurements, due to imperfect coupler directivity.
- Depending on load phase and directivity, a window of possible error is seen in:
 - Measured VSWR
 - Measured forward and reflected power

COUPLING AND DIRECTIVITY



$$C_{dB} = 20 \log(k)$$

$$k = 10^{\left(\frac{C_{dB}}{20}\right)}$$

$$V_c = k V_F \pm k D V_R = k V_F (1 \pm D \rho_{LOAD})$$

$$V_i = k V_R \pm k D V_F = k V_F (\rho_{LOAD} \pm D)$$

$$\rho_{LOAD} = \frac{V_R}{V_F}, \quad VSWR = \frac{(1 + \rho_{LOAD})}{(1 - \rho_{LOAD})}$$

APPARENT LOAD

TRUE LOAD REFLECTION: $\rho_{LOAD} = \frac{V_R}{V_F}$

APPARENT LOAD REFLECTION: $\Gamma_{LOAD} = \frac{V_i}{V_k} = \frac{\rho_{LOAD} \pm D}{1 \pm D \rho_{LOAD}}$

MEASUREMENT LIMITS: $|\Gamma_{MAX}| = \left| \frac{\rho_{LOAD} + D}{1 + D \rho_{LOAD}} \right|,$

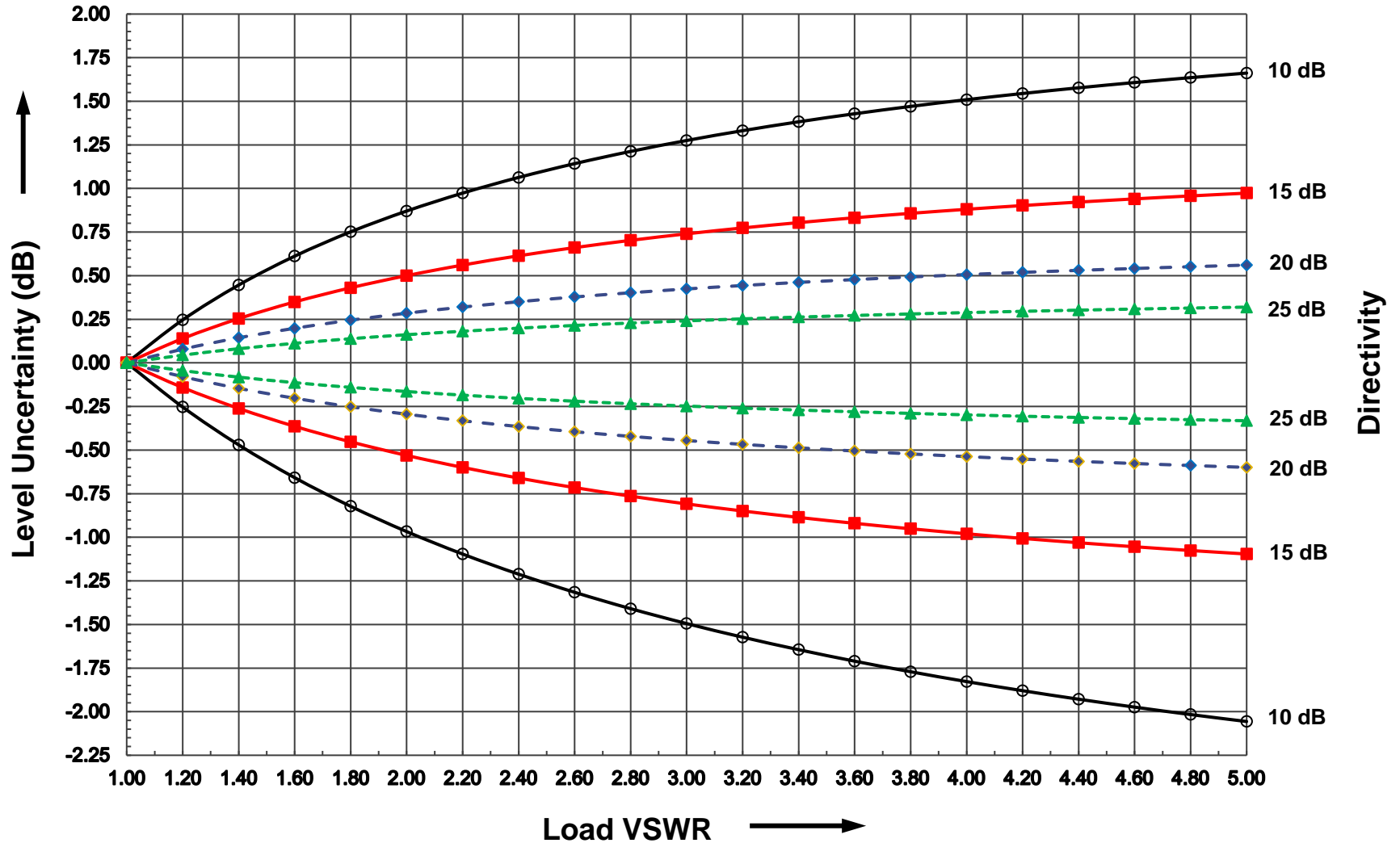
$$|\Gamma_{MIN}| = \left| \frac{\rho_{LOAD} - D}{1 - D \rho_{LOAD}} \right|.$$

$$VSWR_{MAX} = VSWR_{LOAD} \left| \frac{1 + D}{1 - D} \right|$$

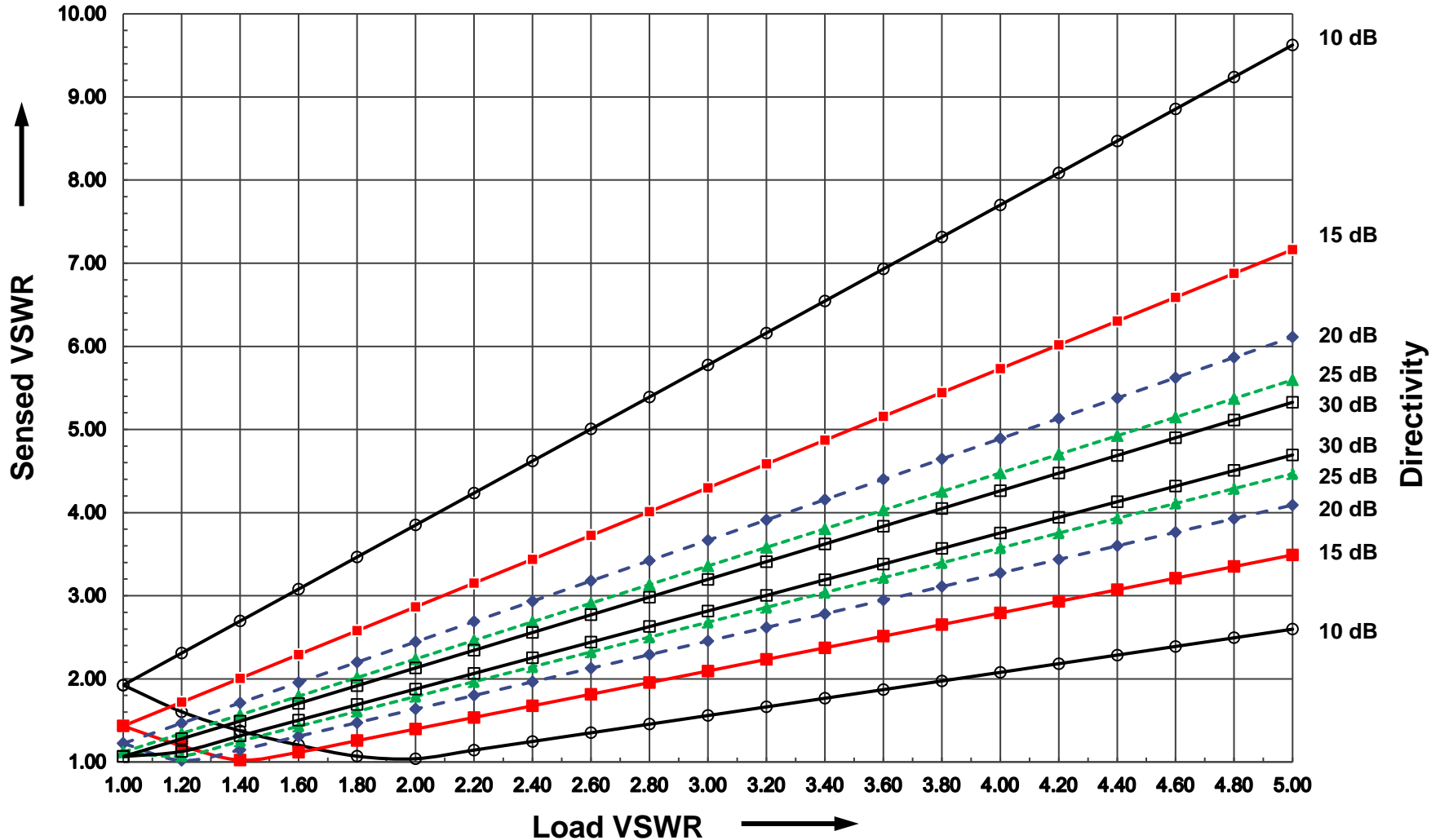
$$VSWR_{MIN} = VSWR_{LOAD} \left| \frac{1 - D}{1 + D} \right|, \quad \text{when } D < \rho_{LOAD}$$

$$VSWR_{MIN} = \frac{1}{VSWR_{LOAD}} \left| \frac{1 + D}{1 - D} \right|, \quad \text{when } D > \rho_{LOAD}$$

DIRECTIVITY ERRORS IN LEVEL MEASUREMENT



DIRECTIVITY ERRORS IN REFLECTOMETRY



SOURCE ERRORS CONTRIBUTE TO LEVEL MEASUREMENTS

**WHEN BOTH SOURCE AND LOAD ARE MISMATCHED
VOLTAGES “TANK-UP” DUE TO MULTIPLE REFLECTIONS**

TOTAL FORWARD VOLTAGE:

$$V_{F\infty} = \frac{V_F}{1 \pm |\rho_{LOAD} \rho_{SOURCE}|}$$

TOTAL REFLECTED VOLTAGE :

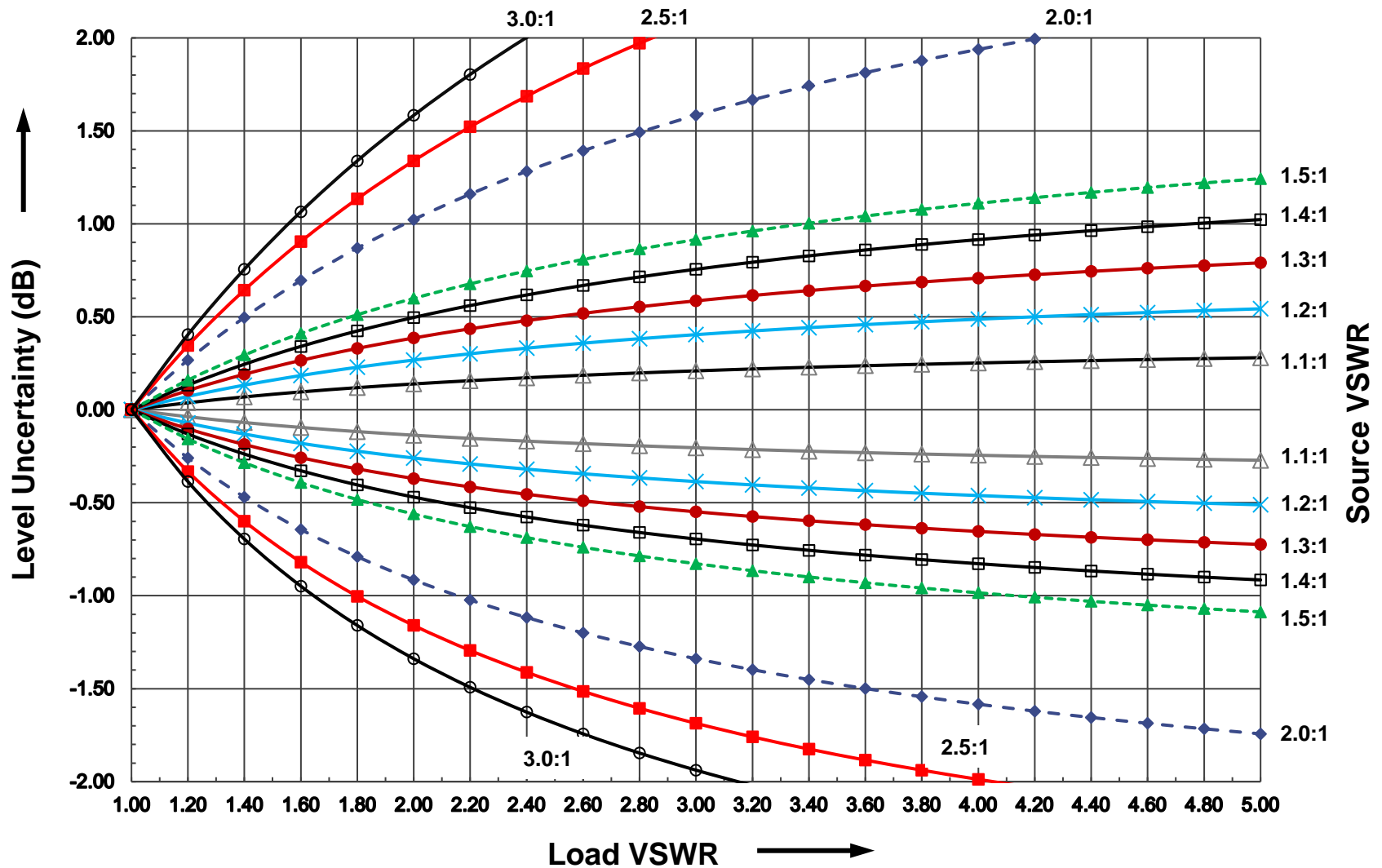
$$V_{R\infty} = \frac{V_F \rho_{LOAD}}{1 \pm |\rho_{LOAD} \rho_{SOURCE}|}$$

LOAD REFLECTION:

$$\rho_{LOAD} = \frac{V_{R\infty}}{V_{F\infty}}$$

**LOAD REFLECTION COEFFICIENT IS UNAFFECTED BY SOURCE
MISMATCH, SINCE IT IS A RATIO OF TANKED LEVELS**

SOURCE MISMATCH ERRORS IN LEVEL MEASUREMENTS



SUMMARY

- RF level measurement error was quantified as a function of coupler directivity, in the presence of load mismatch.
- The corresponding error in sensed VSWR was given.
- When the source is also mismatched, multiple reflections between load and source are present. This causes forward and reflected levels to peak beyond the matched source case.
- The level measurement error, when both source and load are mismatched, was detailed.
- Measured load VSWR is not affected by source mismatch.