



mobile communications series

SOFTWARE-DEFINED RADIO for ENGINEERS

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Software-Defined Radio for Engineers

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Dedication

To my wife Lauren
—Travis Collins

To my wonderful children, Matthew, Lauren, and Isaac, and my patient wife, Michelle—sorry I have been hiding in the basement working on this book. To all my fantastic colleagues at Analog Devices: Dave, Michael, Lars-Peter, Andrei, Mihai, Travis, Wyatt and many more, without whom Pluto SDR and IIO would not exist.
—Robin Getz

To my lovely son Aidi, my husband Di, and my parents Lingzhen and Xuexun
—Di Pu

To my wife Jen
—Alexander Wyglinski

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Trigonometric Identities

$$\exp(\pm j\theta) = \cos(\theta) \pm j \sin(\theta)$$

$$\cos(\theta) = \frac{1}{2}[\exp(j\theta) + \exp(-j\theta)]$$

$$\sin(\theta) = \frac{1}{2j}[\exp(j\theta) - \exp(-j\theta)]$$

$$\sin^2(\theta) + \cos^2(\theta) = 1$$

$$\cos^2(\theta) - \sin^2(\theta) = \cos(2\theta)$$

$$\cos^2(\theta) = \frac{1}{2}[1 + \cos(2\theta)]$$

$$\sin^2(\theta) = \frac{1}{2}[1 - \cos(2\theta)]$$

$$2 \sin(\theta) \cos(\theta) = \sin(2\theta)$$

$$\sin(\alpha \pm \beta) = \sin(\alpha) \cos(\beta) \pm \cos(\alpha) \sin(\beta)$$

$$\cos(\alpha \pm \beta) = \cos(\alpha) \cos(\beta) \mp \sin(\alpha) \sin(\beta)$$

$$\tan(\alpha \pm \beta) = \frac{\tan(\alpha) \pm \tan(\beta)}{1 \mp \tan(\alpha) \tan(\beta)}$$

$$\sin(\alpha) \sin(\beta) = \frac{1}{2}[\cos(\alpha - \beta) - \cos(\alpha + \beta)]$$

$$\cos(\alpha) \cos(\beta) = \frac{1}{2}[\cos(\alpha - \beta) + \cos(\alpha + \beta)]$$

$$\sin(\alpha) \cos(\beta) = \frac{1}{2}[\sin(\alpha - \beta) + \sin(\alpha + \beta)]$$

