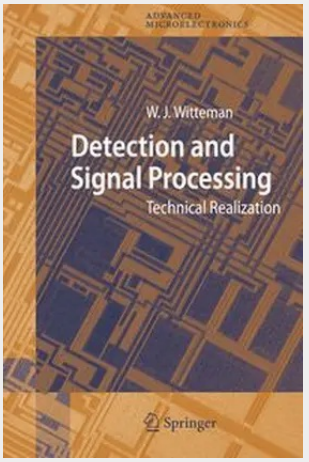
Witteman

Detection and Signal Processing

Technical Realization



Thesecondpartdealswithampli?cationproblemsandtherecovery ofrepetitivesignalsburiedinnoise. Thelastpartisdevotedtosolvingthe problemsconnectedwithreachingtheultimatedetectionlimitorquantum limit. Thisisdoneforheterodynedetectionandphotoncounting. Although VIII Preface heterodynedetectionyieldstheultimatesensitivity,itsspatialmodesel- tivityand,ingeneral,thelowspectralpowerdensityofthesignalrequire sophisticatedprovisions. Thisisdiscussedindetail. Theinherentproblemsare analyzedandappropriatetechnicalsolutionsaredescribedtoreachtheul- matesensitivityfordetectingincoherentradiationandcommunicationsignals thatarerandomlyDopplershifted. Theresultsareillustratedwithexamples ofspacecommunication. Hengelo(O),January2006 W. J. Witteman Contents 1 RandomFluctuations. 1 1. 1 Introduction. 1 1. 2 ThermalNoiseofResistance. 2 1. 3 ShotNoise. 5 1. 3. 1 SpectralDistribution. 6 1. 3. 2 Photons. 10 1. 4 FlickerNoise. 10 1. 5 Generation–RecombinationNoise. 10 1. 6 ThermalRadiationandItsFluctuations. 13 1. 7 TemperatureFluctuationsofSmallBodies. 18 1. 7. 1 AbsorptionandEmissionFluctuations. 20 2 Signal–NoiseRelations. 21 2. 1 SignalLimitation. 22 2. 2 BackgroundLimitation. 22 2. 2. 1 IdealDetection. 24 2. 3 JohnsonNoise. 27 2. 4 DarkCurrentNoise. 27 2. 5 NoiseandSensitivity. 28 2. 6 Ampli?erNoiseandMismatching. 28 3 ThermalDetectors. 31 3. 1 ThermocoupleandThermopile. 31 3. 2 Bolometer. 36 3. 2. 1 MetallicBolometer. 39 3. 2. 2 Thermistor. 40 3. 3 PyroelectricDetector. 44 4 VacuumPhotodetectors. 51 4. 1 VacuumPhotodiode. 52 4. 2 Photomultiplier. 56 X Contents 5 SemiconductorPhotodetectors. 61 5. 1 Photoconductors. 61 5. 1. 1 AnalysisoftheDetectionProcess. 64 5. 1. 2 FrequencyResponse. 69 5. 2 Photodiodes. 69 5. 2. 1 P–NJunction. 70 5. 2. 2 Current–VoltageCharacteristic. 72 5. 2. 3 PhotonExcitation. 75 5. 2. 4 OperationalModes. 79 5. 2. 5 OpenCircuit. 80 5. 2. 6 CurrentCircuit. 82 5. 2. 7 Reverse-BiasedCircuit. 83 5. 3 AvalanchePhotodiodes.

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