

A High Temperature Wideband Low Noise Amplifier

Michael Lawrence Cunningham

Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

**Master of Science
In
Electrical Engineering**

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December 11, 2015
Blacksburg, VA

Keywords: high temperature, extreme environment, low noise amplifier, GaN on SiC,
downhole communications system

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This is not a replacement for professional legal advice but an effort to assist you in making a sound decision.

Name: Michael L Cunningham

Description of item under review for fair use: Figure 1.1: HPHT classification system. Source: G. DeBruijn, C. Skeates, R. Greenaway, D. Harrsion, M. Parris, S. James, et al., "High-pressure, high-temperature technologies," Oilfield Review, vol. 20, pp. 46-60, 1 October 2008.

Report generated on: 12-12-2015 at : 13:04:31

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

Factor 3

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: *in favor of fair use*

Factor 4

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: *in favor of fair use*

Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use*

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 2.1: Two-port network representation for s-parameters. Source: I. J. Bahl, "Linear network analysis," in Fundamentals of RF and microwave transistor amplifiers, 1st ed. Hoboken, NJ: Wiley, 2009, ch. 2, pp. 17-32.

Report generated on: 12-12-2015 at : 13:12:05

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

Factor 3

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: *in favor of fair use*

Factor 4

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: *in favor of fair use*

Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use*

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 2.2: Typical 1-dB compression plot. Source: B. Razavi, "Effects of nonlinearity," in RF microelectronics, 2nd ed. Upper Saddle River, NJ: Pearson Education, 2012, ch. 2, sec. 2, pp. 14-35.

Report generated on: 12-12-2015 at : 13:16:23

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

Factor 3

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Factor 4

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 2.6: Microstrip geometry and field configuration. In (b), the solid lines represent electric field lines and the dashed line represents a magnetic field line.

Source: G. Gonzalez, "Matching networks and signal flow graphs," in Microwave transistor amplifiers - analysis and design, 2nd ed. Upper Saddle River, NJ: Prentice-Hall, 1997, ch. 2, pp. 92-211.

Report generated on: 12-12-2015 at : 13:25:51

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

Factor 3

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 2.7: Block diagram including matching networks.
Source: G. Gonzalez, "Matching networks and signal flow graphs," in Microwave transistor amplifiers - analysis and design, 2nd ed. Upper Saddle River, NJ: Prentice-Hall, 1997, ch. 2, pp. 92-211.

Report generated on: 12-12-2015 at : 13:28:30

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 2.8: Example of impedance transforming effect of transmission line – quarter wave transformer. Source: G. Gonzalez, "Representations of two-port networks," in Microwave transistor amplifiers - analysis and design, 2nd ed. Upper Saddle River, NJ: Prentice-Hall, 1997, ch. 1, pp. 1-91.

Report generated on: 12-12-2015 at : 13:30:14

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 2.9: Common source with inductive load. Source: B. Razavi, "LNA topologies," in RF microelectronics, 2nd ed. Upper Saddle River, NJ: Pearson Education, 2012, ch. 5, sec. 3, pp. 266-305.

Report generated on: 12-12-2015 at : 13:31:36

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 2.10: Common source with inductive load and neutralization of internal feedback capacitance. Source: B. Razavi, "LNA topologies," in RF microelectronics, 2nd ed. Upper Saddle River, NJ: Pearson Education, 2012, ch. 5, sec. 3, pp. 266-305.

Report generated on: 12-12-2015 at : 13:33:21

Based on the information you provided:

Factor 1

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 2.11: Common source with resistive feedback.
Source: B. Razavi, "LNA topologies," in RF microelectronics, 2nd ed. Upper Saddle River, NJ: Pearson Education, 2012, ch. 5, sec. 3, pp. 266-305.

Report generated on: 12-12-2015 at : 13:34:03

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 2.12: Common gate Source: B. Razavi, "LNA topologies," in RF microelectronics, 2nd ed. Upper Saddle River, NJ: Pearson Education, 2012, ch. 5, sec. 3, pp. 266-305.

Report generated on: 12-12-2015 at : 15:54:17

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 2.13: Cascode CS with inductive degeneration.
Source: B. Razavi, "LNA topologies," in RF microelectronics, 2nd ed. Upper Saddle River, NJ: Pearson Education, 2012, ch. 5, sec. 3, pp. 266-305.

Report generated on: 12-12-2015 at : 13:34:46

Based on the information you provided:

Factor 1

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 2.14: Some variants: (a) CG with feedback, (b) CG with feedforward, and (c) Noise cancelling LNAs. Source: B. Razavi, "LNA topologies," in RF microelectronics, 2nd ed. Upper Saddle River, NJ: Pearson Education, 2012, ch. 5, sec. 3, pp. 266-305.

Report generated on: 12-12-2015 at : 13:35:22

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 2.15: Electrical analogy of 1-D heat flow. Source: B. Lindberg. (Nov. 2015). Analogy between thermal and electrical conduction. Available: http://www.egr.msu.edu/~raguin/ME812/FinalProjects/Lindberg_FinalProject.htm

Report generated on: 12-12-2015 at : 13:39:03

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Factor 1

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 2.16: Thermal circuit of basic device on heatsink.
Source: S. Lee. (1995, Nov. 2015). How to select a heat sink. Available: <http://www.electronics-cooling.com/1995/06/how-to-select-a-heat-sink/>

Report generated on: 12-12-2015 at : 13:40:10

Based on the information you provided:

Factor 1

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 2.17: Frequency and power limits of some semiconductor technologies. Source: M. Kasu, "Diamond field-effect transistors as microwave power amplifiers," NTT Technical Review, vol. 8, no. 8, 2014.

Report generated on: 12-12-2015 at : 15:07:28

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 3.4: 0.25 μ m GaN on SiC Field Plate HEMT – Model 0528-Q3. Source: TriQuint, "10W, 28V DC - 6 GHz, GaN RF power transistor," T2G6000528-Q3 datasheet, 2013 [rev. C, Nov. 2014].

Report generated on: 12-12-2015 at : 15:10:38

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 3.18: PATT series Vishay Dale Thin Film Resistors. Source: Vishay, "Precision automotive high temperature (155°C at full rated power) thin film chip resistor, AEC-Q200 qualified," PATT Thin Film Resistor datasheet, 2015 [doc. 60124 rev. Aug. 2014/Jun. 2015].

Report generated on: 12-12-2015 at : 15:12:24

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

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This is not a replacement for professional legal advice but an effort to assist you in making a sound decision.

Name: Michael L Cunningham

Description of item under review for fair use: Figure 3.19: Derating curve for Vishay PATT resistor. Source: Vishay, "Precision automotive high temperature (155°C at full rated power) thin film chip resistor, AEC-Q200 qualified," PATT Thin Film Resistor datasheet, 2015 [doc. 60124 rev. Aug. 2014/Jun. 2015].

Report generated on: 12-12-2015 at : 15:13:36

Based on the information you provided:

Factor 1

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 3.20: Coilcraft 1 μ H inductors (AT549RBT102MLZ). Source: Coilcraft, "Extreme temperature coil," AT549RBT datasheet, [doc. AT098 rev. Jun. 2013].

Report generated on: 12-12-2015 at : 15:14:39

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

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This is not a replacement for professional legal advice but an effort to assist you in making a sound decision.

Name: Michael L Cunningham

Description of item under review for fair use: Figure 3.21: Impedance vs. Frequency – Coilcraft 1 μ H (AT549RBT102MLZ). Source: Coilcraft, "Extreme temperature coil," AT549RBT datasheet, [doc. AT098 rev. Jun. 2013].

Report generated on: 12-12-2015 at : 15:15:30

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 3.22: IPDiA (left). Source: IPDiA, "XTSC IPDiA capacitors – NiAu finishing: Assembly by soldering," ver. 1.4, 2015.

Report generated on: 12-12-2015 at : 15:16:20

Based on the information you provided:

Factor 1

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 3.23: IPDiA's PICS vs. MLCC (Multilayer Ceramic Chip) capacitors. Source: IPDiA, "0201 extreme temperature silicon capacitors," XTSC423.xxxx datasheet, Feb. 2014 [doc. CL431 111 615 123].

Report generated on: 12-12-2015 at : 15:17:56

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 3.24: Natural and forced convection characteristics with 1°C/W line (red). Source: Wakefield-Vette, "Extruded heatsinks," 413/421/423 datasheet, Jun. 2007.

Report generated on: 12-12-2015 at : 15:18:54

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 3.25: Heat sink dimensions Source: Wakefield-Vette, "Extruded heatsinks," 413/421/423 datasheet, Jun. 2007.

Report generated on: 12-12-2015 at : 15:20:44

Based on the information you provided:

Factor 1

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 4.1: R&S ZVL13 VNA. Source: Rohde & Schwarz. (2015). R&S®ZVL13 vector network analyzer [Image]. Available: http://www.rohde-schwarz.us/en/product/zvl13-productstartpage_63493-10575.html

Report generated on: 12-12-2015 at : 15:21:39

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Factor 1

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 4.3: Keysight N8973A NFA Source: K. Technologies. (2015). N8973A noise figure analyzer 10 MHz to 3 GHz [Image]. Available: <http://www.keysight.com/en/pd-1000003275:epsg:pro-pn-N8973A/noise-figure-analyzer-10-mhz-to-3-ghz>

Report generated on: 12-12-2015 at : 15:22:25

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Name: Michael L Cunningham

Description of item under review for fair use: Figure 4.4: (left to right) E4411B, E8257D, and SMB100A signal generators Source E4411B: Used-Line.com. (2015). Agilent E4411B-BAS (ESA-L series) main features and specifications [Image]. Available: <http://www.used-line.com/list-spectrum-analyzer/agilent/agilent-hp-e4411b-bas>

Report generated on: 12-12-2015 at : 15:24:20

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Description of item under review for fair use: Figure 4.4: (left to right) E4411B, E8257D, and SMB100A signal generators Source E8257D: Keysight Technologies. (2015). E8257D PSG analog signal generator, 100 kHz to 67 GHz [Image]. Available: <http://www.keysight.com/en/pd-460865-pn-E8257D/psg-analog-signal-generator?cc=US&lc=eng>

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Factor 4

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: *in favor of fair use*

Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use*

Virginia Tech ETD Fair Use Analysis Results

This is not a replacement for professional legal advice but an effort to assist you in making a sound decision.

Name: Michael L Cunningham

Description of item under review for fair use: Figure 4.4: (left to right) E4411B, E8257D, and SMB100A signal generators Source SMB100A: Rohde & Schwarz. (2015). R&S®SMB100A RF and microwave signal generator [Image]. Available: http://www.rohde-schwarz.us/en/product/smb100a-productstartpage_63493-9379.html

Report generated on: 12-12-2015 at : 15:26:11

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

Factor 3

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: *in favor of fair use*

Factor 4

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: *in favor of fair use*

Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use*

Virginia Tech ETD Fair Use Analysis Results

This is not a replacement for professional legal advice but an effort to assist you in making a sound decision.

Name: Michael L Cunningham

Description of item under review for fair use: Figure 4.5: Anritsu MS2665C Spectrum Analyzer. Source: SGLabs. (2015). Anritsu, MS2665C [Image]. Available: <http://www.sglabs.it/en/product.php?s=anritsu-ms2665c&id=1529>

Report generated on: 12-12-2015 at : 15:26:57

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

Factor 3

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: *in favor of fair use*

Factor 4

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: *in favor of fair use*

Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use*

Virginia Tech ETD Fair Use Analysis Results

This is not a replacement for professional legal advice but an effort to assist you in making a sound decision.

Name: Michael L Cunningham

Description of item under review for fair use: Figure 4.6: Yamato DX302C Natural Convection Oven. Source: Cole-Parmer. (2015). Yamato high-temperature gravity convection oven, 0.9 cu ft, 115 VAC [Image]. Available: http://www.coleparmer.com/Product/Yamato_High_Temperature_Gravity_Convection_Oven_0_9_Cu_Ft_115_VAC/EW-33959-00

Report generated on: 12-12-2015 at : 15:27:42

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

Factor 3

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: *in favor of fair use*

Factor 4

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: *in favor of fair use*

Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use*

Virginia Tech ETD Fair Use Analysis Results

This is not a replacement for professional legal advice but an effort to assist you in making a sound decision.

Name: Michael L Cunningham

Description of item under review for fair use: Figure 4.7: Rigol DP832A Power Supply. Source: Rigol Technologies, Inc. (2015). DP832A | triple output, 195 watt power supply [Image]. Available: <http://www.rigolna.com/products/dc-power-supplies/dp800/dp832a/>

Report generated on: 12-12-2015 at : 15:28:27

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

Factor 3

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: *in favor of fair use*

Factor 4

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: *in favor of fair use*

Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use*

Virginia Tech ETD Fair Use Analysis Results

This is not a replacement for professional legal advice but an effort to assist you in making a sound decision.

Name: Michael L Cunningham

Description of item under review for fair use: Table 2.3: Comparison of Transistor/Monolithic Integrated Circuit Substrates. Source: I. J. Bahl, "Transistors," in Fundamentals of RF and microwave transistor amplifiers, 1st ed. Hoboken, NJ: Wiley, 2009, ch. 4, pp. 61-90.

Report generated on: 12-12-2015 at : 15:08:52

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

Factor 3

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: *in favor of fair use*

Factor 4

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: *in favor of fair use*

Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use*

Virginia Tech ETD Fair Use Analysis Results

This is not a replacement for professional legal advice but an effort to assist you in making a sound decision.

Name: Michael L Cunningham

Description of item under review for fair use: Table 3.3: T2G6000528-Q3 – Absolute maximum ratings and thermal reliability. Source: TriQuint, "10W, 28V DC - 6 GHz, GaN RF power transistor," T2G6000528-Q3 datasheet, 2013 [rev. C, Nov. 2014].

Report generated on: 12-12-2015 at : 15:11:27

Based on the information you provided:

Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

Factor 2

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

Factor 3

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: *in favor of fair use*

Factor 4

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: *in favor of fair use*

Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use*