

**ANTENA SUSUN 5,3 GHZ DENGAN PENCATUAN *PROXIMITY*  
*COUPLED* UNTUK APLIKASI UAV**

**SKRIPSI**

Diajukan untuk memenuhi sebagian syarat  
untuk memperoleh gelar Sarjana Teknik Elektro  
Program Studi Teknik Elektro S1



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Sebuah skripsi yang diajukan untuk memenuhi salah satu syarat memperoleh gelar  
Sarjana Teknik Elektro pada Program Studi Teknik Elektro S1

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## ABSTRAK

Penelitian ini berfokus pada pengembangan *array* antena mikrostrip *patch* persegi untuk komunikasi *Unmanned Aerial Vehicle* (UAV), agar mendapatkan hasil desain dan fabrikasi antena yang memiliki performansi untuk komunikasi UAV. Untuk mendapatkannya, dilakukan perancangan dan optimasi pada simulasi menggunakan *software 3D*. Antena yang memiliki *gain* tinggi dan *bandwidth* lebar diperlukan untuk memenuhi persyaratan komunikasi UAV. Antena mikrostrip memiliki berbagai kelemahan antara lain *bandwidth* yang relatif sempit. Oleh karena itu teknik *proximity coupling* digunakan untuk mendapatkan pita *bandwidth* yang lebar, cara ini dilakukan dengan menggunakan 2 lapis bahan dielektrik. Pada teknisnya saluran pencatu terletak di atas lapisan substrat pertama dengan lapisan *ground* di bawah substrat pertama dan *patch* terletak di atas lapisan substrat kedua. Selanjutnya dalam upaya meningkatkan nilai *gain* menggunakan metode konfigurasi antena *array*. Jenis *array* yang digunakan adalah teknik saluran transmisi serial dengan tipe *out-of-line feed*. Konfigurasi susunan pada antena *array* ini dibuat hingga tercapainya nilai *gain* yang dibutuhkan. Desain rancangan antena yang diusulkan terdiri dari 16 elemen *patch* mikrostrip dengan teknik *proximity coupling*, dirancang pada lapisan dielektrik FR-4 dengan ketebalan 1,6 mm. Hasil akhir dari penelitian ini memiliki nilai  $S_{11} \leq -10$  dB dengan *gain* lebih dari 10 dB pada frekuensi 5,3 GHz dan *bandwidth* lebih dari 600 MHz, memiliki dimensi berukuran 224 mm  $\times$  60,2 mm.

**Kata Kunci:** Antena, Arrays, Bandwidth, Proximity Coupling, UAV.

## **ABSTRACT**

*This research focuses on the development of square patch microstrip antenna arrays for Unmanned Aerial Vehicle (UAV) communications, in order to obtain the design and fabrication of antennas that have performance for UAV communications. To get it, design and optimization is carried out in simulations using 3D software. Antennas that have high gain and wide bandwidth are required to meet the UAV communication requirements. Microstrip antennas have various weaknesses, including relatively narrow bandwidth. Therefore, the proximity coupling technique is used to get a wide bandwidth band, this method is done by using 2 layers of dielectric material. Technically the feed line is located above the first substrate layer with the ground layer below the first substrate and the patch located above the second substrate layer. Furthermore, in an effort to increase the gain value using the antenna array configuration method. The type of array used is a serial transmission line technique with an out-of-line feed type. The array configuration on the antenna array is made until the required gain value is achieved. The proposed antenna design consists of 16 microstrip patch elements with proximity coupling technique, designed on FR-4 dielectric layer with a thickness of 1.6 mm. The final result from this research has a value of  $S_{11} \leq -10$  dB with a gain more than 10 dB at a frequency of 5.3 GHz and a bandwidth more than 600 MHz, has dimensions of 224 mm  $\times$  60.2 mm.*

**Keywords:** *Antenna, Arrays, Bandwidth, Proximity Coupling, UAV.*

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## DAFTAR PUSTAKA

- Arpaio, M. J., Fuschini, F., Vitucci, E. M., Degli Esposti, V., Barbiroli, M., & Masotti, D. (2019). Lightweight Microstrip Patch Array for Broadband UAV Applications over 5G networks. *2019 Conference on Microwave Techniques, COMITE 2019 - Microwave and Radio Electronics Week, MAREW 2019*, 1–5. <https://doi.org/10.1109/COMITE.2019.8733547>
- Arsyad, H. (2020). *DESAIN DAN FABRIKASI ANTENA QUASI-YAGI UDA MIMO 2X2 UNTUK APLIKASI JARINGAN 5G PADA PERANGKAT SELULER*. 117.
- Aswoyo, B. (2007). *ANTENA & PROPAGASI*.
- Balanis, C. A. (2007). Modern antenna handbook. In *Modern Antenna Handbook*. <https://doi.org/10.1002/9780470294154>
- Balanis, C. A. (2016). *Antenna Theory Analysis and Design Fourth Edition*.
- Diawuo, H. A., & Jung, Y. B. (2018). Broadband Proximity-Coupled Microstrip Planar Antenna Array for 5G Cellular Applications. *IEEE Antennas and Wireless Propagation Letters*, 17(7), 1286–1290. <https://doi.org/10.1109/LAWP.2018.2842242>
- Emhemmed, A. S., McGregor, I., & Elgaid, K. (2009). *200GHz Broadband Proximity Coupled Patch Antenna*. 2009, 404–407.
- Gllsson, A. (2003). *Allen Gllsson*. 45(2), 8107.
- Kumar, P. P., Sreelakshmi, K., Sangeetha, B., & Narayan, S. (2017). *Metasurface based Low Profile Reconfigurable Antenna*. 2081–2085.
- L. Stutzman, W & A. Thiele, G. (2013). *Antenna Theory and Design Third Edition*.
- M. Pozar, D. (2012). *Microwave Engineering*.
- Paonessa, F. (2018). UAV-Based Antenna Measurements : Improvement of the Test Source Frequency Behavior. *2018 IEEE Conference on Antenna Measurements & Applications (CAMA)*, 1–3.

- Pratiwi, C. Z., & Munir, A. (2020). Circularly polarized square patch array antenna with multiple rectangular-slots fed by proximity coupling technique. *2020 International Workshop on Antenna Technology, IWAT 2020*, 2–5. <https://doi.org/10.1109/iWAT48004.2020.1570609811>
- Putri, S. M. (2018). Analisis Antena Mikrostrip Fraktal Sierpinski Gasket. *Jurnal Elektro Dan Telekomunikasi*, 4, 55–61.
- R.A., S. (1951). *Antennas. John D. Kraus. New York: McGraw-Hill, 1950.*
- Rahayu, N. (2012). *DESAIN DAN IMPLEMENTASI ANTENA SUSUN PLANAR EMPAT ELEMEN MIKROSTRIP LINGKARAN DENGAN TEKNIK PENCATUAN PROXIMITY COUPLING* (Vol. 3, Issue September).
- Ravindra, P., Ravishankar, B. N., Dasgupta, S., & Selvanayaki, K. (2019). *Conformal Reflector Backed Printed Dipole Antenna For Directional UAV Communications. Icces*, 1613–1617.
- Rizwan, A., Biswas, D., & Ramachandra, V. (2017). Impact of UAV Structure on Antenna Radiation Patterns at Different Frequencies. *2017 IEEE International Conference on Antenna Innovations & Modern Technologies for Ground, Aircraft and Satellite Applications (IAIM)*, 1–5.
- Santosa, C. E., Sri Sumantyo, J. T., Yam, C. M., Urata, K., Ito, K., & Gao, S. (2018). Subarray design for C-band circularly-polarized synthetic aperture radar antenna onboard airborne. *Progress in Electromagnetics Research*, 163(September), 107–117. <https://doi.org/10.2528/pier18060602>
- Santosa, C. E., Sumantyo, J. T. S., Gao, S., & Ito, K. (2021). Broadband Circularly Polarized Microstrip Array Antenna with Curved-Truncation and Circle-Slotted Parasitic. *IEEE Transactions on Antennas and Propagation*, 69(9), 5524–5533. <https://doi.org/10.1109/TAP.2021.3060122>
- Saxena, S., & Saxena, N. (2020). Proximity coupled microstrip patch antenna for gain enhancement. *Proceedings - 2020 International Conference on Advances in Computing, Communication and Materials, ICACCM 2020*, 1, 423–426. <https://doi.org/10.1109/ICACCM50413.2020.9212889>

- Song, J., Sun, X., & Wu, S. (2018). Design of 77 GHz Narrow Beamwidth Antenna for UAVs Obstacle Avoidance Radar. *2018 International Conference on Microwave and Millimeter Wave Technology, ICMMT 2018 - Proceedings*, 1–3. <https://doi.org/10.1109/ICMMT.2018.8563313>
- Sumantyo, J. T. S., Chua, M. Y., Santosa, C. E., Panggabean, G. F., Watanabe, T., Setiadi, B., Tsushima, K., Sumantyo, F. D. S., Sasmita, K., Mardiyanto, A., Supartono, E., Rahardjo, E. T., Wibisono, G., Jatmiko, R. H., Purwanto, T. H., Widartono, B. S., Kamal, M., Triharjanto, R. H., Gao, S., & Ito, K. (2019). *HINOTORI-C2 MISSION: CN235MPA AIRCRAFT ONBOARD CIRCULARLY POLARIZED SYNTHETIC APERTURE RADAR ( CP-SAR )* Chiba University , 2 Japan Radio Company , 3 Universitas Bhayangkara Jakarta Raya , Tentara Nasional Indonesia Angkatan Udara , 5 Universitas Indonesi. 8538–8541.
- Walia, L., Walia, G., & Singh, U. P. (2018). Design and analysis of microstrip patch antenna using DRAF. *Advances in Intelligent Systems and Computing*, 732, 43–51. [https://doi.org/10.1007/978-981-10-8533-8\\_5](https://doi.org/10.1007/978-981-10-8533-8_5)
- Widiandari, R., & Munir, A. (2017). Proximity coupled x-band patch antenna array with dual polarization. *Proceedings - 2016 International Electronics Symposium, IES 2016*, 165–168. <https://doi.org/10.1109/ELECSYM.2016.7860995>
- Yurandi, N., Jambola, L., & Darlis, A. R. (2013). Perancangan dan Implementasi Reflector Antena Wifi dengan Frekuensi 2,4 GHz. *Jurnal Reka Elkomika*, 1(3).
- Yusuf, A. M., Wijanto, H., & Edwar. (2019). Dual C-X-Band E-Shaped Microstrip Antenna Array 1×8 for Synthetic Aperture Radar on UAV. *Proceedings - 2019 IEEE International Conference on Signals and Systems, ICSigSys 2019*, 8(4), 186–189. <https://doi.org/10.1109/ICSIGSYS.2019.8811085>
- Zhou, G. (2019). Energy Efficiency Beamforming Design for UAV Communications with Broadband Hybrid Polarization Antenna Arrays. *IEEE Access*, 7(c), 34521–34532. <https://doi.org/10.1109/ACCESS.2019.2904692>

