Scopus

Documents

Abdulghafor, R.[a] , Turaev, S.[b] , Almohamedh, H.[c] , Alabdan, R.[d] , Almutairi, B.[e] , Almutairi, A.[f] , Almotairi, S.[g]

Recent Advances in Passive UHF-RFID Tag Antenna Design for Improved Read Range in Product Packaging Applications: A Comprehensive Review

(2021) *IEEE Access*, 9, art. no. 9408581, pp. 63611-63635.

DOI: 10.1109/ACCESS.2021.3074339

[a] Department of Computer Science, Faculty of Information and Communication Technology, International Islamic University Malaysia, Kuala Lumpur, Malaysia

[b] Department of Computer Science and Software Engineering, College of Information Technology, United Arab Emirates University, Al Ain, United Arab Emirates

[c] King Abdulaziz City for Science and Technology (KACST), Riyadh, Saudi Arabia

[d] Department of Information Systems, College of Computer and Information Sciences, Majmaah University, Al Majma'ah, Saudi Arabia

[e] Department of Information Technology, College of Computer Sciences and Information Technology, Majmaah University, Al Majma'ah, Saudi Arabia

[f] Information and Computer Center, The Public Authority for Applied Education and Training, Safat, Kuwait

[g] Department of Natural and Applied Sciences, Community College, Majmaah University, Al Majma'ah, Saudi Arabia

Abstract

Radio frequency identification (RFID) is a rapidly developing technology, and RFID sensors have become important components in many common technology applications. The passive ultra-high frequency (UHF) tags used in RFID sensors have a higher data transfer rate and longer read range and usually come in unique small and portable application designs. However, these tags suffer from significant frequency interference when mounted on metallic materials or placed near liquid surfaces. This paper presents the recent advancements made in passive UHF-RFID tag designs proposed to resolve the interference problems. We focus on those designs that are intended to improve antenna read range as well as scalability designs for miniaturized applications. © 2013 IEEE.

Author Keywords

metallic; microstrip antenna; PIFA; RFID; UHF-RFID

Index Keywords

Data transfer, Data transfer rates, Mobile antennas, Product design; Frequency interference, Interference problems, Metallic material, Passive UHF RFID, Portable applications, Product packaging, Technology application, Ultra-High Frequency tags; Radio frequency identification (RFID)

References

- Jia, X., Feng, Q., Fan, T., Lei, Q.
  RFID technology and its applications in Internet of Things (IoT)
  (2012) *Proc. 2nd Int. Conf. Consum. Electron., Commun. Netw. (CECNet)*, pp. 1282-1285.
  Apr

- Xiao, Y., Yu, S., Wu, K., Ni, Q., Janecek, C., Nordstad, J.
  Radio frequency identification: Technologies, applications, and research issues
  (2007) *Wireless Commun. Mobile Comput.*, 7 (4), pp. 457-472.

- Chawla, V., Ha, D.
  An overview of passive RFID
  (2007) *IEEE Commun. Mag.*, 45 (9), pp. 11-17.
  Sep

- Hammer, N., Adrion, F., Jezierny, D., Gallmann, E., Jungbluth, T.
  Methodology of a dynamic test bench to test ultra-high-frequency transponder ear tags in motion
  (2015) *Comput. Electron. Agricult.*, 113, pp. 81-92.
  Apr

- Brown-Brandl, T.M., Adrion, F., Maselyne, J., Kapun, A., Hessel, E.F., Saeys, W., Van Nuffel, A., Gallmann, E.
  A review of passive radio frequency identification systems for animal monitoring in livestock facilities
  (2019) *Appl. Eng. Agricult.*, 35 (4), pp. 579-591.

- Zhang, J., Tian, G., Marindra, A., Sunny, A., Zhao, A.
  A review of passive RFID tag antenna-based sensors and systems for structural health monitoring applications
  (2017) *Sensors*, 17 (2), p. 265.
  Jan

- Cong, N.L., Knyazev, S.T., Xuan, V.T., Quang, H.L.
  Microstrip antenna with an air gap for use in RFID and tracking of cargo containers
  (2018) *Proc. Int. Conf. Adv. Comput., Commun. Informat. (ICACCI)*, pp. 2186-2189.
  Sep

- Bong, F.-L., Lim, E.-H., Lo, F.-L.
  Compact orientation insensitive dipolar patch for metal-mountable UHF RFID tag design
  (2018) *IEEE Trans. Antennas Propag.*, 66 (4), pp. 1788-1795.
  Apr

- Zhang, Y., Yemelyanov, K., Li, X., Amin, M.G.
  Effect of metallic objects and liquid supplies on R_d links isotropic antenna. The transmitted power was 1Win all the cases presented here. It should be noted that FCC regulations allow a maximum transmit power of 1 W, provided that the effective is
  (2009) *Read*, pp. 7-10.
  Jun

- Ferreira, J.B., Salles, A.A.A.D., Bulla, G., Rhod, E.L.
  A new structure of UHF RFID tag antenna mountable on metallic surface using double slits
  (2017) *Proc. IEEE 9th Latin-Amer. Conf. Commun. (Latin-COM)*, pp. 1-3.
  Nov

- Hamani, A., Yagoub, M.C.E., Vuong, T.-P., Touhami, R.
  A novel broadband antenna design for UHF RFID tags on metallic surface environments
  (2017) *IEEE Antennas Wireless Propag. Lett.*, 16, pp. 91-94.

- Yuan, L., Tang, W.
  A compact broadband UHF RFID tag antenna for metallic objects
  (2017) *Proc. Int. Appl. Comput. Electromagn. Soc. Symp. (ACES)*, pp. 9-11.

- Franchina, V., Michel, A., Nepa, P., Salvatore, A.
  Compact in-metal UHF RFID tag for manufactured metallic components
  (2018) *Proc. 3rd Int. Conf. Smart Sustain. Technol.*, pp. 1-5.
  Jun

- Li, H., Zhu, J., Yu, Y.
  Compact single-layer RFID tag antenna tolerant to background materials
  (2017) *IEEE Access*, 5, pp. 21070-21079.

- Zannas, K., El Matbouly, H., Duroc, Y., Tedjini, S.
  Antenna design for compact RFID sensors dedicated to metallic environments
  (2017) *Proc. 32nd Gen. Assem. Sci. Symp. Int. Union Radio Sci. URSI GASS*, pp. 1-3.
  Aug

- Zhang, J., Guo, C., Xing, Z., Yuan, W., Wang, W.
  Design of low profile RFID tag antenna with 5.8GHz used in ETC under the metallic environment
  (2017) *Proc. 6th Asia-Pacific Conf. Antennas Propag. (APCAP)*, pp. 1-3.
  Oct

- Gao, B., Yuen, M.M.F.
  Passive UHF RFID packaging with electromagnetic band gap (EBG) material for metallic objects tracking
  (2011) *IEEE Trans. Compon., Packag., Manuf. Technol.*, 1 (8), pp. 1140-1146.
  Aug

- Lopez-Soriano, S., Parron, J.
  Small UHF RFID tag antenna for metallic objects
  (2015) *Proc. 9th Eur. Conf. Antennas Propag. (EuCAP)*, pp. 1-5.
  Apr

- Kang, F., Cheng, Y.
  A miniature RFID tag antenna mounted on metallic objects
  (2016) *Proc. IEEE Int. Conf. Ubiquitous Wireless Broadband (ICUWB)*, pp. 1-3.
  Oct

- Jeong, S.-H., Son, H.-W., Yeo, J.
  A low-cost, wideband RFID tag antenna on metallic surfaces using proximity-coupled feed
  (2009) *Proc. Asia Pacific Microw. Conf.*, pp. 2409-2411.
  Dec

- Mo, L., Zhang, H.
  RFID antenna near the surface of metal
  (2007) *Proc. Int. Symp. Microw., Antenna, Propag. EMC Technol. Wireless Commun.*, pp. 803-806.
  Aug

- Zannas, A.S., Chrousos, G.P.
  Epigenetic programming by stress and glucocorticoids along the human lifespan
  (2017) *Mol. Psychiatry*, 22 (5), pp. 640-646.
  May

- Hamani, A., Allard, B., Vuong, T., Yagoub, M.C.E., Touhami, R.
  Design of rectenna series-association circuits for radio frequency energy harvesting in CMOS FD-SOI 28 nm
  (2018) *IET Circuits, Devices Syst.*, 12 (1), pp. 40-49.
  Jan

- Khamlichi, M.E., Mrabet, O.E., Bakkali, M.E., Khalladi, M., Ennasar, M.A.
  T-shaped tag antenna for UHF RFID applications
  (2018) *Proc. 6th Int. Conf. Multimedia Comput. Syst. (ICMCS)*, pp. 1-4.
  May

- El Yassini, A., Ibnyaich, S., Jallal, M.A., Chabaa, S., Zeroual, A.
  Design of a miniaturized microstrip patch antenna for a passive UHF RFID tag
  (2017) *Proc. Int. Conf. Wireless Technol., Embedded Intell. Syst. (WITS)*, pp. 4-7.
  Apr

- Chen, S.-L., Lin, K.-H., Mittra, R.
  A low profile RFID tag designed for metallic objects
  (2009) *Proc. Asia Pacific Microw. Conf.*, pp. 226-228.
  Dec

- Choi, W., Bae, J.-H., Chae, J.-S., Park, C.-W.
  U-shaped slot-array antenna for RFID shelf in the UHF
  (2011) *Proc. IEEE Int. Symp. Antennas Propag. (APSURSI)*, pp. 1449-1451.
  Jul

- Chen, Q.Z., Hu, B.J.
  Novel UHF RFID tag antenna with shorted stubs mountable on the metallic objects
  (2008) *Proc. Int. Conf. Microw. Millim. Wave Technol.*, 4, pp. 1822-1824.
  Apr

- Chen, S.-L.
  A miniature RFID tag antenna design for metallic objects application
  (2009) *IEEE Antennas Wireless Propag. Lett.*, 8, pp. 1043-1045.

- Ng, W.H., Lim, E.H., Chung, B.K.
  Compact folded patch antenna for UHF RFID
  (2017) *Proc. Prog. Electromagn. Res. Symp.*, pp. 132-134.
  Nov

- Bashri, M.S.R., Ibrahimy, M.I., Motakabber, S.M.A.
  A planar wideband inductively coupled feed patch antenna for UHF RFID tag
  (2013) *Proc. IEEE Int. Conf. RFID-Technol. Appl. (RFID-TA)*, pp. 4-5.
  Sep

- Chen, S.-L., Lin, K.-H.
  A slim RFID tag antenna design for metallic object applications
  (2008) *IEEE Antennas Wireless Propag. Lett.*, 7, pp. 729-732.

- Choi, W., Kim, J.-S., Bae, J.-H., Choi, G.-Y., Chae, J.-S.
  Small RFID tag antenna for metallic surface
  (2008) *Proc. Asia-Pacific Microw. Conf.*, pp. 12-15.
  Dec

- Bong, F.-L., Lim, E.-H., Lo, F.-L.
  Miniaturized dipolar patch antenna with narrow meandered slotline for UHF tag
  (2017) *IEEE Trans. Antennas Propag.*, 65 (9), pp. 4435-4442.
  Sep

- Ng, W.-H., Lim, E.-H., Bong, F.-L., Chung, B.-K.
  E-shaped foldedpatch antenna with multiple tuning parameters for on-metal UHF RFID tag
  (2019) *IEEE Trans. Antennas Propag.*, 67 (1), pp. 56-64.
  Jan

- Wu, J.-B., Lin, M.-L., Cong, X., Liu, H.-N., Tan, P.-H.
  Raman spectroscopy of graphene-based materials and its applications in related devices
  (2018) *Chem. Soc. Rev.*, 47 (5), pp. 1822-1873.

- Zamali, M., Osman, L., Ragad, H., Latrach, M.
  Miniaturized circularly polarized patch antenna for RFID system
  (2018) *Proc. 18th Medit. Microw. Symp. (MMS)*, pp. 32-35.
  Oct

- Saluja, N., Khanna, R.G.
  (2014) *Design and Implementation of Multiband and Broadband Microstrip Antennas for Wireless Systems*,
  Thapar Inst. Eng. Technol., Patiala, India, Tech. Rep.

- Moh, C.-W., Lim, E.-H., Bong, F.-L., Chung, B.-K.
  Miniature coplanar-fed folded patch for metal mountable UHF RFID tag
  (2018) *IEEE Trans. Antennas Propag.*, 66 (5), pp. 2245-2253.
  May

- Paredes, F., Zamora, G., Nguyen, T.M., Martin, F., Bonache, J.
  Anovel design strategy for small on-metal UHF-RFID tags with long read range based on complementary split-ring resonator (CSRR)
  (2018) *Proc. 48th Eur. Microw. Conf. (EuMC)*, pp. 985-989.
  Sep

- Sharif, A., Imran, M.A., Ouyang, J., Abbasi, Q.H., Yan, Y.
  Circular polarized RFID tag antenna design using characteristic mode analysis
  (2019) *Proc. Int. Workshop Antenna Technol. (IWAT)*, pp. 62-64.
  Mar

- Ng, W.-H., Lim, E.-H., Bong, F.-L., Chung, B.-K.
  Compact planar inverted-S antenna with embedded tuning arm for on-metal UHF RFID tag design
  (2019) *IEEE Trans. Antennas Propag.*, 67 (6), pp. 4247-4252.
  Jun

- Mokhtar, M.H., Rahim, M.K.A., Murad, N.A., Majid, H.A.
  A compact slotted microstrip patch antenna for RFID applications
  (2013) *Proc. IEEE Int. Conf. RFID-Technol. Appl. (RFID-TA)*, pp. 4-5.
  Sep

- Islam, M.R., Yussuf, A.A., Alam, A.Z., Ismail, A.F., Chebil, J., Khan, S.
  Design of a passive RFID tag antenna at 2.45 GHz for mounting on various platforms
  (2011) *Proc. IEEE Int. RF Microw. Conf.*, pp. 293-297.
  Dec

- Ouazzani, O., Bennani, S.D., Jorio, M.
  Design and simulation of two elements rectangular microstrip patch antenna at 5.8 GHz for RFID reader applications with high directivity and gain
  (2018) *Proc. 6th Int. Conf. Multimedia Comput. Syst. (ICMCS)*, pp. 1-5.
  May

- Huang, J.Z., Yang, P.H., Chew, W.C., Ye, T.T.
  A compact broadband patch antenna for UHF RFID tags
  (2009) *Proc. Asia Pacific Microw. Conf.*, pp. 1044-1047.
  Dec

- Tiwari, R., Bagwari, A., Kushwah, V.S.
  Parameter improvement of micro strip patch antennas using various techniques: A review
  (2020) *Mater. Today, Proc.*, 29 (2), pp. 492-500.

- Sharma, A., Syed, A., Harish, A.R.
  Miniature slotted RFID tag antenna for metallic objects
  (2011) *Proc. Int. Conf. Commun. Signal Pro-cess.*, pp. 353-357.
  Feb

- Phatarachaisakul, T., Pumpoung, T., Phongcharoenpanich, C.
  Dualband RFID tag antenna with EBG for glass objects
  (2015) *Proc. IEEE 4th Asia-Pacific Conf. Antennas Propag. (APCAP)*, pp. 199-200.
  Jun

- Deshmukh, A.A., Verma, P., Singh, D.
  Rectangular slot cut circular microstrip antennas
  (2016) *Proc. 2nd Int. Conf. Adv. Elect., Electron., Inf., Commun. Bio-Inform. (AEEICB), Chennai, India*,

- Zakaria, N.A., Sulaiman, A.A., Latip, M.A.A.
  Design of a circular microstrip antenna
  (2008) *Proc. IEEE Int. RF Microw. Conf.*, pp. 289-292.
  Dec

- Ferdous, T., Nayna, A., Ahmed, F.
  Comparative study of rectangular and circular microstrip patch antennas in X band
  (2014) *Proc. Int. Conf. Elect. Eng. Inf. Commun. Technol., Dhaka, Bangladesh*,

- Kumar, B.P., Kumar, C., Guha, D.
  A new design approach to improve the circular polarization characteristics of a microstrip antenna
  (2018) *Proc. IEEE Indian Conf. Antennas Propag. (InCAP)*, pp. 1-2.
  Dec

- Quang, H.L., Phuong, L.N., Van, R.V., Dinh, T.N.
  Microstrip dipole antenna with reduced dimensions with cutouts
  (2018) *Proc. Int. Conf. Adv. Comput., Commun. Informat. (ICACCI)*, pp. 2190-2192.

Sep

- Yang, S., Scirocco, N., Crisp, M., Penty, R.V., White, I.H.
Large metal objects as near field UHF RFID antennas
(2017) *IEEE J. Radio Freq. Identifocat.*, 1 (1), pp. 13-21.
Mar

- Zannas, K., El Matbouly, H., Duroc, Y., Tedjini, S.
Self-tuning RFID tag: A new approach for temperature sensing
(2018) *IEEE Trans. Microw. Theory Techn.*, 66 (12), pp. 5885-5893.
Dec

- Lv, Y.-X., Zhong, S., Tang, H., Luo, B., Chen, S.-J., Chen, L., Zheng, F., Tang, J.-M.
VEGF_A and VEGF-B coordinate the arteriogenesis to repair the infarcted heart with vagus nerve stimulation
(2018) *Cellular Physiol. Biochem.*, 48 (2), pp. 433-449.

- Hu, X.H.X., Zhang, Q.Z.Q.
Compact slot antenna for 2.4 GHz RFID tags
(2009) *Proc. 3rd Eur. Conf. Antennas Propag.*, pp. 2796-2798.
Mar

- Abdulhadi, A.E., Abhari, R.
Passive UHF RFID printed monopole tag antenna for identification of metallic objects
(2012) *Proc. IEEE Int. Symp. Antennas Propag.*, 2, pp. 1-2.
Jul

- Gupta, S.K., Mishra, R.
A compact band notched monopole antenna with defected ground plane for UWB applications
(2018) *Proc. 5th IEEE Uttar Pradesh Sect. Int. Conf. Electr., Electron. Comput. Eng. (UPCON)*, pp. 1-4.
Nov

- Wang, L., Yu, J., Li, Y.
Microwave photonic antenna for fiber radio application
(2018) *Proc. IEEE 3rd Optoelectron. Global Conf. (OGC)*, pp. 122-125.
Sep

- Niew, Y.H., Lim, E.H., Lee, K.Y., Bong, F.L., Chung, B.K.
Compact Z-slotted patch antenna for UHF metal-mountable tag
(2018) *Proc. IEEE Int. RF Microw. Conf. (RFM)*, pp. 100-102.
Dec

- Liu, J.
Dual-band RFID tag antenna using coplanar inverted-F/L structure
(2010) *Proc. IEEE Int. Conf. RFID-Technol. Appl.*, pp. 96-99.
Jun

- Ukkonen, L., Engels, D., Sydanheimo, L., Kivikoski, M.
Planar wiretype inverted-F RFID tag antenna mountable on metallic objects
(2004) *Proc. IEEE Antennas Propag. Soc. Symp.*, 1, pp. 101-104.
Jun

- Mei, L.H., Ming, S.S., Hua, Z., Bo, L.X.
  The effect of slots on PIFA performance
  (2015) *Proc. IEEE 4th Asia-Pacific Conf. Antennas Propag. (APCAP)*, pp. 485-487.
  Jun

- Lan, W., Jianguo, Y.
  A novel UHF-RFID tag using a planar inverted-F antenna mountable on the metallic objects
  (2018) *Proc. IEEE Int. Conf. Comput. Commun. Eng. Technol. (CCET)*, pp. 146-149.
  Aug

- Xi, J., Zhu, H., Ye, T.T.
  Platform-tolerant PIFA-type UHF RFID tag antenna
  (2010) *Proc. IEEE Int. Conf. RFID (IEEE RFID)*, pp. 174-180.
  Apr

- Sidén, J., Nilsson, H.
  An electrically small elliptic PIFA for RFID in harsh metallic environments
  (2013) *Proc. IEEE Int. Conf. Microw., Com-mun., Antennas Electron. Syst. (COMCAS)*, 2, pp. 1-4.
  Oct

- Lee, S.-R., Lim, E.-H., Bong, F.-L., Chung, B.-K., Lee, K.-Y.
  Miniature PIFA-like patch antenna for UHF RFID tag design
  (2018) *Proc. IEEE Asia-Pacific Conf. Antennas Propag. (APCAP)*, pp. 492-493.
  Aug

- Bhuiyan, R.H., Dougal, R., Ali, M.
  A novel multi-element fractal PIFA with wide pattern coverage for 915 MHz RFID wireless sensors
  (2009) *Proc. IEEE Antennas Propag. Soc. Int. Symp.*, pp. 1-4.
  Jun

- Chen, H.-D., Tsao, Y.-H.
  Low-profile PIFA array antennas for UHF band RFID tags mountable on metallic objects
  (2010) *IEEE Trans. Antennas Propag.*, 58 (4), pp. 1087-1092.
  Apr

- Tsai, M.-C., Li, I.-G., Chiu, C.-W., Wang, H.-C.
  UHF RFID PIFA array tag antenna for human body applications
  (2012) *Proc. 15th Int. Symp. Wireless Pers. Multimedia Commun.*, pp. 434-437.
  Sep

- Hirvonen, M., Pursula, P., Jaakkola, K., Laukkanen, K.
  Planar inverted-F antenna for radio frequency identification
  (2004) *Electron. Lett.*, 40 (14), p. 848.

- Alhawari, A.R.H., Ismail, A., Jalal, A.S.A., Abdullah, R.S.A.R., Rasid, M.F.A.
  U-shaped inductively coupled feed RFID tag antenna for gain enhancement
  (2013) *Proc. IEEE Int. Conf. RFID-Technol. Appl. (RFID-TA)*, pp. 4-5.
  Sep

- Costa, F.C., Yoshioka, R.T., Lima, E.R., Leite, F.I.
  T-matching variation effect of RFID tag antenna for 915 MHz
  (2014) *Proc. IEEE Brazil RFID*, pp. 7-9.
  Sep

- Hongwei, W., Jie, T., Wensheng, Y.
  UHF RFID tag antenna mounted on metallic objects
  (2008) *Proc. China-Jpn. Joint Microw. Conf.*, pp. 684-686.
  Sep

- Hotte, D., Siragusa, R., Tedjini, S., Duroc, Y.
  A new concept of UHF RFID tag for metallic object tracking with embedded cavity
  (2014) *Proc. IEEE RFID Technol. Appl. Conf. (RFID-TA)*, pp. 237-240.
  Sep

- Chen, S.L., Lin, K.H., Mittra, R., Su, H.L.
  A triple-feed Y-shaped slot antenna for metallic RFID tag design
  (2010) *Proc. Asia-Pacific Microw. Conf.*, 2, pp. 2048-2051.
  Dec

- Aznabet, I., Mrabet, O.E., Khalladi, M.
  Free and on metal modi-fied T-shaped tag antenna for UHF-RFID applications
  (2014) *Proc. Medit. Microw. Symp. (MMS)*, pp. 1-3.
  Dec

- Daiki, M., Perret, E., Tedjini, S.
  Design of near field UHF RFID reader antenna integrated into clothing
  (2014) *Proc. IEEE RFID Technol. Appl. Conf. (RFID-TA)*, pp. 261-265.
  Sep

- Rao, K.V.S., Nikitin, P.V., Lam, S.F.
  Antenna design for UHF RFID Tags: A review and a practical application
  (2005) *IEEE Trans. Antennas Propag.*, 53 (12), pp. 3870-8376.
  Dec

- Bong, F.-L., Lim, E.-H., Lo, F.-L.
  Flexible folded-patch antenna with serrated edges for metal-mountable UHF RFID tag
  (2017) *IEEE Trans. Antennas Propag.*, 65 (2), pp. 873-877.
  Feb

- Chen, H.-X., Ma, Z.-H.
  Design of a miniaturized UHF RFID tag antenna
  (2018) *Proc. IEEE Int. Conf. Adv. Manuf. (ICAM)*, pp. 475-476.
  Nov

- Singh, R.K., Michel, A., Nepa, P., Salvatore, A.
  Wearable dualband quasi-yagi antenna for UHF-RFID and 2.4 GHz applications
  (2020) *IEEE J. Radio Freq. Identifocat.*, 4 (4), pp. 420-427.
  Dec

- Le, D., Ukkonen, L., Bjorninen, T.
  A dual-ID RFID tag for headgear based on quasi-Yagi and dipole antennas
  (2020) *IEEE Antennas Wireless Propag. Lett.*, 19 (8), pp. 1321-1325.

Aug

- Soodmand, S., Zhao, A., Tian, G.Y.
UHF RFID system for wirelessly detection of corrosion based on resonance frequency shift in forward interrogation power
(2018) *IET Microw., Antennas Propag.*, 12 (12), pp. 1877-1884.
Oct

- Zhao, A., Zhang, J., Tian, G.Y.
Miniaturization of UHF RFID tag antenna sensors for corrosion characterization
(2017) *IEEE Sensors J.*, 17 (23), pp. 7908-7916.
Dec

- Zhao, A., Tian, G.Y., Zhang, J.
IQ signal based RFID sensors for defect detection and characterisation
(2018) *Sens. Actuators A, Phys.*, 269, pp. 14-21.
Jan

- Marindra, A.M.J., Tian, G.Y.
Chipless RFID sensor for corrosion characterization based on frequency selective surface and feature fusion
(2020) *Smart Mater. Struct.*, 29 (12).
Dec

- Popov, A., Dudnikov, S., Mikhaylov, A.
Passive UHF RFID tag with increased read range
(2008) *Proc. 38th Eur. Microw. Conf.*, pp. 1106-1108.
Oct

- Andrenko, A.S., Kai, M.
Novel design of UHF RFID near-field antenna for smart shelf applications
(2013) *Proc. Asia-Pacific Microw. Conf. Proc. (APMC)*, pp. 242-244.
Nov

- Borisov, D.N., Zuev, S.A.
Modeling microstrip antennas for UHF RFID tags
(2017) *Proc. Int. Conf. Antenna Theory Techn. (ICATT)*, pp. 261-263.
May

- Cho, C., Park, I., Choo, H.
Design of a circularly polarized tag antenna for increased reading range
(2009) *IEEE Trans. Antennas Propag.*, 57 (10), pp. 3418-3422.
Oct

- Koswatta, R., Karmakar, N.C.
Investigation into antenna performance on read range improvement of chipless RFID tag reader
(2010) *Proc. Asia-Pacific Microw. Conf.*, pp. 1300-1303.
Dec

- Zaid, J., Mantash, M., Kesavan, A., Denidni, T.A.
Miniaturized microstrip patch antenna using magneto-dielectric substrate for RFID applications
(2018) *Proc. IEEE Int. Symp. Antennas Propag. USNC/URSI Nat. Radio Sci.*

Meeting, pp. 645-646.
Jul

- Kurian, J., Rajan M N, U., Sukumaran, S.K.
Flexible microstrip patch antenna using rubber substrate for WBAN applications
(2014) *Proc. Int. Conf. Contemp. Comput. Informat. (IC3I)*, pp. 983-986.
Nov

- Mahamine, S.D.
Effects of different substrates on rectangular microstrip patch antenna for S-band
(2016) *Proc. Int. Conf. Autom. Control Dyn. Optim. Techn. (ICACDOT)*, pp. 1142-1145.
Sep

- Liu, Z., Wang, P., Zeng, Z.
Enhancement of the gain for microstrip antennas using negative permeability metamaterial on low temperature cored ceramic (LTCC) substrate
(2013) *IEEE Antennas Wireless Propag. Lett.*, 12, pp. 429-432.

- John, M., Prof, A., Rodrigues, S.
Design of slotted rectangular microstrip patch antenna operated in ISM band using RT-Duroid substrate
(2016) *Proc. Int. Conf. Elect., Electron., Optim. Techn. (ICEEOT)*, pp. 3076-3080.
Mar

- Ghosh, A., Banerjee, A., Das, S.
Dual-band notched wide-slot UWB antenna for low-cost RFID applications
(2017) *Proc. Conf. Inf. Commun. Technol. (CICT)*, pp. 1-4.
Nov

- Tu, M.-T., Choi, W.-W., Cheong, P.
Defected ground structure of UWBchipless RFID tag forFMCWradar
(2018) *Proc. IEEE Int. Conf. RFID Technol. Appl. (RFID-TA)*, pp. 1-4.
Sep

- Ziai, M.A., John, C.B.
UWB/UHF RFID tag
(2015) *Proc. Loughborough Antennas Propag. Conf. (LAPC)*, pp. 8-10.
Nov

- AlShareef, M.R., Behairy, H.M., Haraz, O.M., Ashraf, M., Alshebeili, S.
A circular monopole antenna with two steps and an offset circular slot for passive UWB-RFID tag localization applications
(2015) *IEEE MTT-S Int. Microw. Symp. Dig.*, pp. 326-328.
Dec

- Cheng, T., Wang, L.-K., Cheong, P., Ho, S.-K., Choi, W.-W., Yang, G.-H., Tam, K.-W.
Design ofUWBchipless RFID tag using microstrip and slot cross-shaped resonators
(2018) *Proc. Int. Flexible Electron. Technol. Conf. (IFETC)*, pp. 1-4.
Aug

- Singh, K.M.J., Mishra, R.
A circular microstrip patch antenna with dual band notch characteristics forUWBapplications
(2018) *Proc. Int. Conf. Power Energy, Environ. Intell. Control (PEEIC)*, pp. 153-156.

Apr

- Sethi, W.T., Ashraf, M., Alshebeili, S., Al-Shareef, M.R., Behairy, H.M.
  Design of dual polarized hybrid LTCC antenna for UWB RFID applications
  (2016) *Proc. 5th Int. Conf. Electron. Devices, Syst. Appl. (ICEDSA)*, pp. 2-5.
  Dec

- Ziai, M.A., John, C.B.
  UWB/UHF RFID tag
  (2015) *Proc. Loughbor-ough Antennas Propag. Conf. (LAPC)*, pp. 1-3.
  Nov

Correspondence Address
Abdulghafor R.; Department of Computer Science, Malaysia; email: rawad@iium.edu.my
Turaev S.; Department of Computer Science and Software Engineering, United Arab Emirates; email: sherzod@uaeu.ac.ae
Almotairi S.; Department of Natural and Applied Sciences, Saudi Arabia; email: almotairi@mu.edu.sa

Publisher: Institute of Electrical and Electronics Engineers Inc.

ISSN: 21693536
Language of Original Document: English
Abbreviated Source Title: IEEE Access
2-s2.0-85104577631
Document Type: Review
Publication Stage: Final
Source: Scopus