

(12) **United States Patent**
Hui et al.

(10) **Patent No.: US 6,501,364 B1**
(45) **Date of Patent: Dec. 31, 2002**

(54) **PLANAR PRINTED-CIRCUIT-BOARD TRANSFORMERS WITH EFFECTIVE ELECTROMAGNETIC INTERFERENCE (EMI) SHIELDING**

(75) Inventors: **Ron Shu Yuen Hui**, Shatin (HK); **Sai Chun Tang**, Yuen Long (HK)

(73) Assignee: **City University of Hong Kong**, Kowloon (HK)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/883,145**

(22) Filed: **Jun. 15, 2001**

(51) **Int. Cl.⁷** **H01F 5/00**

(52) **U.S. Cl.** **336/200; 336/232; 336/223**

(58) **Field of Search** **336/200, 232, 336/223; 29/606, 602.1**

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | | |
|-----------|-----|---------|------------------|---------|
| 3,866,086 | A | 2/1975 | Miyoshi et al. | |
| 4,494,100 | A | 1/1985 | Stengel et al. | |
| 4,510,915 | A | 4/1985 | Ishikawa et al. | |
| 4,613,843 | A | 9/1986 | Esper et al. | |
| 4,748,532 | A | 5/1988 | Commander et al. | |
| 4,890,083 | A * | 12/1989 | Trenkler et al. | 335/301 |
| 5,039,964 | A | 8/1991 | Ikeda | |
| 5,431,987 | A | 7/1995 | Ikeda | |
| 5,502,430 | A * | 3/1996 | Takahashi et al. | 336/232 |
| 5,579,202 | A | 11/1996 | Tolfsen et al. | |
| 5,592,089 | A * | 1/1997 | Danby et al. | 324/318 |
| 5,844,451 | A | 12/1998 | Murphy | |
| 6,023,161 | A * | 2/2000 | Dantsker et al. | 324/248 |

FOREIGN PATENT DOCUMENTS

| | | |
|----|---------------|--------|
| EP | 0 147 499 | 7/1985 |
| JP | 54-110424 | 8/1979 |
| JP | 4-10680 | 1/1992 |
| JP | 6013247 A * | 1/1994 |
| JP | 200111651 A * | 4/2001 |

OTHER PUBLICATIONS

Tang et al., "Coreless planar printed-circuit-board (PCB) transformers—A fundamental concept for signal and energy transfer," *IEEE Transactions on Power Electronics*, vol. 15, No. 5, pp. 931-941 (Sep. 2000).
Hui et al., "Coreless printed-circuit board transformers for signal and energy transfer," *Electronics Letters*, vol. 34, No. 11, pp. 1052-1054 (May 1998).
Hui et al., "Some electromagnetic aspects of coreless PCB transformers," *IEEE Transactions on Power Electronics*, vol. 15, No. 4, pp. 805-810 (Jul. 2000).
Onda et al., "Thin type DC/DC converter using a coreless wire transformer," *IEEE Power Electronics Specialists Conference*, pp. 1330-1334 (Jun. 1994).
Coombs, C.F., "Printed Circuits Handbook," 3rd Ed. McGraw-Hill, p. 6.32 (1998). No month.
Tang et al., "Characterization of coreless printed circuit board (PCB) transformers," *IEEE Transactions on Power Electronics*, vol. 15, No. 6, pp. 1275-1282 (Nov. 2000).
Paul, C.R., *Introduction to Electromagnetic Compatibility*, Chapter 11—Shielding, pp. 632-637 (1992), no month.
Tang et al., "A low-profile power converter using printed-circuit board (PCB) power transformer with ferrite polymer composite," *IEEE Transactions on Power Electronics*, vol. 16, No. 4, pp. 493-498 (Jul. 2001).
Hui et al., "Coreless PCB based transformers for power MOSET/IGBT gate drive circuits," *IEEE Power Electronics Specialists Conference*, vol. 2, pp. 1171-1176 (1997). No month.
Bourgeois, J.M., "PCB Based Transformer for Power MOS-FET Drive," *IEEE*, pp. 238-244 (1994). No month.
Goyal, R., "High-Frequency Analog Integrated Circuit Design," pp. 107-126 (1995). No month.

* cited by examiner

Primary Examiner—Anh Mai

(74) *Attorney, Agent, or Firm*—Merchant & Gould P.C.

(57) **ABSTRACT**

Novel designs for printed circuit board transformers, and in particular for coreless printed circuit board transformers designed for operation in power transfer applications, are disclosed in which shielding is provided by a combination of ferrite plates and thin copper sheets.

5 Claims, 13 Drawing Sheets

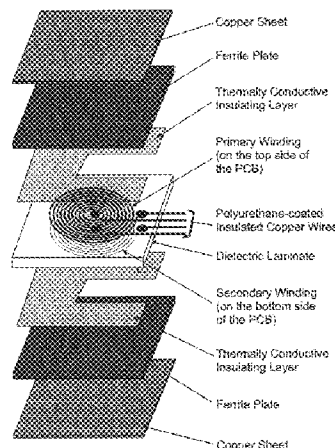


FIG. 1
(Prior Art)

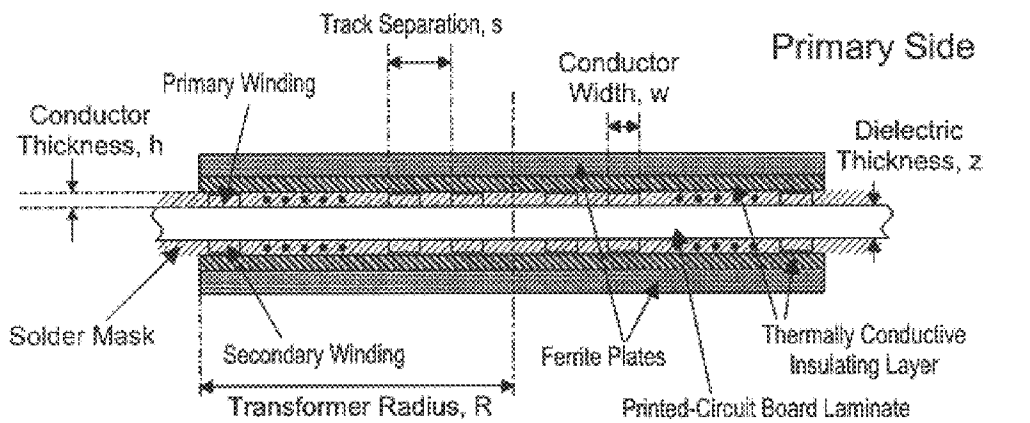
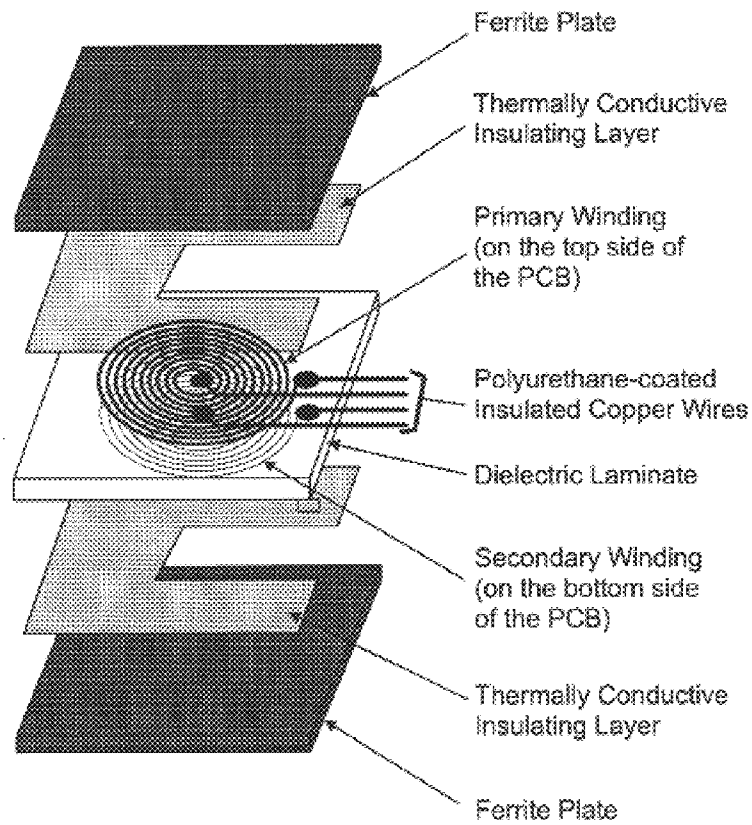


FIG. 2
(Prior Art)

FIG.3(a)

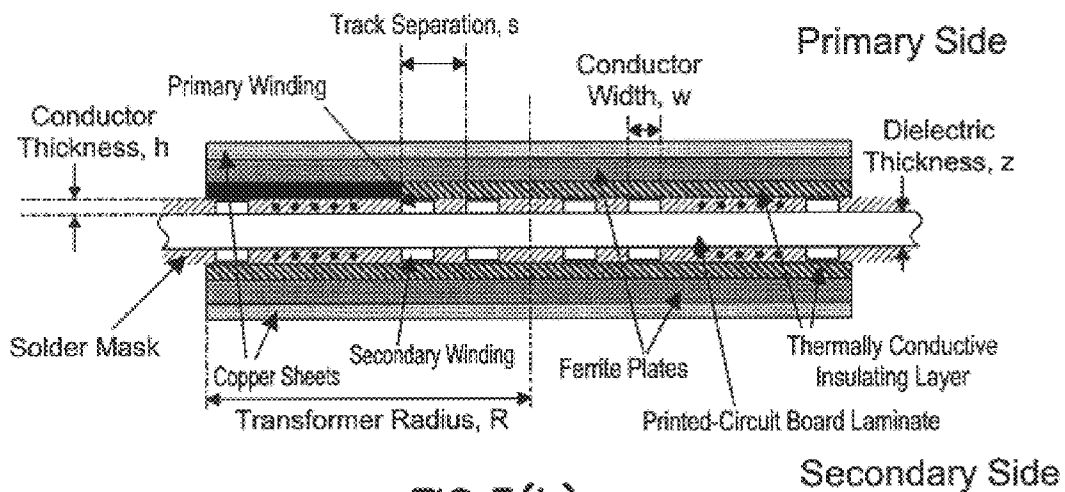
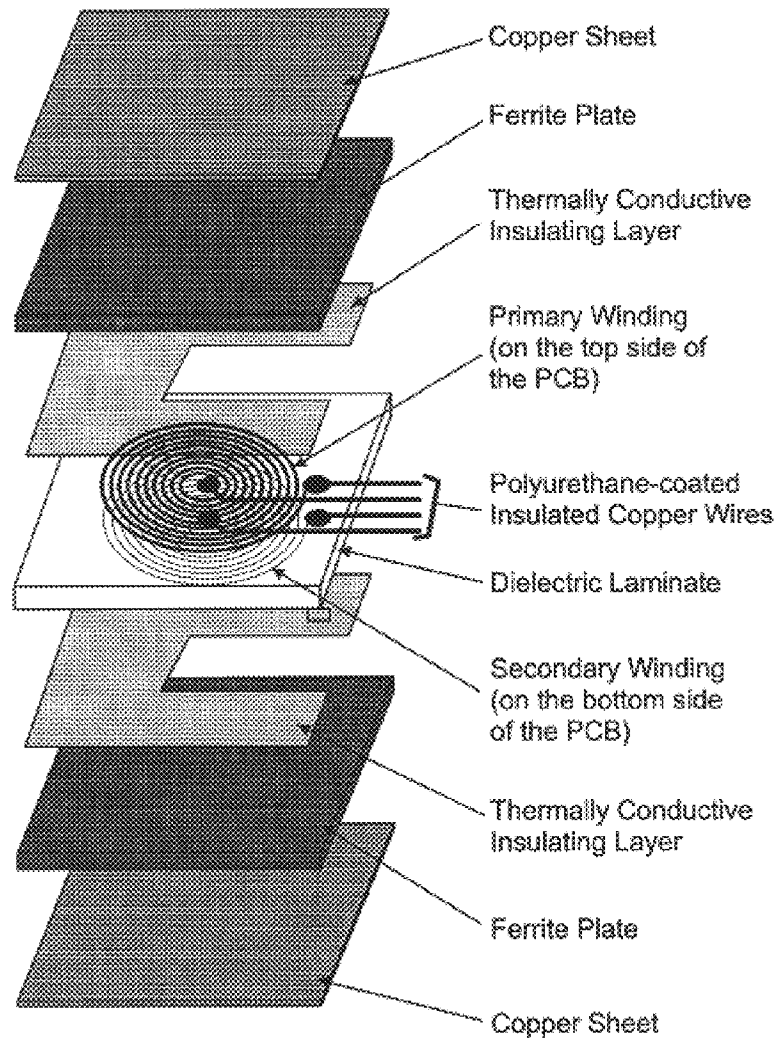


FIG.3(b)

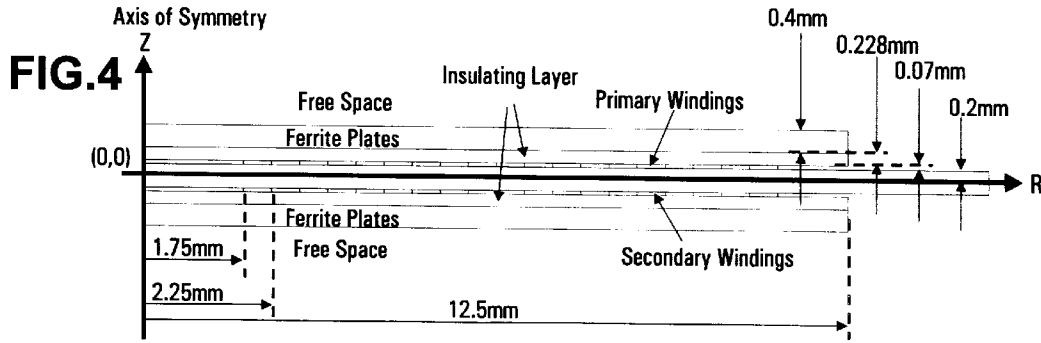


FIG.5

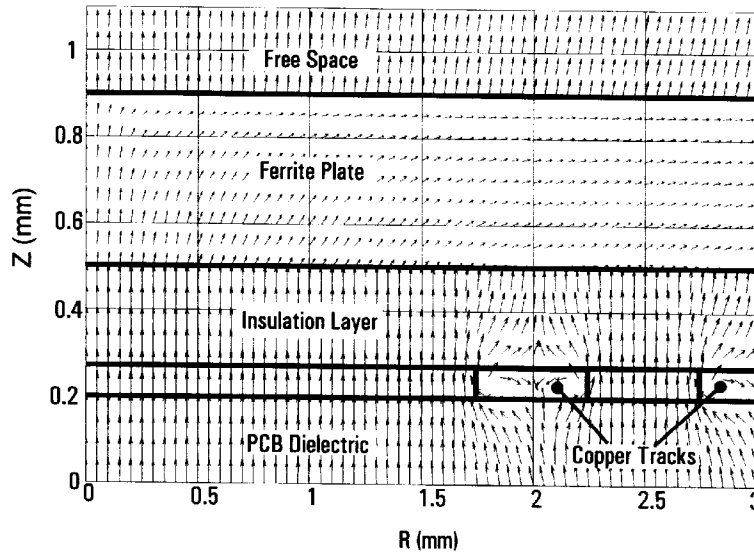


FIG.7

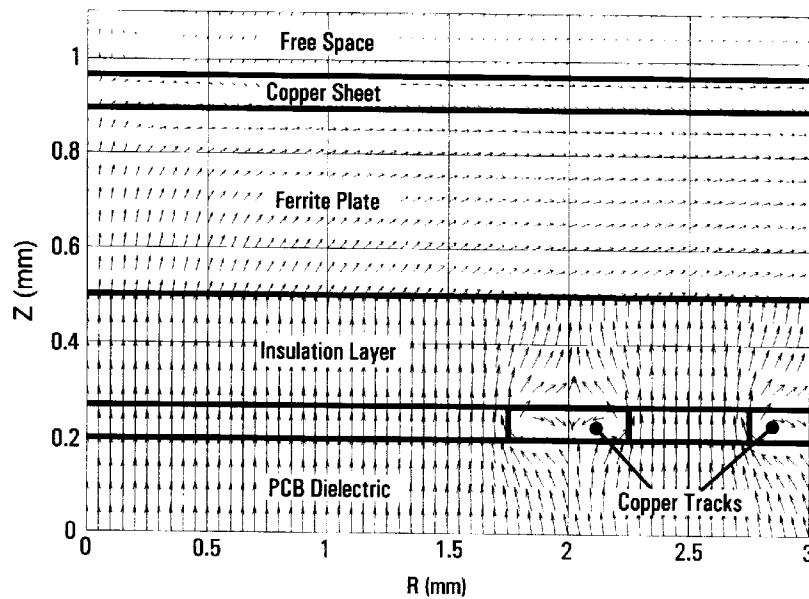


FIG.6

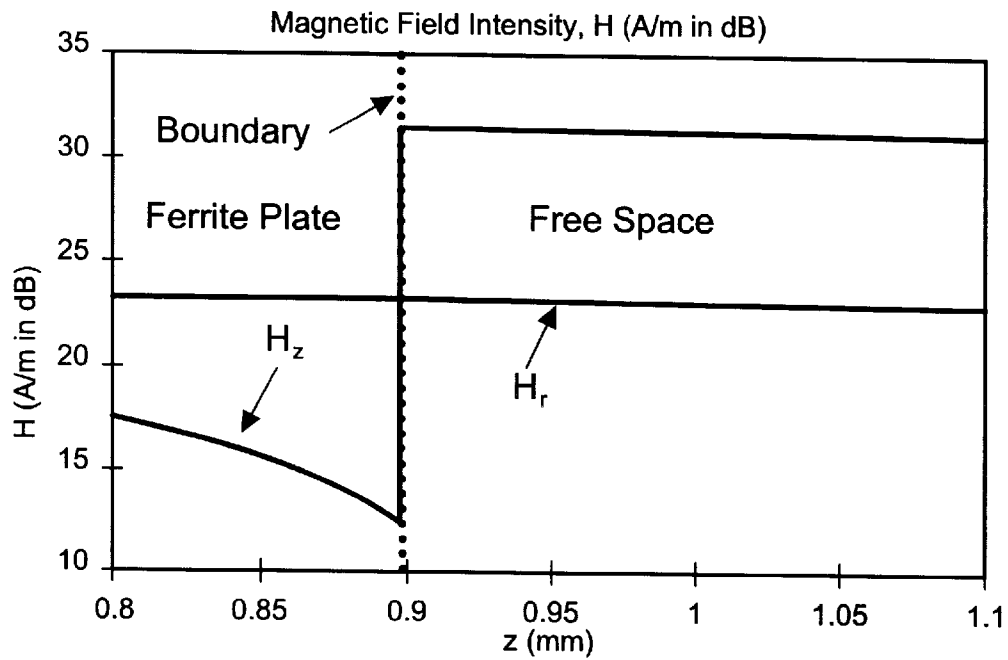
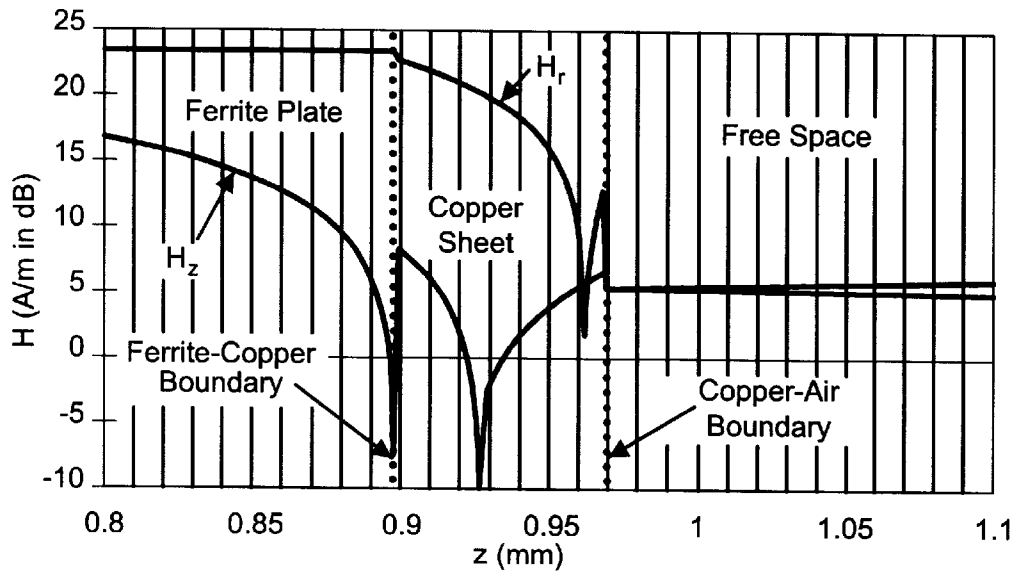


FIG.8



Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.