Recent Progress in Planar Microwave Filter Technology

J.-S. Hong*, Z.-C. Hao*, W. Tang*, A. Miller*, S. Qian*, J. Ni*

*Heriot-Watt University, UK

School of Engineering and Physical Science

Heriot-Watt University

Edinburgh, EH14 4AS, UK

Email: J.Hong@hw.ac.uk

Summary Paper:

This paper aims to review recently developed planar microwave filter technologies, including the follows.

Liquid crystal polymer is a new and promising thermoplastic material. The liquid crystal polymer film has excellent electrical characteristics such as stable low dielectric constant of 3.15 in a wide frequency range and low loss tangent of 0.002-0.004 at millimetre-wave frequency. It has extraordinary barrier properties comparable to that of glass and low coefficient of thermal expansion. Moreover, it also has low moisture absorption. These characteristics make liquid crystal polymer can be used as both substrate and package material. Two types of liquid crystal polymer films such as bonding film and core film are available with different melting temperatures. In fabrication, by controlling fabrication temperature, the bonding film can bond core films together. Thus, it is possible for liquid crystal polymer film to implement multilayer architectures. The cost of liquid crystal polymer (LCP) is comparable to that of conventional print-circuit-board material and is much cheaper than that of Low Temperature Co-fired Ceramic (LTCC). LCP can package both active and passive devices in compact, vertically integrated RF modules using homogeneous multilayer dielectric laminations at a low temperature (about 290 ºC), which would be more challenging for the LTCC technology due to its much higher (~850 ºC) processing temperature. The unique combination of properties makes liquid crystal polymer technology ideally suitable for designing compact microwave circuits and high density system-in-package applications. To this end, several planar ultra-wideband (UWB) filters based on multilayer LCP circuit technology will be presented with both simulated and measured results.

Electronically reconfigurable or tunable microwave filters have attracted more and more attention for research and development because of their increasing importance in improving the capability of current and future wireless systems. To response to this, a new type of varactor-tuned dual-mode bandpass filter has been developed. By employing the unique characteristic of the dual-mode open-loop resonator, that is, whose two operating modes (odd-and even-modes) do not couple, tuning the passband frequency becomes simple with single DC bias circuit. Another novel building block for developing tunable wideband bandpass filters is presented. The proposed circuit block mainly consists of short circuit coupled lines and short circuit stubs with pin diodes as tuning elements. The new concepts of these tunable or reconfigurable filters are verified experimentally.

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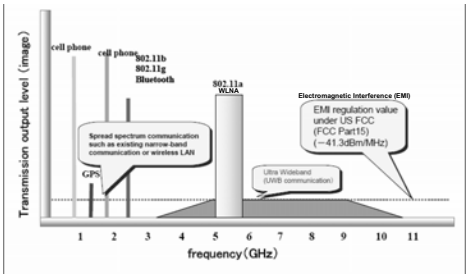
Heriot-Watt University
Edinburgh, UK

Outline

- Introduction
- LCP filters
- Reconfigurable filter
- Summary

Introduction- Filter Technology

RF/microwave filtering technologies are key to controlling the spectrum of RF signals and tackling interference issues



Introduction- Driving forces

Recent development of miniature RF/microwave filters has been driven by applications -

- **Wireless communications**
- **Wireless sensor/radar systems**
- .....

Driven by technologies -

- **High temperature superconducting**
- **Micromachining**
- **LTCC, LCP**
- **Ferroelectric**
- .....

Prof Jia-Sheng Hong, DPhil (Oxford)
Department of Electrical, Electronic and Computer Engineering
Heriot-Watt University, UK
J.Hong@hw.ac.uk
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Challenges-

- ✓Small size
- ✓High performance
- ✓Low cost
- ✓More functionalities - multi-band reconfigurable

Approaches-

- ➢Innovation in filter designs
- ➢Innovation in filter implementations

Prof Jia-Sheng Hong, DPhil (Oxford)
Department of Electrical, Electronic and Computer Engineering
Heriot-Watt University, UK
J.Hong@hw.ac.uk
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Why use Liquid Crystal Polymer (LCP) material ?

1. Low dielectric Loss, Low cost, Lightweight Recyclable material
2. Low water absorption make it stable across a wide range of environments by preventing changes in the relative dielectric constant and loss tangent
3. Near hermetic nature and low moisture permeability which make LCP is suitable for both microwave substrate and package
4. Conveniently laminated films for multilayer structure in system in package (SiP) design
5. Micromachining ability

✓ **LCP is a good choice for developing UWB devices with low cost, low loss, lightweight, multilayer integration and packaging compatibility.**

Prof Jia-Sheng Hong, DPhil (Oxford)
Department of Electrical, Electronic and Computer Engineering
Heriot-Watt University, UK
J.Hong@hw.ac.uk
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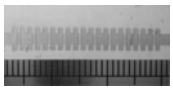
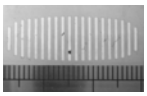
UWB Filter using Multilayer LCP Technology

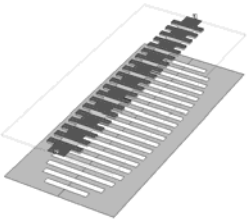
3D structure



(a) top layer



(b) bottom layer



➢The thickness between top and middle layers is 25 μm, and 750 μm for the thickness between middle and ground layers.

Prof Jia-Sheng Hong, DPhil (Oxford)
Department of Electrical, Electronic and Computer Engineering
Heriot-Watt University, UK
J.Hong@hw.ac.uk

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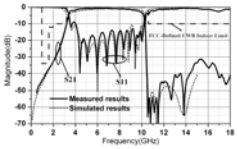
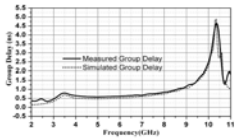
UWB Filter using Multilayer LCP Technology

Measured and simulated results





Prof Jia-Sheng Hong, DPhil (Oxford)
Department of Electrical, Electronic and Computer Engineering
Heriot-Watt University, UK
J.Hong@hw.ac.uk

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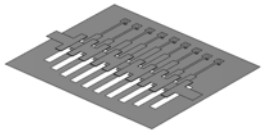
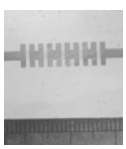
Nonuniform DGS UWB BPF: UWB BPF with Quasi-Elliptic Response

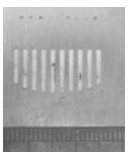


3D Structure of proposed UWB BPF

Photograph for fabricated UWB BPF



Top layer



Bottom layer

Prof Jia-Sheng Hong, DPhil (Oxford)
Department of Electrical, Electronic and Computer Engineering
Heriot-Watt University, UK
J.Hong@hw.ac.uk

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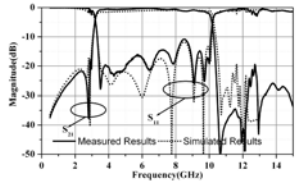
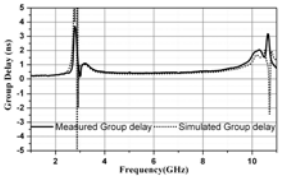
Nonuniform DGS UWB BPF: UWB BPF with Quasi-Elliptic Response

Transmission zeros are designed to improve the selectivity



Measured S-parameter



Measure Group Delay

Prof Jia-Sheng Hong, DPhil (Oxford)
Department of Electrical, Electronic and Computer Engineering
Heriot-Watt University, UK
J.Hong@hw.ac.uk

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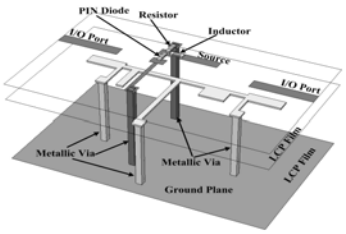
Reconfigurable UWB BPF having switchable notching response using PIN diodes

- **Only 3 components are used in the design, which result in the low power consumption and low cost;**
- **No complicated wideband DC-Bias Circuit;**
- **Small size;**



Prof Jia-Sheng Hong, DPhil (Oxford)
Department of Electrical, Electronic and Computer Engineering
Heriot-Watt University, UK
J.Hong@hw.ac.uk

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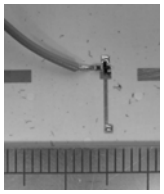
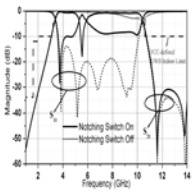
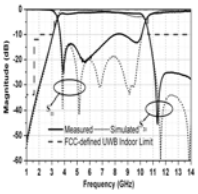
Experiment of Reconfigurable UWB Filter with Switchable Notched Band using PIN Diodes



Photograph of fabricated Filter



Notched Band is Switched On



Notched Band is Switched Off

Prof Jia-Sheng Hong, DPhil (Oxford)
Department of Electrical, Electronic and Computer Engineering
Heriot-Watt University, UK
J.Hong@hw.ac.uk

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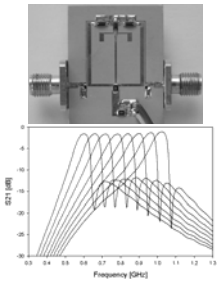
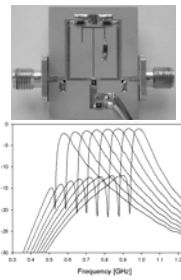
Tunable Dual-Mode Filter





Tuning range=41.5% from 0.6-1.03GHz

3dB-bandwidth=85 ± 5MHz

Tuning range=41.4% from 0.57-0.98GHz

3dB-bandwidth=91 ± 6MHz

Prof Jia-Sheng Hong, DPhil (Oxford)
Department of Electrical, Electronic and Computer Engineering
Heriot-Watt University, UK
J.Hong@hw.ac.uk

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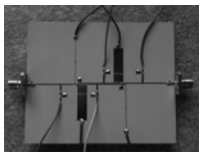
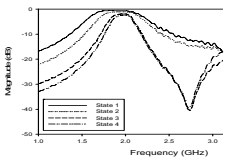
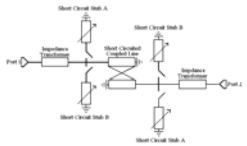
Filter layout with Four Reconfigurable Bandwidth States







	State 1	State 2	State 3	State 4
3-dB FBW	33.50 %	23.23%	14.65%	13.06 %
fo	1.9 GHz	1.94GHz	1.95GHz	1.95GHz
Insertion Loss	-0.62 dB	-1.07 dB	-1.91 dB	-2.5 dB

Prof Jia-Sheng Hong, DPhil (Oxford)
Department of Electrical, Electronic and Computer Engineering
Heriot-Watt University, UK
J.Hong@hw.ac.uk

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Summary

- ✓ Some recently developed microwave planar filters have been described.
- ✓ Driven by applications and emerging device technologies, there are many other microwave planar filters reported in the open literatures, and we will certainly expect more in future.
- ✓ The challenges remain for

➢Smaller size
➢Lower cost

but

➢Higher performance
➢More functionalities

Prof Jia-Sheng Hong, DPhil (Oxford)
Department of Electrical, Electronic and Computer Engineering
Heriot-Watt University, UK
J.Hong@hw.ac.uk

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Reference:

Prof Jia-Sheng Hong, DPhil (Oxford)
Department of Electrical, Electronic and Computer Engineering
Heriot-Watt University, UK
J.Hong@hw.ac.uk
16

Thank you

Prof Jia-Sheng Hong, DPhil (Oxford)
Department of Electrical, Electronic and Computer Engineering
Heriot-Watt University, UK
J.Hong@hw.ac.uk
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