Broadband OMT Design
2009
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Chapter 1
Design Requirements

1.1 Design Requirements

- Operating frequency: 70-87GHz (21.6%)
- Insertion loss: less than 0.5dB
- Isolation: greater than 30dB
- Reflection: less than -20dB

1.2 Commercial Products

○ Quinstar 사에서는 K 대역에서부터 W 대역까지 full band OMT 제품(QOT series)을 판매하고 있음.
○ Radiometer Physics 사에서는 150GHz 대역까지 대역폭 2%인 OMT 제품을 판매하고 있음.
○ Cernex 사에서는 WR-90 (최대 12.4GHz) 도파관 대역에서부터 WR-8 (최대 140GHz) 도파관 대역까지 대역폭 3%인 OMT를 판매하고 있음.
○ Millitech 사에서는 325GHz 대역까지 동작하며 도파관 사용 주파수 대역의 50% 대역폭을 가지는 OMT를 판매하고 있음.
○ 미국 국립전파천문대에서는 밀리미터파 및 서브밀리미터파 대역 전파원기능을 위한 대역 OMT를 개발하고 있음.
Chapter 2
Survey of Broadband OMT Structures

2.1 Type 1 OMT [1]

1) Structure
- Common port: square guide
- Vertical polarization: stepped transition, rectangular guide
- Horizontal polarization: slot coupled, rectangular guide

![Type 1 OMT](image)

Fig. 2.1.1 Type 1 OMT.

2) Performance
-20dB reflection bandwidth: 10.7-13.36GHz (22%)

![Type 1 OMT theoretical reflection coefficient](image)

Fig. 2.1.2 Type 1 OMT theoretical reflection coefficient: solid line = vert. pol., dashed line = horiz. pol.

2.2 Type 2 OMT [1]

1) Structure
- Common port: square or circular guide
- Horizontal polarization: slot coupled, short-circuited by a thin septum
- Vertical polarization: placed in series with horiz. pol. port, slot coupled, short-circuited by a thin septum
2) Performance
-20dB reflection bandwidth: 9.95-13.18 (27.7%)
Isolation greater than 40dB

2.3 Type 3 OMT [1]-[5]
1) Basic structure [1]
- Common port: square
- Horizontal polarization: short-circuited by tapered septum, symmetric sidewall slot coupling, tuning post in the coupling slot, two arms are joined by Y-junction, rectangular guide
- Vertical polarization: stepped height transition, rectangular guide

Fig. 2.3.1 Polarization separation in type 3 OMT.

2) Performance
2.1) Design example 1 [1]

o. Structure

Fig. 2.3.2 Fabricated products of type 3 OMT.

o. Performance

20dB return loss bandwidth: 3.5 or lower to 6.5 or greater (greater than 57.4%)
Isolation greater than 50dB
Fig. 2.3.3 Measured performance of a C-band OMT of type 3. (a) Vert. pol. port reflection and (b) isolation.

2.2) Design example 2 [2]

o. Structure

![Type 3 OMT in WR-10](image)

Fig. 2.3.4 Type 3 OMT in WR-10.

o. Performance

- 20dB return loss bandwidth: 75.5-98.5GHz (26.4%)
- Insertion loss: < 0.4dB (vert. pol.), < 0.2dB (horiz. pol.)
- Isolation: > 30 dB
2.3) Design example 3 [3]

o. Structure

Fig. 2.3.6 Type 3 OMT in WR-42.

o. Performance

20dB return loss bandwidth: 16.6-27.3 (48.7%)

Insertion loss: < 0.1dB (vert. pol.), <0.15dB (horiz. pol.)
Isolation: > 40dB

Fig. 2.3.7 Performance of type 3 OMT in WR-42.

2.4) Design example 4 [4]

o. Structure

Fig. 2.3.8 Split-block type 3 OMT in WR-10. Left: split-block fabrication, Right: septum.
o. Performance

15dB return loss bandwidth: 75-110GHz (37.8%)

Insertion loss: < 0.3dB (both pol.)

Isolation: not given

Fig. 2.3.9 Performance of split-block type 3 OMT in WR-10.

2.5) Design example 5 [4]

o. Structure

Fig. 2.3.10 Type 3 OMT for 250GHz band.
2.6) Design example 6 [5]

o. Structure

Fig. 2.3.12 Type 3 OMT for Ku-band.

o. Performance

Fig. 2.3.11 Theoretical performance of 250GHz OMT.

Performance

20dB return loss bandwidth: 191-284GHz (39.2%)
Fig. 2.3.13 Performance of Ku-band OMT.

(a) Test junction

Fig. 2.3.14 Test junction for Ku-band OMT.

(b) Test junction

Fig. 16. Test junction

(a) Performance of test junction for Ku-band OMT.

(b)
2.4 Type 4 OMT [6]

o. Structure

Fig. 2.3.16 Type 4 OMT.

Fig. 2.3.17 Reflection and transmission coefficients of type 4 OMT.

Fig. 2.3.18 Isolation performance of type 4 OMT.
Chapter 3
OMT Design

3.1 Introduction

- Tools used
  - Microwave Studio (MWS) v. 2009: easy to use and fast
  - HFSS: 3D model input inconvenient, result display requires some labor, boundary setting requires effort, used only for confirming Microwave Studio results.

- Considerations in simulation
  - Initial dimension taken from literature: dimensions directly specified, measure approximate dimension from photos
  - Modify initial structures for fabrication. Rounded corners, exclusion of too thin structures, etc.
  - Optimization from initial dimension: use parameter sweep in MWS, use normal mesh
  - Mesh refinement: only after final optimized dimensions are obtained. to obtain more accurate results
  - Even with best efforts, the final design requires some modification for fabrication especially when the structure is very complicated.
  - Optimize with modified structure
  - Increased insertion loss in fabricated devices is difficult to simulate. Use an imperfect conductor instead of perfect conductor. Conductivity is reduced up to 4 times to include the effect of surface roughness. Losses due to imperfect contact in devices fabricated by split-block method require some ingenuity.
3.2 OMT Design

1) Design of Type 4 OMT (WR-12)

o. Structure

- Common port: circular wg diameter 3.00mm
- Vert. & horiz. port: WR-12
- Stepped transitions are avoided as much as possible
o. Performance

- Reflection less than -20dB at 67.5-90.0GHz
- Isolation greater than 60dB at 67.5-90.0GHz
o. Further work

- Check fabrication difficulties. Modify structure if necessary to ease the fabrication.

- Stepped transitions can be more suitable for fabrication! We have to consult a fabrication specialist.

- Come up with the final design. Refine mesh and get more accurate simulation results.

- Fabricate and measure.

- Prepare test accessories:
  - Test fixture: 3.00-diameter circular guide to WR-12 transition.
  - WR-12 calibration kit.
  - Matched load for 3.00-diameter circular guide.
2) Design of Type 4 OMT (WR-10)

- Structure
  - Common port: circular wg diameter 2.20mm
  - Vert. & horiz. port: WR-10
  - Stepped transitions are avoided as much as possible
o. Performance

- Reflection less than -20dB at 85.0-107.0GHz

- Isolation greater than 60dB at 67.5-90.0GHz
<Results with normal mesh size>

<Results with fine mesh size>
Results with normal mesh size

Results with fine mesh size
Chapter 4
OMT Fabrication

4.1 Summary

o. Fabrication methods
   - Split-block NC machining
   - Injection molding (metal casting)
   - Micro-machining

o. Considerations in fabrication
   - Dimensional accuracy
   - Joining accuracy: guide pin
   - Surface finish
   - Plating: gold, silver
   - Reduction of loss: contacting surface geometry in split-block modules

4.2 Fabrication Examples

1) Example 1 - ALMA 84-116GHz OMT

2) Example 2 - ALMA 211-275GHz OMT
3) Fabrication example 3
Peverini, IEEE, 2006

Fig. 2. Three-dimensional view of the OMT architecture described in the text. (a) Circular-to-square waveguide transition. (b) V-coupling structure. (c) Polarization discriminator. (d) H-coupling structure. (e) and (f) C-shaped junctions. (g) and (h) Rectangular waveguide transformers. (i) and (l) 45° rectangular waveguide twists.
References


