Power Amplifiers for Ku- and Ka-band
VSAT Applications

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Outline

- Introduction of United Monolithic Semiconductors (UMS)
- Ku- and Ka-band high power amplifiers for VSAT applications
  - Motivation
  - Current developments of Ku- and Ka-band HPAs at UMS
  - Packaging concepts for VSAT
- ESA Contract: Low cost 30GHz SSPA
- Conclusions
UMS Company Structure

EADS Deutschland GmbH

THALES (former Thomson-CSF)

50%

UMS Holding S.A.S. (Orsay - France)

100%

UMS GmbH (Germany)

UMS S.A.S (France)

100%

UMS Sales Office (USA)

50%

EADS Deutschland GmbH

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UMS Company Overview

UMS
United Monolithic Semiconductors

- UMS is an independent supplier of GaAs MMICs
- UMS is an open GaAs Foundry
- UMS offers >40 years experience from RF to mm-wave applications...
- … and the largest choice of GaAs leading edge technologies
- UMS has built its success with mm-wave MMICs in the Telecom market
- UMS provides large production quantities on industrial lines
- UMS delivers guaranteed quality products, worldwide
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New microwave and mm-wave applications for the telecommunication and automotive market:

- ku and ka-band VSAT
- 24 GHz short range radar
- others

How to solve?

⇒ Success depends on final cost for RF module

The Chicken - Egg Problem
Module Cost

Point-to-multipoint transceiver module:

Cost for RF modules:
- MMICs (active devices) 30-35%
- other materials 5%
- package / housing 15%
- assembly / manufacturing 20%
- testing and tuning 30-25%

- Material
  - package / housing
  - substrate
  - MMICs and passive devices
  - others

- Assembly / manufacturing
  - die attach
  - wire bonding

- Testing and tuning
  - measurements
  - tuning
  - burn-in

Courtesy of Thales Microwave
26 GHz PTM transceiver module
Motivation

What limits market introduction of mm-wave point-to-multipoint systems?

- Cost for user: equipment and installation
  - ownership model: was too expensive
  - leasing / fee model requires low investment costs
- Content to be distributed: was not available!
  - originally video-on-demand
  - today: broadband / fast internet
- Competition:
  - ADSL
  - Cable TV
  - MMDS
  - VSAT

VSAT power lineup have to be very cheap or will never happen!
VSAT Ku and Ka-band

Frequency allocation for VSAT in Ku and Ka-band:

- VSAT frequencies in Ku-band:
  - Transmit (ground segment): 14.00 – 14.50 GHz
  - Receive (ground segment): 10.95 – 12.75 GHz
- VSAT frequencies in Ka-band:
  - Transmit (ground segment): 29.50 – 30.00 GHz
  - Receive (ground segment): 17.70 – 20.20 GHz

KEY component for VSAT applications is the high power amplifier (HPA)

- Classes of power required for both frequency bands:
  - 1 Watt power amplifier (+30dBm)
  - 2 Watt power amplifier (+33dBm)
  - 4 Watt power amplifier (+36dBm)
- HPAs to be operated in saturation, but are more and more used near $P_{-1}$dB, for linearity raisons (side-lobe re-growth)
VSAT Ku-band

- CHA6042 - PPH25x (3.3mm²): engineering samples
  - $V_{ds} = 9$ Volt / $I_{ds} = 1.0$ A
  - 13.5 - 17 GHz
  - $G_{linear} > 30$ dB
  - $P_{-1dB} > 31$ dBm
- **CHA4042 – PPH25 (2.1mm²):** engineering samples
  - $V_{ds} = 5$ Volt / $I_{ds} = 250$mA
  - $G_{linear} = 15$ dB
  - $P_{-1dB} > 25$ dBm

![Graph showing Gain (dB) and Output power $P_{-1dB}$ vs Frequency (GHz)]
VSAT Ka-band

- Pa-PO9981 – PPH25 (2.47 mm²) : engineering samples
  - $V_{ds} = 6$ Volt / $I_{ds} = 700$ mA
  - 28-35 GHz
  - $G_{\text{linear}} = 18$ dB
  - $P_{-1\text{dB}} > 28$ dBm

![Image of the VSAT Ka-band circuit](image_url)

![Graph of Gain (dB) and Output Power $P_{-1\text{dB}}$ vs Frequency (GHz)](graph_url)

PA-PO9981: $V_d=6V, I_d=700$ mA
HPA Ka-band

Raytheon RMPA29200 29-31GHz
32.5dBm, 12mm²

Fujitsu FMM 5803 X 27-32 GHz
30dBm, 7mm²

UMS CHA5093 28-35GHz
29dBm, 7.7mm²

TriQuint TGA9070 23-29GHz
30dBm, 12.3mm²

UMS PA-PO9981 28-35GHz
29dBm, 2.5mm²

UMS
United Monolithic Semiconductors
DCA ⇔ SMD

DCA = Direct Chip Attach

Packaged MMICs (e.g. SMD)

For volume applications in the telecom and automotive business, production cost must be significantly reduced!

- low cost assembly on standard manufacturing lines
- use of pre-tested components

Courtesy of Thales Microwave
Flange Mount Package

- Standard packaging technology for Ku-band HPA
  - ceramic layer with leads mounted on Cu-composite heat sink
  - MMIC soldered (AuSn) directly on heat sink
  - capacitors incorporated to avoid oscillations
  - standard bondwires can be used

- Advantages:
  - good electrical performance for Ku-band applications
  - excellent heat transfer due to Cu-composite base
  - well know and proven concept (qualified by system houses)

- Disadvantages:
  - volume testing difficult to perform
  - high cost for package (> 10 USD) and assembly (manual lead soldering)

Courtesy of Stratedge
Plastic QFN Package

Example of QFN package

Leadless Plastic Chip Carrier for $f < 20$ GHz
CHA2066 in QFN package

CHA2066 (self-biased low noise amplifier) in ASAT LPCC package

- Results: good performance shown up to 18 GHz
- Improvement possible with modified motherboard (f < 32 GHz)
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ESA Contract: 30GHz SSPA

ESA (AO/1-4166/02/NL/US): Low Cost 30GHz SSPA Development:

- Development of low-cost packaged SSPAs for VSAT at Ka-band
  - 1-Watt output power class
  - 2-Watt output power class

- Consortium
  - UMS, European manufacturer of millimetre wave MMICs
  - TNO-FEL, design centre of microwave and millimetre wave MMICs
  - HYMEC, volume assembly and manufacturing capabilities
Project Flow and Organisation

Phase 1: SSPA module definition and prototyping
- Technology assessment
- MMIC design
- Package
- Processing
- Package assembly
- Test

Phase 2: Manufacturing of preprod. batch
- MMIC redesign
- Package
- Processing
- Package assembly
- Final test

Management and commercial evaluation

project starts in 04/03
duration: 22 months
Conclusions

- United Monolithic Semiconductors is the leading European source for microwave and mm-wave ICs
- VSAT is a volume market requiring low cost components / materials and assembly methods
- UMS has developed several MMICs for these applications
  - HPA for Ku-band VSAT (e.g. CHA6042)
  - HPA for Ka-band VSAT (e.g. PO-PA9981)
  - Size reduction due to advanced design concepts leads to lower cost
- Packaging allows to simplify the assembly and to use pre-tested components
  - Flange mount package with Cu-composite heat sink
  - QFN package
- ESA Contract: Low Cost 30GHz SSPA
Thank you for your attention!