

ITG 2016
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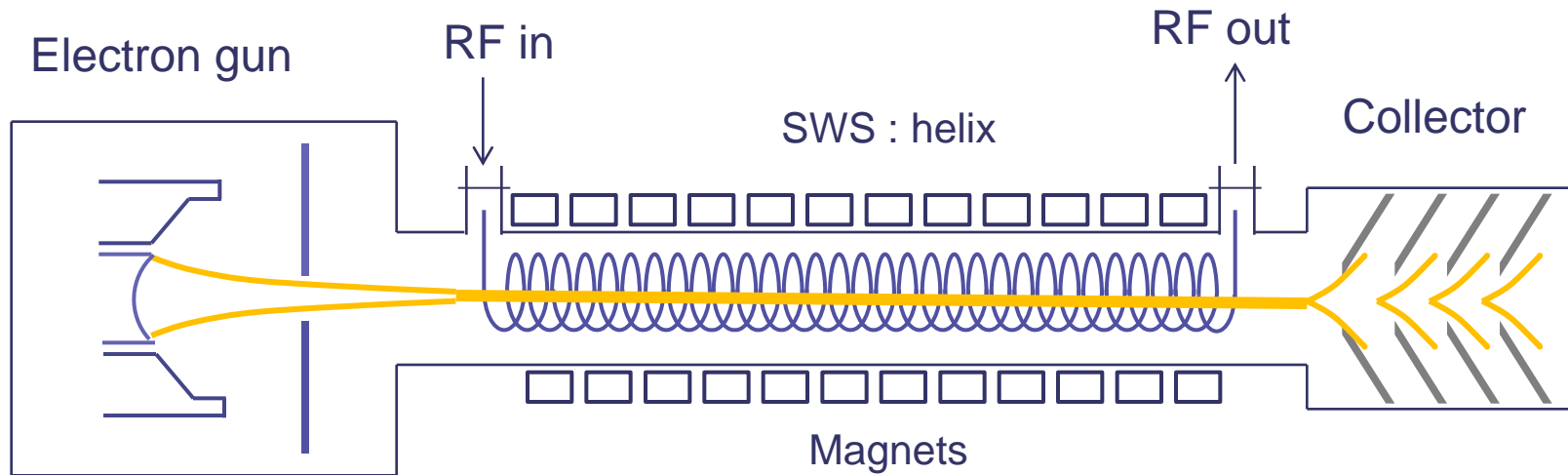
170W Ka Wideband Space TWT

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- Basic principle of operation of TWTs
- Applications of the 170W Ka band space TWT
- Qualification
- Main performance
- Technology
- Electrical performance of the industrial batches
- Measurements of the TWTs in life tests
- Conclusion

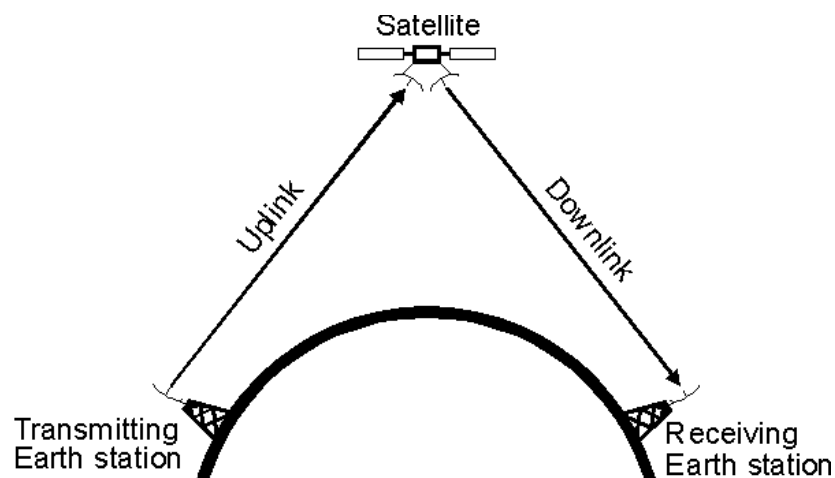
Space traveling wave tube : basic principle of operation



Applications of the 170W Ka band TWT

Communication satellites (downlink)

- HDTV
 - Internet
 - Required lifetime : typically 15 years
- } Require high data rates



TWTs from TED have cumulated more than 500 million hours of operation in space

Qualification

- Goal is to demonstrate
 - The tube feasibility
 - The tube reliability over the required lifetime
 - The compliance between the tube cost and the market requirements

- Successful qualification => authorization to sell the product

■ Model TH4816C conduction cooled TWT

- Full qualification passed in 2013
 - 1 Engineering Qualification Model (Po)
 - Specific Margin Tests
 - Life tests
 - **Production of several tens of units for on-going commercial programs**

■ Model TH4816R radiation cooled TWT

- Full qualification passed in Q1 2015
 - 1 Engineering Qualification Model (Po)
 - 1 Flight Model (Po+5%)
 - 1 Margin TWT (Po+10%)
 - Specific Margin Tests
 - Life tests

Qualification based on the most severe specifications of our customers

Engineering Qualification tests

Tubes tested under representative space environmental conditions

➤ Mechanical tests

- Vibration (to simulate rocket launch)
- Shock (to simulate solar panels deployment)

Test	Level		Remarks
	TH4816C	TH4816R	
Vibration (Sine)	25g		On three axes
Vibration (Random)	19.7grms // 30.2grms ⊥	17.7grms // 31.1grms ⊥	3mn by axes
Shock	2000g		On three axes

➤ Thermal vacuum tests (to simulate environmental temperatures)

		TH4816C	TH4816R
Base plate temperature	Storage	-35°C/+95°C	
	Cold start	-35°C	
	Operating	-15°C / +90°C	
Shroud Temperature	Operating & non Operating	-180°C/+130°C	

■ Goal : raise the confidence in the design reliability

■ Many different tests

➤ Power tests

- Output power capability at $P_o + 10\%$
- Delay line dissipation capability at 2 times nominal RF power

➤ Insulation tests

- Gun and collector sub-assemblies qualified at 10kV

➤ Mechanical tests

- High vibration level : random envelope level for 6 mn
- Pyroshock : 3500g

➤ Tests in case of misuse operation

- TWT attenuator dissipation capability
- Operation with High base plate temperature
- Overdrive capability

➤ Cycling tests

- TWT thermal cycling : to reproduce daily transitions
- High voltage on/off transients
- RF transients

Conduction Cooled 170WKa TWT

Model TH4816C TWT

- Frequency Bandwidth 17.3-21.2GHz

- Useful bandwidth up to 2.9GHz

- Output power from 140 to 170W

- Global Efficiency 63% over 2.9GHz

- Gain : 48-56 dB

- Noise Figure : 35 dB max

- Phase-shift :

- 55° if 2.9GHz BW

- 45° if 1GHz BW

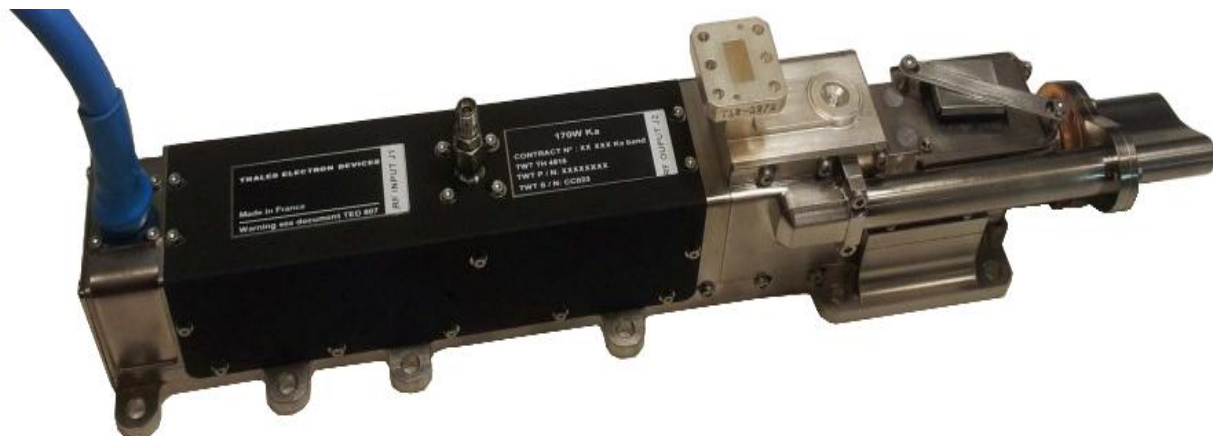
- Input port : Type K-coax

- Output port : WR51

- Dimensions

- 34.5 x 6.3 x 6.6 cm

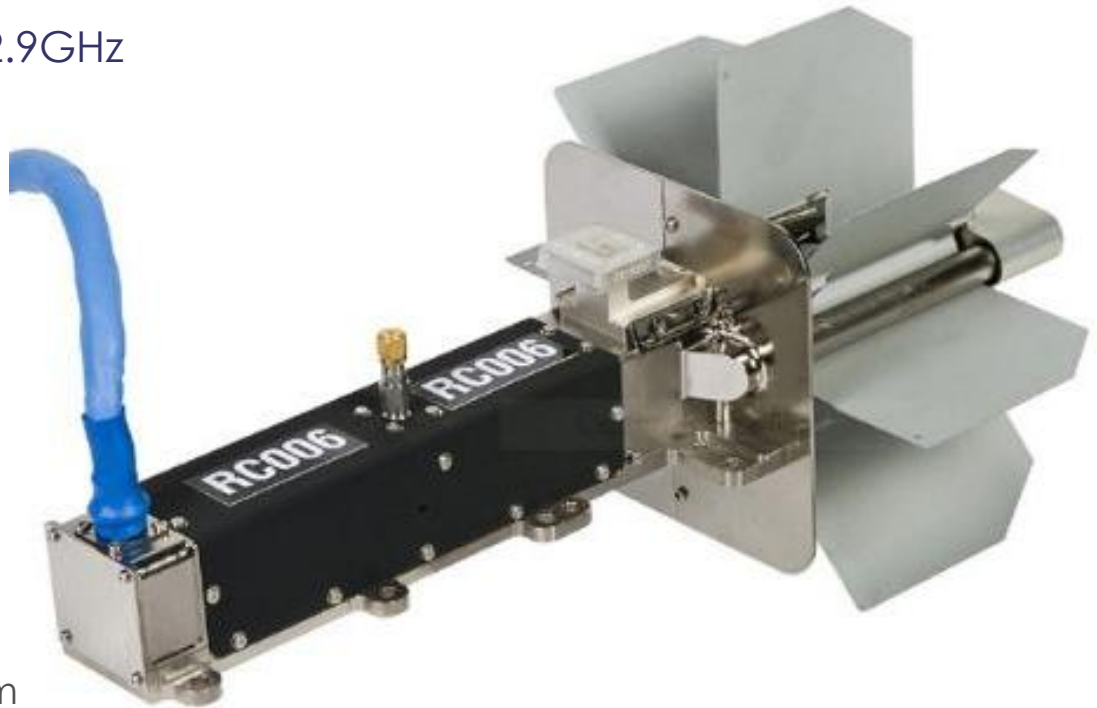
- Mass : 890g



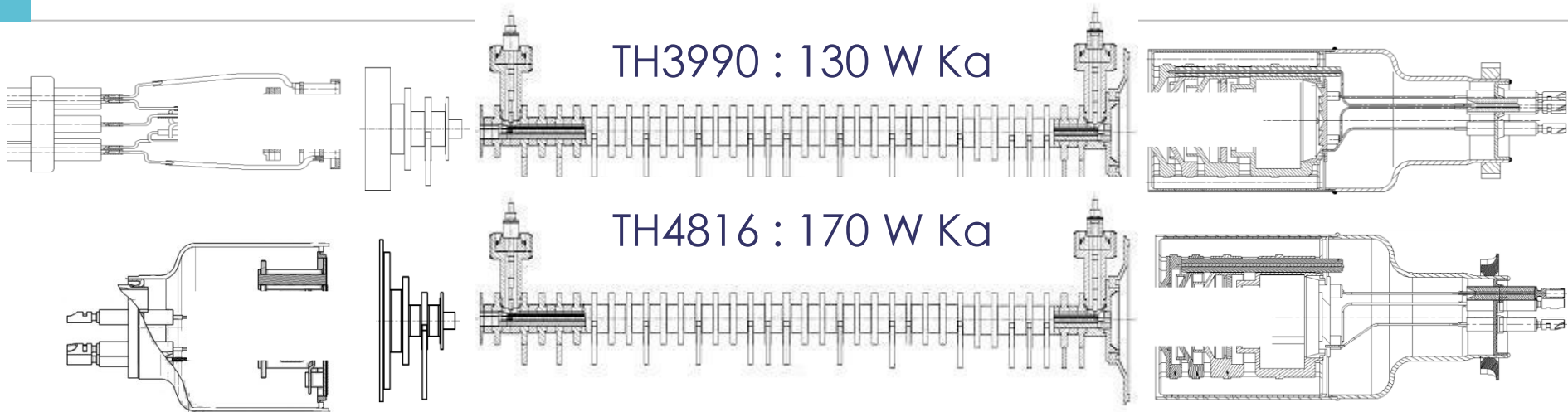
Radiation Cooled 170W Ka

Model TH4816R TWT

- Frequency Bandwidth 17.3-21.2GHz
 - Useful bandwidth up to 2.9GHz
- Output power from 140 to 170W
- Global Efficiency 63% over 2.9GHz
- Gain : 48-56 dB
- Noise Figure : 35 dB
- Phase-shift :
 - 55° if 2.9GHz BW
 - 45° if 1GHz BW
- Input port : Type K-coax
- Output port : WR51
- Dimensions
 - 33.0 x 6.5 x 9.1 cm
 - Radiator diameter*: 18.5 cm
- Mass : 1200g



From TH3990 to TH4816



	TH 3990 (130W Ka)	TH 4816 (170W Ka)
Type	Radiative or Conductive	
Gun	Metallic envelop	
Delay line	Helix	Helix : same technology with optimized dimensions
PPM stack	Same dimensions	
RF output	Waveguide on coax connector (housing)	
Collector	Shrunk collector	

Sub-assemblies dimensions optimized to keep same margins as TH3990

TH3990 technology used to keep heritage

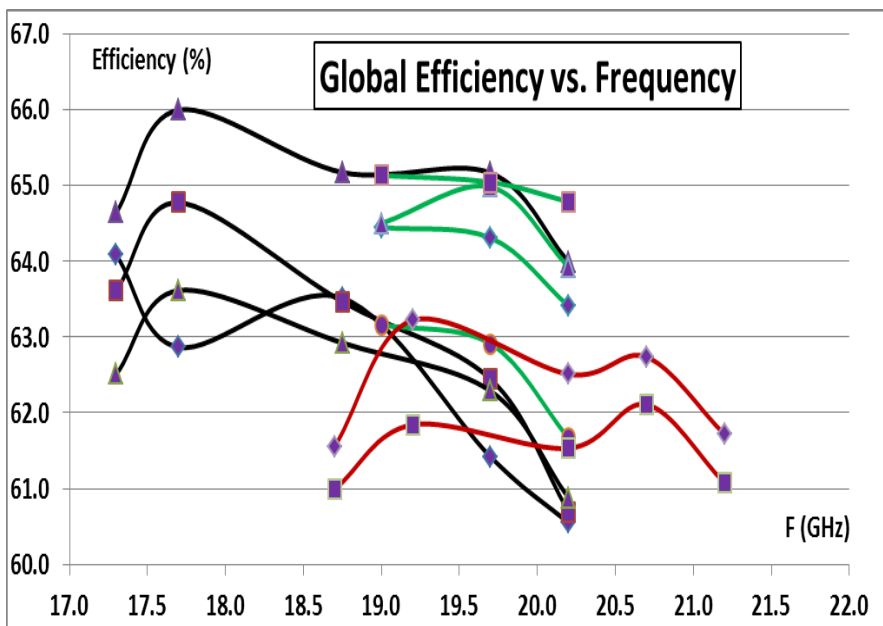
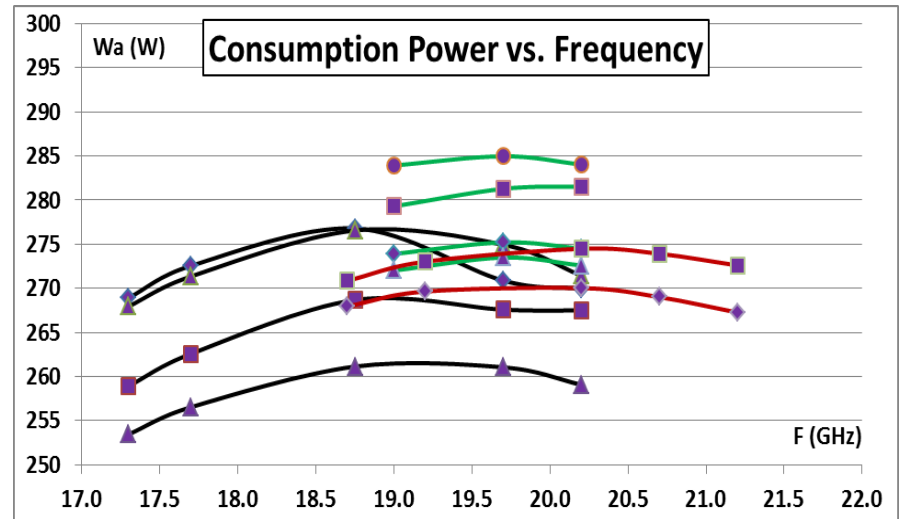
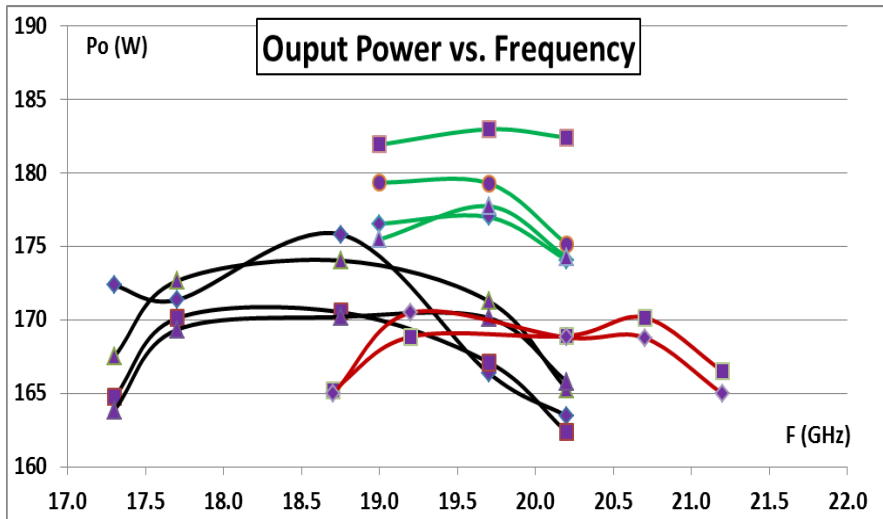
Electrical Interface over wide bandwidth

Parameters	Unit	Typical Value	
		TH3990	TH4816
Po min	W	120	160
Vh	V	6600	7300
Ik	mA	75	93
Vc1	V	3600	4000
Vc2	V	3000	3200
Vc3	V	2250	2400
Vc4	V	750	900
Ion Barrier	V	160	160
Wehnelt	V	-5	-5

Paired units will be delivered on on-going commercial projects

- Preseries performed with CC & RC versions
- TH4816 tuning time identical to TH3990
- Same criteria for acceptance test as for TH3990
- Parameters stability survey in burn-in
 - Cathode activity
 - Insulation
 - Helix current
 - RF performances

Typical RF performances obtained on industrial batches



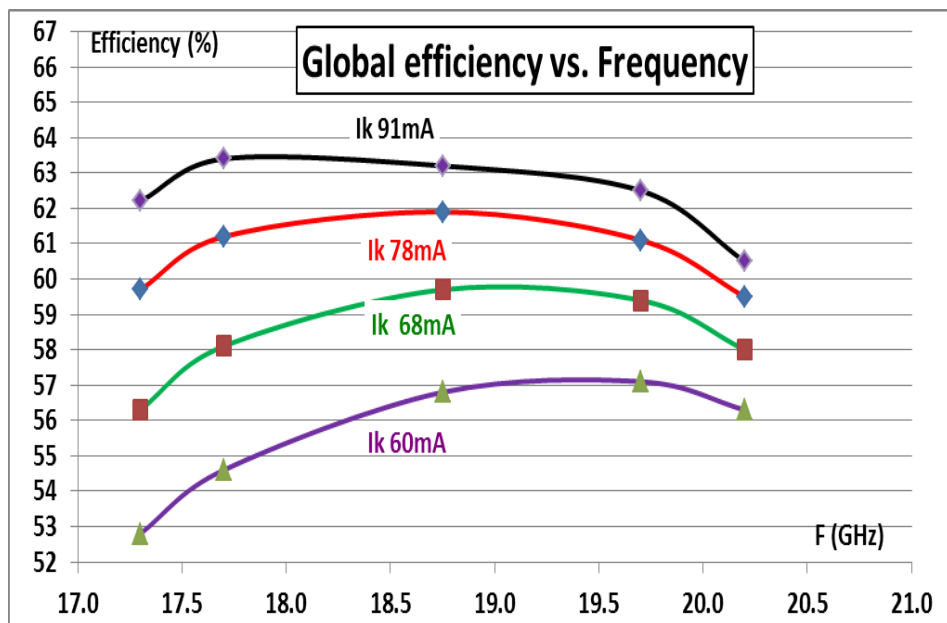
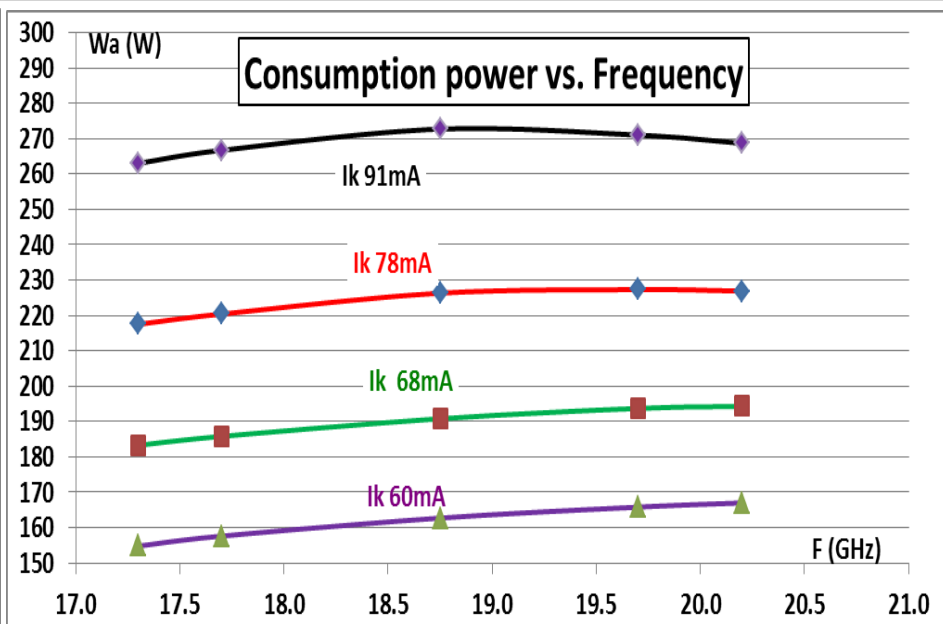
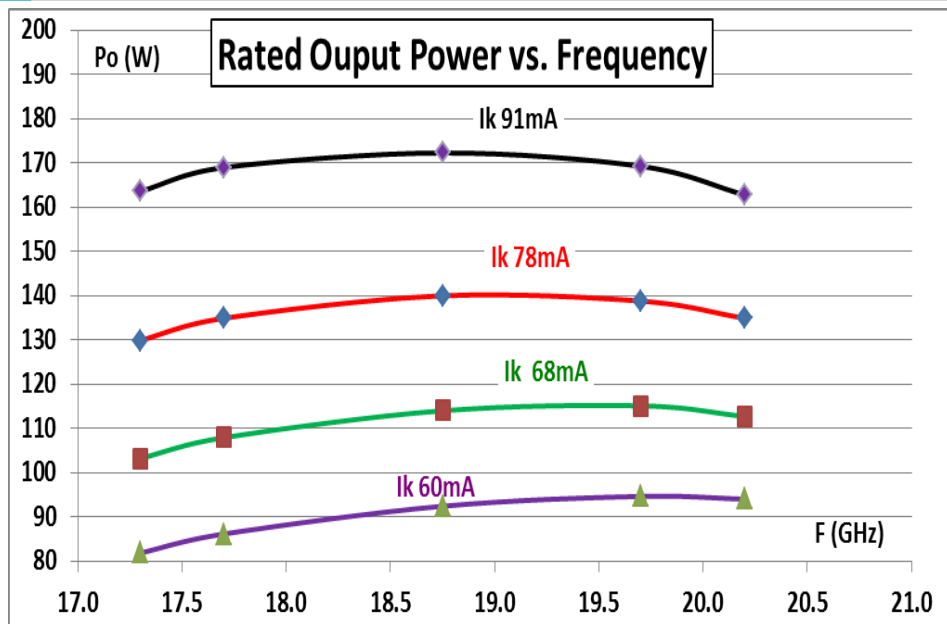
Over 2.9GHz

- Minimum output power 160W
- Maximum DC power 280W
- Small Signal Gain variation 2dBpp

Below 2GHz

- Minimum output power 170W
- Maximum DC power 285W
- Small Signal Gain variation 1.5dBpp

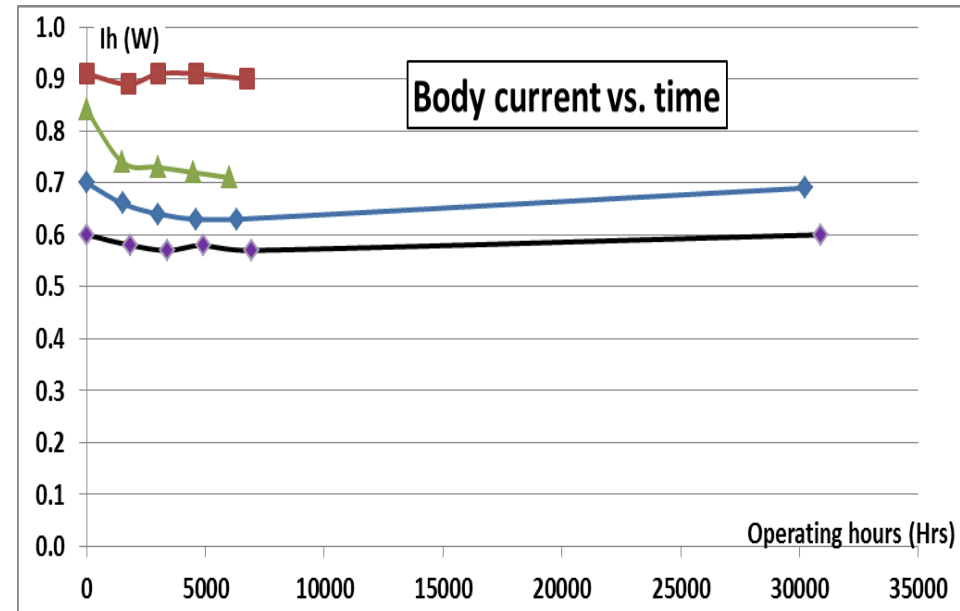
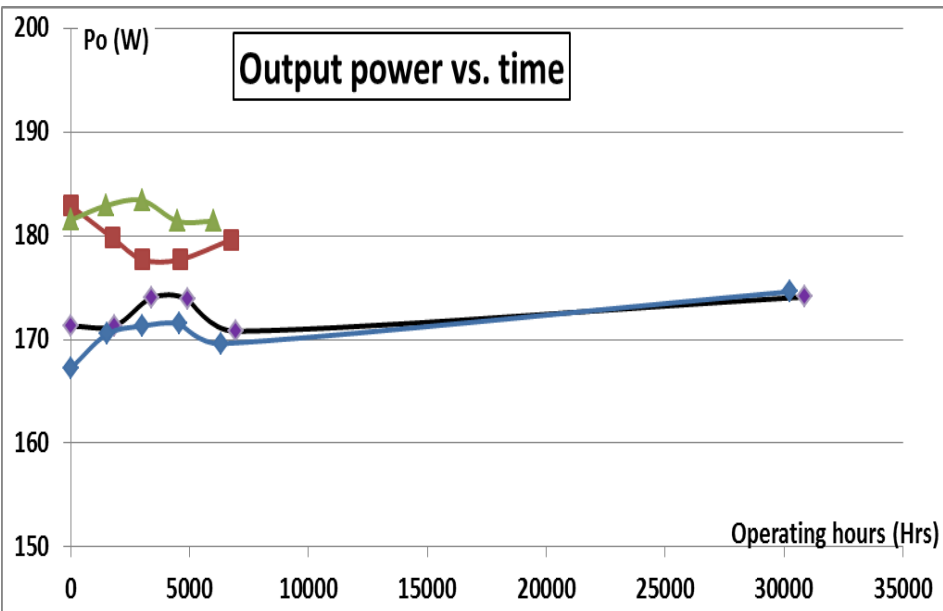
TH4816 flexibility over 2.9GHz



High Flexibility

Lifetest results 1/2

Lifetests running on TH4816 TWTs

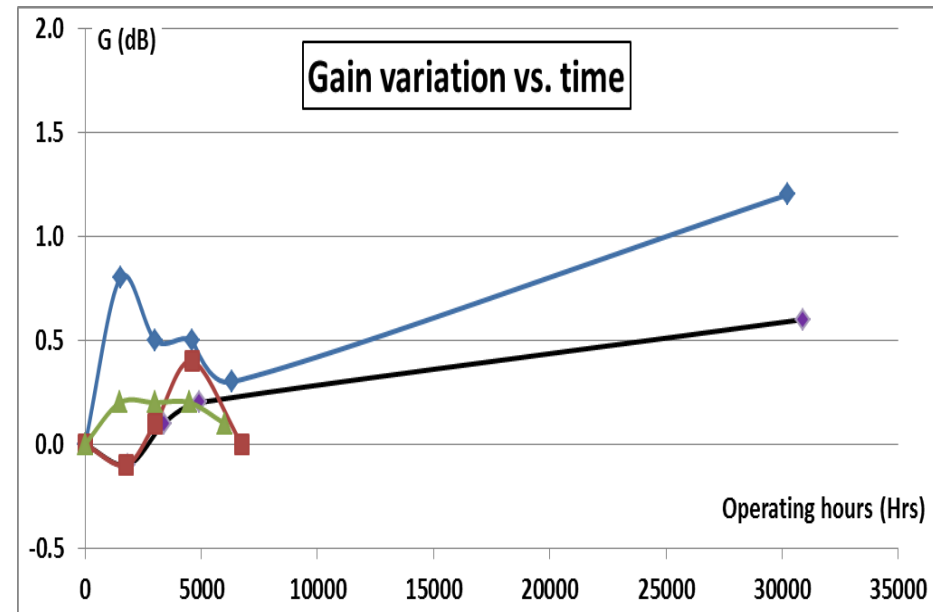
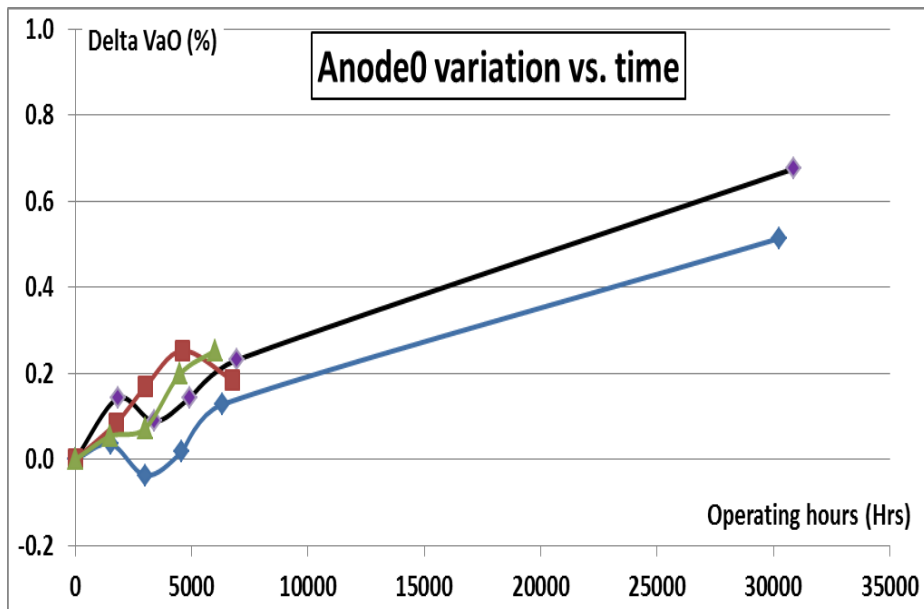


High stability of output power vs. time

High stability of body current vs. time

Lifetest results 2/2

Lifetests running on TH4816 TWTs



Anode0 voltage variation compatible with 15 years lifetime

Low gain variation

■ To support the trend toward high power satellite systems, TED :

- Has qualified a conduction cooled version, TH4816C
 - Has qualified a radiation cooled version, TH4816R
- } of the 170W Ka wideband space TWT

■ TH4816 is based on the proven TED technology

■ Industrial batches showed :

- Good behavior over time at each step of production
- Compliance to all TED space production criteria

Several tens of TWTs already awarded for Geostationary Satellites

Thank you for your attention

