A hybrid wideband amplifier module for digital CATV networks with the BGD902

Application Note AN98109

INTRODUCTION

Today's wideband CATV networks transform into a huge information highway system, including analog and digital TV channels, telemetric signals, telephone and multimedia services and Internet access.

The trend is to use higher frequencies and incorporating digital transfer. The trends for increasing information density and higher bandwidth for information transport demand higher performed CATV semiconductor devices.

Therefore, Philips Semiconductors developed a new CATV hybrid module - the BGD902. This BGD902 CATV module (a 900 MHz module) delivers the performance that is demanded by the future multimedia coaxial networks. It is equipped with silicon bipolar transistors, virtually always used in broadband applications such as CATV amplifiers. This technology enables excellent modules with extremely good characteristics, especially for the demands of the future digital CATV networks.

WIDEBAND HYBRID MODULES

A simplified version of a typical wideband amplifier is given in Fig.1.

The first transformer balances the input signal V_i and takes care of impedance matching for maximum power transfer to the inputs of the transistors. The output of the push-pull amplifier, yielding low second order distortion, is fed to the output via the output transformer.

A biasing circuit sets the DC current of the transistors which is normally rather high to minimize the third order distortion d3. The emitter resistors linearize the behaviour of the device by which the distortion has been improved, while some feedback via a RC network is applied to reduce distortion even further.

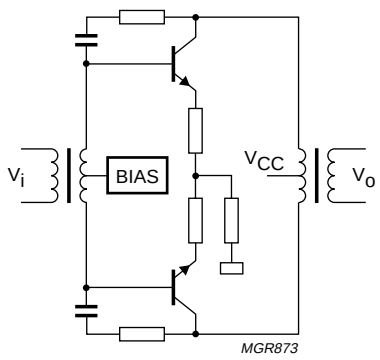

Fig.1 Simplified wideband module.

Many improvements are applied such as applying darlingtons or transistors in a cascade configuration or using a two-stage cascade configuration to obtain higher gains.

Although the basic circuit looks relatively simple the final design in all its details is rather complex with tuned correction networks, carefully designed transformers and the very fine geometric bipolar transistors, optimized for use in CATV amplifier modules.

The most important characteristics of wideband amplifier modules are the following:

- Gain, frequency range, flatness (linearity of the frequency characteristic) and slope
- Second order distortion d2 or CSO
- Third order distortion d3 or CTB
- Cross modulation (X_{MOD}) at a given output voltage V_O
- Input and output reflections (return losses S_{11} and S_{22})
- Noise figure
- Current consumption.

Normally trade-off exist between many of these parameters. Improving one of them may effect another one negatively, so carefully designing these modules is an art in itself.

THE DEMANDS FOR FUTURE MULTIMEDIA NETWORKS

Especially for the multimedia CATV networks of tomorrow, it is very important to invest into the right solutions. For such systems, the planned lifetime is about 15 to 20 years. Therefore, it is necessary to choose high quality components that will survive the environment hazards that reduce the performance of a CATV hybrid both long-term and short-term. The most important influences are:

- Temperature (decreases CTB values at high output levels)
- Surge pulses (may damage, the transistor dies in milliseconds)
- Overvoltage (may damage, the transistor dies instantaneously)
- Quality aspects of the hybrids.

Other important parameters that have a major influence in the performance of future digital transmission in CATV networks are:

- CTB performance, especially at high temperatures, high channel loading and sloped conditions
- Flatness; very important for transmission of linear signals and to decrease failure rate of digital signals
- S_{11} and S_{22}; especially for digital signal transmission one of the parameters that could have big influence on the signal quality.

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Philips Semiconductors, as a major player in the CATV hybrid market, has a long experience in designing circuits for highest technical performance and for longest lifetimes. By deciding for the right mix of quality and technical performance of a CATV module we developed the BGD902, the module for future multimedia CATV networks.

COMPARISON OF MAIN PARAMETERS FROM SEVERAL EXISTING WIDEBAND MODULES FOR CATV APPLICATION

This section compares some commercially available state-of-the-art wideband modules using different technologies. Philips Semiconductors' BGD902, the new high performance 900 MHz power doubler is compared to a US made bipolar competitor (called Si. 2) and to a GaAs using MESFETs of Japanese origin.

For reference, a specification summary with all essential characteristics is shown in the Table 1.

Table 1

PARAMETER	CONDITIONS	BGD902	Si. 2	GaAs	UNIT
Frequency range	$f_{MIN} - f_{MAX}$	40 to 900	40 to 860	50 to 860	MHz
Gain	f_{MAX}	19 to 20	19 to 20.5	18.5 to 20.0	dB
Slope	$f_{MIN} - f_{MAX}$	0.4 to 1.4	0 to 1.5	0 to 2.0	dB
Flatness		0.6	1.0	1.0	dB
CSO	110 channels; V_O = 44 dBmV	–61.0	–62.0	–59.0; note 1	dB
CTB	110 channels; V_O = 44 dBmV	–62.0	–62.0	–59.0; note 1	dB
X_{MOD}	110 channels; V_O = 44 dBmV	–63.5	–63.0	–59.0; note 1	dB
Noise	$f = f_{MAX}$	8.0	8.0	7.0	dB
I_{DC}	typical	420	400	355	mA

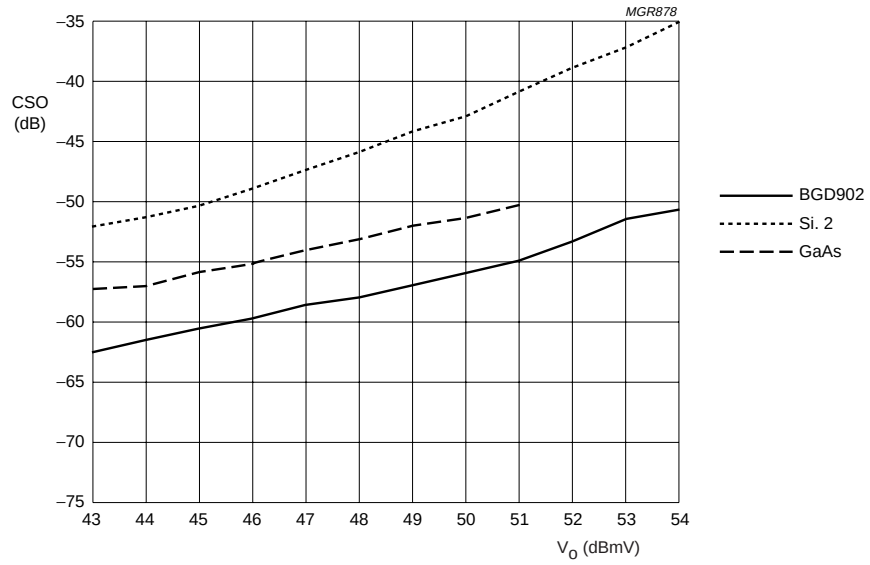
Note

1. Not specified, calculated back from tilted conditions.

Measurement results

Figures 2 to 8 show the test results of extensive measurements on a multitude of products, set up in our development laboratories.

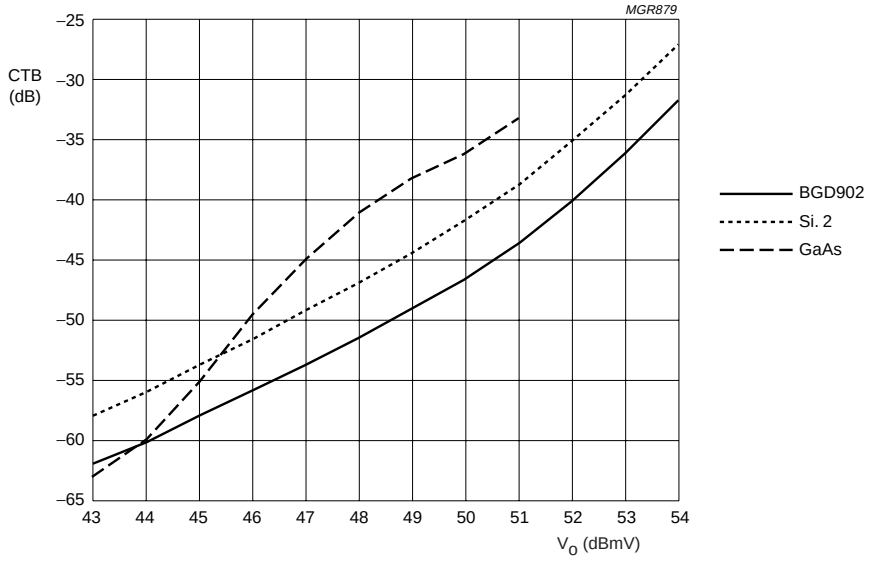
Distortion at various levels of the output voltage



Average value at 860.5 MHz.

Tested with 129 channels, it appears that at high output voltages BGD902 is unbeatable for CSO. One competitor is around 2 dB worse, the other around 4 to 5 dB.

Fig.2 CSO/129 channels (dB) as function of V_O (dBmV).



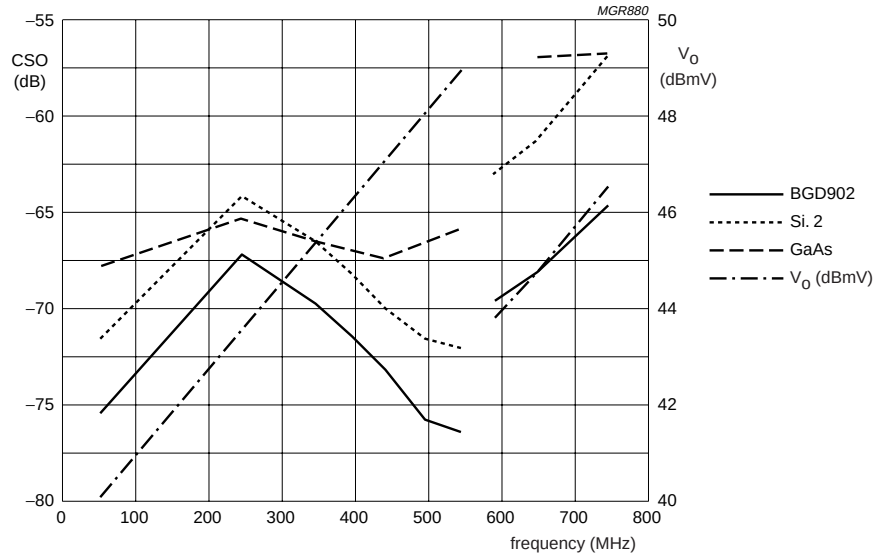
Average value at 859.25 MHz

CTB for 129 channels is best for BGD902 especially at higher output voltages.

Fig.3 CTB (dB) as function of V_O (dBmV).

CTB, XMOD and CSO as function of frequency under tilted conditions

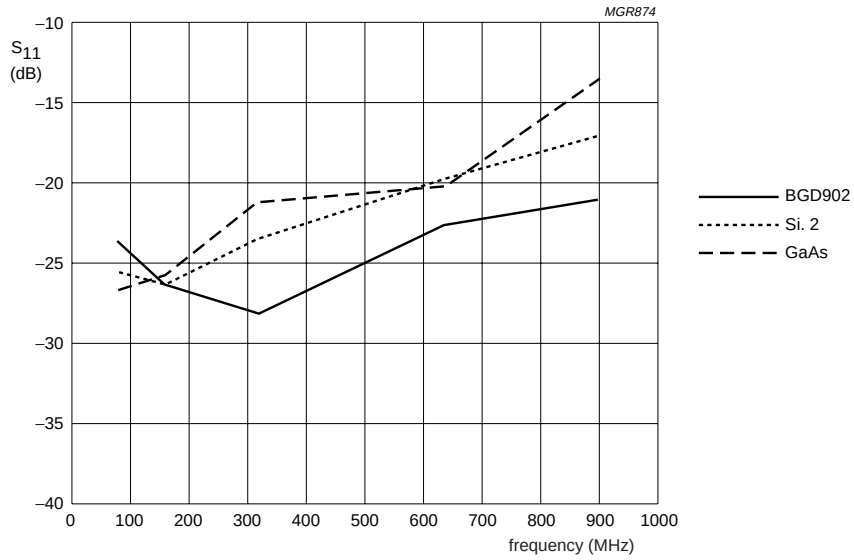
Figure 4 shows the performance for a channel distribution which is partly analogue (f < 750 MHz), partly digital (750 to 870 MHz). Due to the built-in cable loss correction, the input voltage, given as a thin black line in Fig.4, rises as a function of the frequency ('sloped' or 'tilted' conditions). The required output voltage for digital is less as is shown in Fig.4. Clearly, the BGD902 outperforms the competition; the silicon devices are in this case better than the GaAs one.



Mean values at 9 dB tilt.

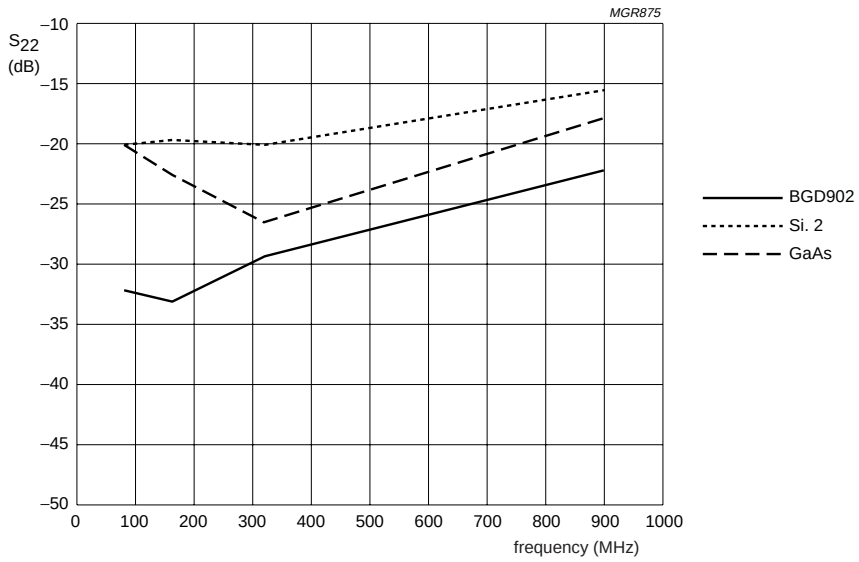
Fig.4 CSO (dB) and V_O (dBmV) as a function of frequency.

S_{11}/S_{22} as function of frequency



The input reflection S_{11} underlines the excellent performance of BGD902.

Fig.5 S_{11} as function of frequency, mean values.

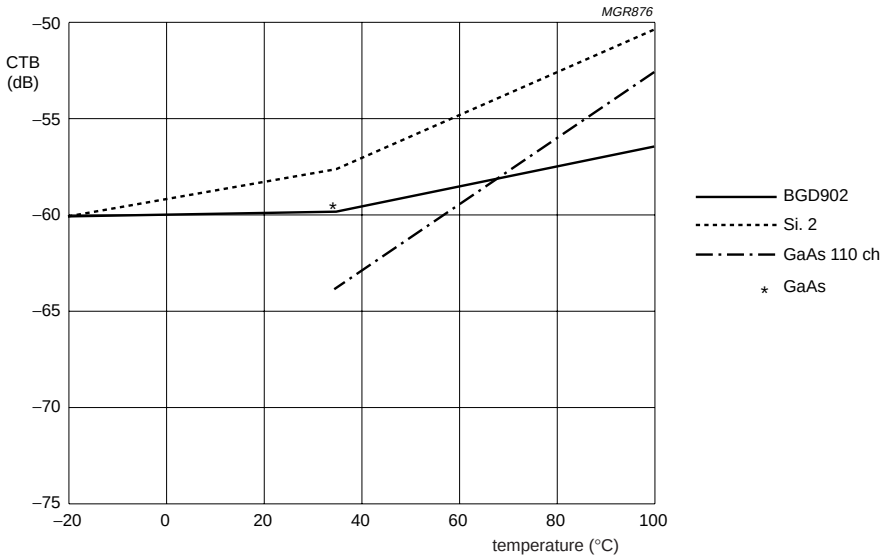


Clearly, the BGD902 is the leader in output reflection.

Fig.6 S_{22} as function of frequency, mean values.

Temperature dependency

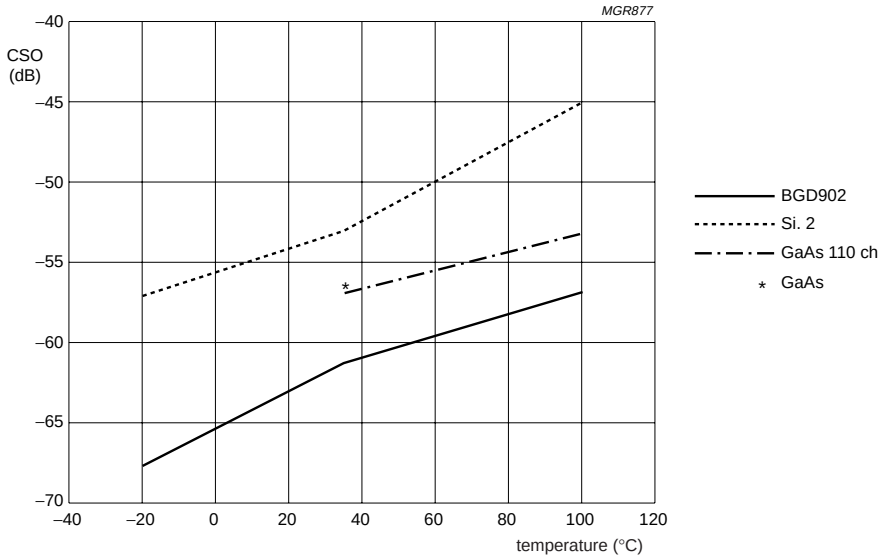
Figure 7 shows the temperature dependency of CTB. It shows a very big effect on GaAs distortion by temperature changes. Its 35 °C behaviour may be OK, at higher temperatures it degrades seriously. Both its high temperature behaviour and its temperature dependency are doubtful.



The temperature graphs show the performance of GaAs at 110 channels (only one test point is available for 129 channels). Silicon devices were all tested at 129 channels.

Mean values V_o = 44 dBmV.

Fig.7 CTB (dB) as function of temperature.



Mean values (V_O = 44dBmV).
This figure shows the excellent behaviour of the BGD902 over temperature on CSO.

Fig.8 CSO (dB) as function of temperature.

SUMMARY

The advantages of the BGD902 - achieved by the properties of state-of-the-art silicon devices - are clearly given and show the big improvements in overall performance of this new developed CATV hybrid amplifier when compared to some other state-of-the-art hybrid modules. The BGD902 is the basis for the entree into the digital millennium, a time with higher channel loading and more coaxial bandwidth that will let multimedia become a ‘virtual reality’.