Gunn Diode Oscillator Minutes

David Headland

2003-10-16 14:00

Attendance

- Fourth year students
  - DP Headland
  - RE Irwin
  - AJ Nelms
  - R Wan
  - JM Higginbotham
  - MP Gaskill
- UMIST staff
  - WS Truscott
  - R Sloan [Arrived 14:45, Left 14:47, Arrived 15:05]

Announcements

- An inaccuracy in the attendance list was discovered in the minutes for 2003-10-14.
- The address for the paper R Wan found for negative differential resistance oscillators was provided.

Time plan

- The time plan was discussed with the group and the project directors.
- It was suggested that the design time for the single diode oscillator was too optimistic. It may be acceptable if the design was based around an existing oscillator, but research time would been to be added. This was decided as the preferred was of creating this prototype, as it avoids potential mistakes calculating output power, Q values, impedance, etc.
- Time for researching designs should be scheduled in.
- WS Truscott liked the inclusion of holidays as buffer time in case of slippage.
- R Sloan liked the general time plan design.
- The timing of writing the interim report was questioned. The new order decided upon was:

    1. Body.
    2. Introduction.
    3. Summary.
    4. Executive summary.

- WS Truscott expects the executive summary to be a one-page bullet-point summary of the whole project.
- The summary should be prose, explaining the project.
- The structure is not fixed to the example given at the project introduction.
- The executive summary start should be altered to depend on the completion of the summary.
- WS Truscott commented that based on past experience, few groups had working hardware to demonstrate at the first presentation. This is acceptable (but should not be planned for), but it is probably not a good idea to plan showing hardware into the presentation. "We planned x but couldn't because y happened" may not provide a positive impression.
- It was decided that a further week should be added to the single circuit design.

- Test can be broken into sections, with each testing session followed by an analysis section.
- As measurements are taken and graphs are drawn, it may be that new figures are needed for other graphs. This can result in new testing phases being required.
- We may need to schedule a test session after the first presentation to implement suggestions provided by third parties.

Circuit Testing

- If diodes are damaged in a waveguide, the diode can be replaced.
- In a planar circuit, the process is not that simple.
- For a planar circuit, multiple PCBs should be manufactured at once to help in the testing process.
- Bread board prototyping is not possible because of the short wavelengths involved.

Low frequency development

- 20 GHz waveguides can be made in the workshops.
- A 20 GHz design was suggested as a good starting point.
- In theory, for a waveguide system, changing the size of the waveguide by $\frac{1}{n}$ results in an n times frequency increase.
- Measurement equipment is present in UMIST for up to 140 GHz.
- If we started with a high frequency design and accidentally produced a system with double the expected frequency output, be would not be able to measure it.
- There may not be any devices in the UK capable of measuring 300 GHz microwaves.
- Industrial practice is to develop at around 20 GHz then extend the ideas to higher frequencies.

- We may practically aim for a working 20 GHz output, along with an extended 90 GHz design.
- e2v's single 80 mW 90 GHz device is probably a one-off device. We should concentrate in using commercially available Gunn diodes and *use power combining.*
- MP Gaskill presented a paper describing dual power combining of Gunn diodes in detail.

Further time plan discussions

- Many marks are available for the demonstration.
- The time usage for the interim report and presentation should be recorded and used as a basis for re-building the time allocation for the final demonstration.

Practical investigation

- The bias investigation section would be helped by having commercially available oscillator circuits to work with. WS Truscott will try to organise this.
- Planar circuits formed from dual sided PCBs can be produced by PCB services in 2 days off-peak.
- Time should be schedules for practical investigation of existing circuits.
- The planar equivalent of existing waveguide circuits could be simulated as part of the microwave simulation lab sessions.
- The back of a waveguide is a short circuit.
- Arranging for a Gunn diode in a planar circuit to be the same number of wavelengths away from a short circuit as it would be from the back of a waveguide should produce similar results.
- R Sloan suggestions getting hold of some Gunn diodes and trying to practically make oscillators as a good accompaniment to written theory.
- All measurements should be checked for validity for the first few simulations.

Microwave measurements

Power	The heat produced in a resistor is measured accurately. The resistor is heated electrically, and as the microwave energy is dissipated in the resistive load, the electrical power is reduced to maintain a constant temperature. This reduction should be equal to the power output of the microwave generator.
Spectrum analysis	Power is measured at each frequency within a defined range. The target is to have a single peak at the target oscillation frequency.
Vector network	Vector network analysis feeds power down a 50Ω coaxial cable, measuring the reflected and transmitted power as a function of frequency. The outputs are the magnitude and phase of reflected and transmitted power. From this, inductance, capacitance and resistance can be calculated, as transmission line impedance is equal to $\sqrt{\frac{L}{C}}$.

Scattering parameters

- S (scattering) parameters are used by microwave engineers to define microwave systems:

$$\begin{aligned} B &= SA \\ \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} &= \begin{bmatrix} s_{11} & s_{12} \\ s_{21} & s_{22} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} \end{aligned}$$

so

$$\begin{aligned} b_1 &= s_{11}a_1 + s_{12}a_2 \\ b_2 &= s_{21}a_1 + s_{22}a_2 \end{aligned}$$

Where the indices of s_{nm} represent input (n) and output (m) terminals. To measure forward and reflected waves, a directional coupler is used. One can be designed in the simulation lab. Assuming the reflection coefficient is defined as:

$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0}$$

Assuming $a_2 = 0$:

$$\left.\begin{array}{lcl} b_1 & = & s_{11}a_1 \\ b_2 & = & s_{21}a_1 \end{array}\right|_{a_2=0}$$

so $s_{11} = \frac{b_1}{a_1}$ is the reflection coefficient and and $s_{21} = \frac{b_2}{a_1}$ is the gain.

- We are only dealing with a one-port device, which simplifies the matter by only dealing with the reflection coefficients.

Microwave simulation lab

- The simulation will take place in E16.
- Later the group decided that Tuesday 21 October at 10:00AM would be a good time.
- Check results for validity – circuits with impedances in the range of 20–200Ω can be produced by PCB services.

Further time plan discussions

- The time plans should be kept updated online.
- The time line will move across to show progress.
- Slips can be calculated, and corrective action such as increasing man power can be taken if required.
- Adding man power resources should be considered as the project progresses.

Microwave oscillator seminar

- Friday 25 October in C53 at 12:00.
- Light lunch will be provided.
- It was suggested that we may find it interesting and useful to attend.

Resonant caps

- Resonant caps are small discs placed above Gunn diodes.
- They effectively provide two resonant circuits.
- The cap tunes the frequency of oscillation.
- The paper provided by MP Gaskill provides information on how this is combined with a system whereby part of the power from one diode is fed to the other and vice versa to lock the oscillation frequency.
- Tuning the output power to be as large as possible without affecting the oscillation is a major part of this project.
- There is no planer equivalent of the resonant cap.

Miscellaneous

- LyX and LaTeX for Win32 CDs were distributed.
- No name ideas were presented.
- It was agreed that the name and logo need to be catchy.

Proposed actions

All	Research the subjects assigned at the end of the meeting. Summarise any research, including pros, cons and reasoning. Copies should be made available to the rest of the group.	
	JM Higginbotham	Waveguide circuits..
	DP Headland	Phase locked loops and injection locking.
	RE Irwin	Waveguides and microstrips.
	MP Gaskill	Power supplies.
	R Wan	Diode biasing.
	AJ Nelms	GaAs vs. InP.

DP Headland	Install LyX, LaTeX and related packages in our lab workspace computer.
DP Headland	Mail R Sloan with the proposed time for the microwave simulation lab.
DP Headland	Make discussed changes to the time plan and publish the new copy.
DP Headland	Add link to the information on NDR oscillators as provided by R Wan.
All	Find circuits to ask questions about.
WS Truscott	Look into the availability of waveguide circuits and testing equipment

Next meeting

Time	Tuesday, 21 October, 09:00
Place	D-floor coffee room

Meeting adjourned, 16:45.