Gunn Diode Oscillator Minutes

David Headland

2003-09-30 09:00

Attendance

- Fourth year students
  - MP Gaskill
  - DP Headland
  - JM Higginbotham
  - RE Irwin
  - AJ Nelms
  - R Wan
- UMIST staff
  - WS Truscott

Project assignment

The project members met initially and were provided with a copy of the project title.

Assignment of roles

The following positions have been provisionally appointed within the project team:

Manager RE Irwin

Auditor MP Gaskill

Secretary DP Headland

Summary of discussions

- Description of the project: to produce a power source using Gunn diodes. They are known to be efficient for frequencies less than 10 GHz, but as frequency increases heat becomes a major problem. Parallel usage is a possibility, but positioning is not trivial.
- Types of resonant circuit with inductance and capacitance
  - Wave guide circuits.
  - Planar microstrip circuits. These will be preferential for mass production due to lower manufacturing costs.
- Suggestion of starting at lower frequencies, to get a working model, then scaling the model to work at higher frequencies.
- Information on the industrial collaborator: Nigel Priestley, e2v Technologies, Lincoln. A site visit will be made during reading week, by which time a good background in the subject is required.
- Major project areas:
  - Heat and heat dissipation.
  - EM fields, modelling and simulation.
  - Power supply, as each diode may require different voltages, which optimum values varying for different power outputs. Sequential starting may be advantages with multiple diodes.

Objectives

DP Headland	Create two mailing lists, one for the project students only, and one for the students, project directors and industrial collaborator.

All	Read journal articles from the list below, along with any other relevant material. Summarise important findings and report back to the group at the next meeting	
	AJ Nelms	IEEE Transactions on Microwave Theory and Techniques, v38, n1, January 1990, pp 86-7.
	R Wan	Semiconductor Science and Technology, v14, n5, May 1999, pp 19-20.
	RE Irwin	Journal of Applied Physics, v39, n8, 15 April 2003, pp 4836-42.
	DP Headland	IEEE Transactions on Microwave Theory and Techniques, v48, n4, pt2, April 2000, pp 626-31.
	MP Gaskill	Solid-State Electronics, v36, n11, November 1993, pp 1547-55.
	JM Higginbotham	IEEE Transactions on Microwave Theory and Techniques, v39, n6, June 1991, pp 1000-9.

Next meeting

Time Thursday, 2 October 2003, 14:00

Place D-floor coffee room

Meeting adjourned, 11:50.

Gunn Diode Oscillator Minutes

David Headland

2003-10-02 14:00

Attendance

- Fourth year students
  - MP Gaskill
  - DP Headland
  - JM Higginbotham
  - RE Irwin
  - AJ Nelms
  - R Wan
- UMIST staff
  - WS Truscott
  - R Sloan

Introduction

All students and the two project directors were introduced to each other.

Web site

- Suggested to set the site up on familiar web space (winterwolf.co.uk is available for this purpose), and link to it from the UMIST web space.

- The HOTFET project used pages on CUS' server.
- Photographs, student biographies and information relevant to the project should be placed here.
- It will be marked aspects such as:
  - Professional appearance
  - Hyperlinking accurately
  - Being up-to-date
  - Accuracy
- It should advertise the quality of the fourth year.
- Could be linked to, for example, on CVs.

Question

Question: Should the site be informative or technical [R Irwin]

- It should be part of each. There should be an interesting and informative at the top level, with links to pages containing more detailed, technical information so the reader can access exactly the information they require.
- A top-down approach should be taken, looking from a system point of view.
- Any interesting and clever aspects should be explained on separate pages, concentrating in why they're particularly clever.
- It should show competence.
- The level of detail should be judged by the group members.

Swipe card lab access

It was suggested that swipe card access to the lab should be set up later that afternoon.

Prizes

- There will be at least two prizes relevant to the project
- Prize from Accenture Consulting for the best links with the industrial collaborator.
  - Suggestion to present information to e2v Technologies at the site visit in November.
- Teamwork prize from UMIST to be announced in early 2004.

Records

- Record keeping is important to provide documentation for prizes, management marking, presentations, etc.
- Accumulate documents to present as the project:
  - The final report, which should not be longer than required to explain the concepts.
  - Appendices containing supporting documentation, so that parties interested in certain aspects can find the correct section quickly.

Appointed positions

- Manager, secretary and auditor positions were announced to the project directors.
- Previous projects required flexibility at certain times as the workload fluctuated. This is also likely to be the case for this project.

Questions

Question: Clarify the target frequency. [R Irwin]

- The target frequency will be 87 GHz.

- Designs for these types of oscillator are often practically lower than in theory, so tuning may be required.
- Designing initially for 96 GHz was suggested, then parameters can be adjusted.

Question: Will we be manufacturing the Gunn diodes? [J Higginbotham]

- Not necessarily. This choice is up to the group.
- If a new packaging method is designed to allow multiple diodes in one package without causing overheating, we can manufacture.
- Existing single devices could be used.

Question: Will e2v help with fabrication?

- They will help with some of the machining if required.
- e2v will prefer planar circuits because of ease of manufacture.
- If new methods, eg. gold plating pasta shells, is found to be better than other methods, it can be considered.

Multiple possibilities

- All possible methods of reaching the goal should be considered.
- Include documentation even for systems that will not be used as proof of consideration.

Recommended research

- Use the first few weeks as time for information pursuit.
- Useful information should be distributed.
  - By hard copy at meeting.
  - In PDF format to the mailing lists.

  - Copyright was considered, but as this is student research this type of pooling would be considered acceptable.

- IEEE Xplore is suggested as a useful source of information. It categorises and allows searches through all IEEE journals, then retrieval of PDF copies.
- Electronic journals are available in the library.
  - IEEE "Electronic Devices" was suggested as a good source of relevant information.
- Will need to know the basic operation of Gunn diodes, but not too in-depth.
- Oscillation circuits are important.
  - How to get it to oscillate at the correct frequency.
  - How to combine multiple oscillators.
  - Why they don't oscillate at different frequencies.
  - How do you get them to oscillate coherently.
- Don't limit research to microwaves. All oscillators are similar.
- Look for synchronisation methods, possibly even down to the level of the National Grid.
- Injection locking, for example for phase locked loops.
- Summary: Although the context is specialised, the methods used could be applicable to many situations.

Help from the directors

- The project directors feel that students researching for themselves is more beneficial then lecturing.
- They will answer any relevant questions presented to them.
- Reverse engineering current solutions is a good idea, but they should not be considered to be the only solution.

- Although other diode types can be used, it's probably useful to stick to Gunns for this project.
- Use IEEE Xplore and look for more generalised papers, such as "The Gunn-diode: Fundamentals and Fabrication".

Overall project aim

- To engineer a solution to a project, to gain skills that can be used throughout life.

Wave guide circuits were shown to the group as a physical example of similar systems.

Project marks

- The constitution of individual and team marks was discussed.
  - A project mark is awarded for overall work.
  - This is multiplied by a number based on individual input to give a student's individual mark.
- Input from students on individual contributions will be taken into account.
- The team can present information on how the group is working at any time.
- It is preferable to sort out our own management, conflict, etc. problems, as we will be credited for that.

Accommodation

- Few people are willing to give fourth year project students lab space.
- The lab next to the coffee room on C floor is available for use.
- Swipe card access will be arranged soon.

- Work will start in there, but there is the possibility of moving elsewhere if required.
- Books available in the coffee room are available for use. Several were suggested.

Question

Question: What is negative differential resistance? [R Irwin]

- Pushing a box over was given as an example. The box resists positively as the centre of mass lies within the base. After this point, the box resists negatively, pulling your hand down with it.
- In an electronic context, as potential is increased, current flow decreases in negative resistance.
- Current will π^{c} out of phase with negative resistance.

Safety

- A safety audit will be required.
- One consideration is cooking eyeballs, as there is no means for them to distribute heat through the blood system.
- Never look down a waveguide, even if it appears to be off.

Timetabling

- Timetabled slots were discussed.
- If the directors are required on a Tuesday, appointments can be arranged by email for 11:00.
- Directors will be present at the 14:00 meetings on Thursdays.

Workspace

- Swipe card system installation was suggested, but Ian Hawkings could not be found, so this was deferred.
- The labs were shown to us, and a workspace was assigned within the lab.
- E16 will also be available for use when it is not otherwise required.

Welcome party

- This is a welcome party for postgraduates tomorrow at 16:00. The group has been invited to attend if desired.

Objectives

DP Headland	Create a further mailing list for just the students and the directors.
MP Gaskill	Research safety with a view to creating the safety audit.
All	Read the provided copy of "The Gunn-diode: Fundamentals and Fabrication" provided by W Truscott.
All	Research any information for relevant to the project. Information should be pooled either in hard copy, or in PDF format on the mailing list. Useful links should be sent to the mailing list, and an online copy will be created and maintained by category. Information on which papers are being research should be posted to the list to reduce duplicated efforts.

Next meeting

Time	Tuesday, 7 October 2003, 09:00
Place	D-floor coffee room

Meeting adjourned, 16:00.

Gunn Diode Oscillator Minutes

David Headland

2003-10-07 09:00

Attendance

- Fourth year students
  - MP Gaskill
  - DP Headland
  - JM Higginbotham
  - RE Irwin
  - AJ Nelms
  - R Wan

Swipe cards

It was agreed that after the meeting we should try to find Ian Hawkings to grant us access to the lab with our swipe cards.

New information gathered

General information

- Several useful papers had been found, and will be mailed to DP Headland for inclusion on the links section of the web site.
- A paper from MDT has been found with uses of Gunn oscillators and resonant circuits.

Device operation

- It was noted that few papers go into detail about the thermal properties and considerations of Gunn diodes.
- Injection locking was found as a theme and should be investigated further as a synchronisation method.
- It seems that in-depth knowledge of the Gunn device is not required. Each person can specialise in a certain area, making sure that the most important information is understood by all.

Circuit types

- Coaxial cavities, waveguides and planar circuits all need to be considered, and the final choice should be qualified in the documentation. We cannot just assume that planar circuits are the best and discount everything else.
- Coaxial cavities only seem suitable for frequencies less then approximately 15 GHz.

Oscillation circuits

- General oscillators have been researched in detail, which has proven to give a good understanding of microwave circuits.
- We will be using the W and F bands, mainly the W band.
- RF power depends on the device's cross-sectional area.
- Frequency is dependant on device length.

GaN Gunn diodes

- GaN provides high RF power levels at high frequencies, but require very efficient cooling methods.
- GaN devices are currently only being made in research quantities.

Combining diodes

- Certain experiments have shown that an arrangement of three diodes provides the greatest efficiency.

Safety audit

- MP Gaskill has experience in creating risk assessments.
- It would be difficult to create one assessment for the whole project.
- It is easier to take each activity and draw up a risk assessment.
- An example form for risk assessment was produced.
- A blank form will be placed on the web site for people to download, print and complete before an activity is started.
- Safety is a major priority.

Mailing lists

- The third mailing list, gunn-umist@winterwolf.co.uk, has been announced.
- All three mailing lists were summarised.

Financial control

- Several possibilities were considered:
  - Mailing MP Gaskill on making any purchase.
  - Starting a book to record all transactions.
  - Relying on statements from stores.
- It was agreed that a book should be started to record all transactions.
- The book will be checked by the auditor against statements and discrepancies can be investigated.

Web site

- Description: until further information is available, this should be based on the objectives sheet and aims memo.
- Biographies: all members were asked to start work on a biography based on the HOTFET site from last year.
- Links: all links will be updated as new ones are provided. Live links will be archived.
- Additional sections: none at present, but should be added as needed.
- An interest in the design of the web site was expressed. It was suggested that DP Headland gives a demonstration after the meeting.

Filing system

- Hard copies of all minutes, agendas, research information and any other document used in the project should be taken.
- Two files should be started:

    1. A research file for all information found during research. This should be indexed by subject.
    2. A file for recording everything else, such as minutes, reports, safety information, costings and presentation resources.

- If particularly useful information is discovered, a short summary should be produced for the benefit of the rest of the group. This could be used as a working document.
- The issue of typesetting vs. word processing was discussed, but the difference was not apparent to many members.
- A comparison will be shown at the next meeting.

November presentation

- Does not have to involve everyone physically presenting.
- Powerpoint was suggested as a display method.
- It should show our current understanding of Gunn diodes, oscillators, etc. and present the pros and cons of methods considered. It should also be considered as an opportunity to ask and relevant questions.
- Practise is essential.

Cruise control application

- Mercedes adaptive cruise control.
- Information may be available from TRW automotive ("TRW Conekt").

Objectives

R Wan	Mail PDF copies of the useful documents to DP headland for inclusion in the links section of the web site.
MP Gaskill	Mail the MDT paper to DP headland for inclusion in the links section of the web site.
AJ Nelms	Research injection locking.
All	Read Nigel Priestley's paper.
DP Headland	Provide a comparison between a word processed and a typeset document.
All	Start creating a biography for the web site.
All	Submit useful links for the web site as and when they are discovered.
DP Headland	Bring in lever arch files and dividers for the filing system.
MP Gaskill	Create a blank risk assessment form and mail to DP Headland for inclusion on the web site.
DP Headland	Update the front page of the web site as discussed.

Next meeting

Time Thursday, 9 October, 14:00

Place D-floor coffee room

Meeting adjourned, 10:33.

- Ian Hawkings could not be found, so swipe card access was not arranges.
- A demonstration of the web site was given in A19.

Gunn Diode Oscillator Minutes

David Headland

2003-10-09 14:00

Attendance

- Fourth year students
  - MP Gaskill
  - DP Headland
  - JM Higginbotham
  - RE Irwin [Arrived 14:20]
  - AJ Nelms
  - R Wan
- UMIST staff
  - R Sloan
  - WS Truscott

Swipe cards

The meeting will be temporarily adjourned when Ian Hawkins arrives in order to obtain swipe card access to the lab.

Approval of minutes

The minutes from the last meeting were approved.

Power combining

- A paper on power combining for oscillation circuits was discussed.
- WS Truscott claims the experiment should not have worked, but did not say why.

Risk assessment

- The risk assessment form was approved.
- The form must be signed by all group members.
- The form must be countersigned by a representative of the university.

Non-GaAs materials

- A paper on using InP Gunn diodes was discussed.
- Power combining at 90 GHz was documented.
- InP is considered to be a superior than GaAs material for high power, high frequency applications.
- GaAs is suitable for frequencies up to approximately 60 GHz.
- Second harmonic mode is required for running GaAs Gunn diodes above 60 GHz.
- A paper on GaN Gunn diodes was discussed.
- They would be useful for very high power, high frequency applications.
- So far, only theoretical experiments have been performed.
- Heat production is likely to be far too high for current heat sinking technology.
- Serious research into using InP diodes was suggested.

Injection locking

- An introduction to injection locking was discussed.
- The paper in question referred to IMPATT diodes, but the injection locking technique should apply to any type of diode.

Group identity

- WS Truscott suggested defining a group identity:
  - Team name.
  - Logo.
  - Mascot.
  - WS Truscott suggested adopting a wallaby, after which we'd be able to "make great leaps".

Inspec

- Inspec was mentioned as a good database of papers.
- The following path should be taken to access Inspec:
  1. Go to the library web site
  2. List of databases.
  3. I
  4. Inspec
- An Athens login is required.
- Boolean searches can be performed.
- Full references are provided, but you must find the material yourself from the reference.
- This is the recommended way of searching academic papers.

Holzman book

- R Sloan does not suggest this book at an in-depth reference.
- It has been suggested as a good introduction.
- It is suggested as a good reference for injection locking.
- J Carroll was suggested by WS Truscott as a good book on oscillators.

Web site

- R Wan was created web site graphics and HTML.
- The HTML is not standards compliant, but looks good.
- The HTML can be sanitised and used as a template for content on the web site.

Planar power combining

- A paper on planar power combining was discussed.
- The idea was praised, but the radiation pattern was considered very bad.
- The preferable method is for manufacture in a coplanar circuit to drive schottkySchottky diodes.
- Quasi-optical methods were mentioned.

Swipe card access

The meeting was temporarily adjourned to get gain swipe card access to the lab.

Heat sinking

- A paper on second harmonic mode IMPATT diode operation was discussed.
- These operate in pulsed rather than continuous wave mode.
- Pulsed operation at target power levels would fry Schottky diodes.
- Heat is again the main problem, and must be sunk quickly.
- e2v may be able to provide custom packaging of Gunn diodes if appropriate documentary reasoning can be provided.
- Ceramic discs can be used with multiple devices mounted on top.
- Discs can be made down to approximately 125 μm thick.
- Sever good heat sink materials were discussed:
  - Copper.
  - Single crystal diamond.
  - Ceramics.
- It was suggested that we could enquire of e2v Technologies what substrates are available for their devices and what the heat dissipation properties of them are.
- Device dimensions are small, down to approximately $10\times10\,\mu$m.
- This is a very small area for lots of power to be dissipated in.
- The metal on the substrate is important in how well the heat will be spread sideways.

Diode similarity

- The issue of whether all Gunn diodes would be the same was considered.
- Vertical structure will probably be the same for all devices from the same wafer.
- Etching may produce diodes with slightly differing areas.

- As the area increases, the current and capacitance increases and the inductance decreases.
- The actual reproducibility is unknown.
- This point could be raised with e2v technologies.
- Differences in the devices must be account for in the theory and simulations.

Simulations

- Simulations will be required at some point.
- Everyone should know how to use the simulation packages.
- ADS or microwave office were suggested.
- Gunn diodes can be treated as AC point sources.
- We must try to combine four whilst maintaining in-phase operation.
- They can be placed in a planar circuit and simulated.
- R Sloan will give a grounding in how to use the simulation software.
- This could be used at an interview as an example of leaning to use an engineering software package.

Circuit simplification

- Most components in the circuit will be linear.
- Gunn diodes and non-linear.
- The impedance of the circuit apart from the Gunn diode can be calculated.
- If the diode is then placed in the equivalent circuit, it should operate in the same manner.
- Power will be radiated in all directions.

- Mirrors at the end of the wave guides must reflect the waves in phase.
- Devices are spaced at a distance of approximately $\frac{1}{2}\lambda$.
- The diodes will have a capacitance, so tuning of the positions may be required.
- They will find their own oscillation frequency if placed at a distance of approximately $\frac{1}{2}\lambda$ from each other.

Device limitations

- It is suggested that the first circuit is designed to output at 20 GHz.
- InP devices should be capable of operation up to 200 GHz.

Time planning

- A timescale must be drawn up.
- Tasks must be defined and split up into components.
- Based on the finishing date, tasks be be placed backwards to find the required start date.
- The critical path can then be found.
- Realistic deadlines must be imposed.
- It is likely that the design must be fixed by the December interim presentation.

Mental manipulation

- On seeing the worried looks of the students, R Sloan and WS Truscott decided that "we should sit here for a further ten minutes and really twist the knife".

Impedance matching

- Sometimes a device will radiate 1 W, but with unusual voltage and current requirements.
- Most impedances realisable will be in the range of 50–100 Ω.
- As an example, to radiate 1 W, 10 A may be required at 10 V.
- Knowledge of the device impedance is therefore required.
- Maximum power is obtained when the impedance of the source and load are equal.

Mounting configuration

- All companies will provide guidelines for mounting
  - From a thermal point of view
  - To provide information when deciding upon combination topologies

Team building exercise

- We should challenge the other teams to something we're good at.
- This will build confidence and trust.

Waveguide power combining

- We may wish to find papers for power combining using waveguides (already completed).
- Waveguides may be used if time is short because of their natural heat sinking advantages.
- A deliverable could be a working waveguide power combining circuit, along with a design that was not meant to be fabricated for a planar version.

Information storage

- Certain items will be kept in our lab space:
  - Financial records book.
  - Borrowing log.
  - Research hard copies.
  - Minutes and agendas.

Proposed actions

All	Any further relevant research.
R Sloan	Copy operation notes on Gunn diodes for distribution.
All	Provide suggestions for a group name, logo and mascot.
All	Provide suggestions for tasks involved and how to split them up, along with times associated with each task. This can be arranged into a draft time plan next meeting.
Sloan, Truscott	Try to find a model of a Gunn diode for ADS.
R Wan	Provide HTML and graphics.
DP Headland	Sanitise the HTML and build into the PHP wrapper to form a new template.
All	Gain Athens access from the Library for Inspec.
All	Provide a hard copy of all useful information found to be filed in the lab.
DP Headland	Package the Win32 version of LyX and dependencies for those who require it.
All	Investigate LyX for Win32 as a typesetting environment.

Next meeting

Time Tuesday, 14 October, 09:00

Place D-floor coffee room

Meeting adjourned, 16:10.

Gunn Diode Oscillator Minutes

David Headland

2003-10-14 09:00

Attendance

- Fourth year students
  - DP Headland
  - RE Irwin
  - AJ Nelms
  - R Wan

Apologies

- Fourth year students
  - JM Higginbotham
  - MP Gaskill

Changes

- An inaccuracy in the adjournment time was discovered in the minutes for 2003-10-09.
- Changes to the risk assessment forms in the form of space for signing were announced.

Reading week presentation

- Should be based upon what we know
- Should precede pertinent questions to e2v Technology.
- Should last 5–10 minutes and be presented by one or two people.
- Ruth does not mind presenting, but does not want to decide without all group members present.

Group identity

- Current no decisions have been made on a group name, logo or mascot.
- This decision has been deferred until all group members are present.

Miscellaneous

- The new structure of the paper filing system was announced.
- A document effectively describing negative differential resistance oscillators was presented by R Wan, and will be made available to the group.
- The offer of CDs containing Win32 versions of LyX and LaTeX was made.
- The CD offer was accepted by:
  - AJ Nelms
  - The group to install the software on the lab computer.

Time planning

- A skeleton task list produced by MP Gaskill was presented.
- Various comments were made on the document:

  - The Monte Carlo simulation needs more research.
  - Documentation and presentations were not present in the main tasks list.
  - The number of marks awarded should be compared to the time assigned to each task.
  - The team self-appraisals were missing from the plan

- Work started on a time plan based on this document. A draft time plan was produced by the end of the meeting.

Proposed actions

All	Any further relevant research.
DP Headland	Correct the adjournment time in the 2003-10-09 minutes.
All	Gain Athens password from the Library.
All	Check the time line for problems and possible changes.
DP Headland	Print off a copy of the draft time plan.
All	Provide suggestions for team names and logos.
R Wan	Provide links to the document of NDR oscillators.

Next meeting

Time	Thursday, 16 October, 14:00
Place	D-floor coffee room

Meeting adjourned, 12:35.

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.

Gunn Diode Oscillator Minutes

David Headland

2003-10-21 09:00

Attendance

- Fourth year students
  - DP Headland
  - AJ Nelms
  - R Wan
  - JM Higginbotham
  - MP Gaskill

Apologies

- RE Irwin

Time plan

- It was decided that a task checklist should be created to be kept updated at UMIST.
- The results from the practical testing of commercial Gunn diode oscillators should be used to help with designing a single Gunn diode oscillator.

Group identity

- Gunn-a-lator was suggested.
  - Combination of the words “Gunn” and “oscillator”.
  - Designed to be catch and grab interest.
  - A corresponding logo was provided.
- The deadline was suggestions was set to Thursday, at which point all suggestions can be presented and a vote taken to choose the name and logo to be adopted.

Research so far

- JM Higginbotham will find various examples of microwave oscillator circuits to discuss at the next meeting with the group members, R Sloan and WS Truscott.
- Waveguide and planar circuit length tuning methods were discussed.
- Power supply parameters were discussed.
  - Variable output between around 5–8 V would be required.
  - Multiple individual variable outputs may be required.
  - The possibility of building or buying was discussed.
  - The facilities of specialised off-the-shelf Gunn diode power supplies are not currently known.
- Data sheets of the Gunn diodes e2v provide are hard to find.
- Previous experiments have shown than the diodes need forward biasing by around 6–8 V.
- Actual biasing requirements have been discovered by trial and error to compensate for slight differences in the diode design and manufacturing processes.
- Synchronisation through phase locked loops and injection locking was discussed.
- Wilkinson power combiners have been used in the past.

Miscellaneous

- A provisional risk assessment for working with microwaves has been drawn up.
- Remote access to IEEE Xplore was discussed.
- The lab session organised by R Sloan will start in E16 at 10:00 this morning.

Proposed actions

All	Continue research into the subjects assigned at the end of last 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	Update time plan to link commercial testing and the single diode oscillator design.	
All	Provide suggestions for a name, logo and mascot for the team.	

Next meeting

Time	Thursday, 23 October, 14:00
Place	D-floor coffee room

Meeting adjourned, 09:45.

Gunn Diode Oscillator Minutes

David Headland

2003-10-23 14:00

Attendance

- Fourth year students
  - DP Headland
  - AJ Nelms
  - RE Irwin
  - R Wan
  - JM Higginbotham
  - MP Gaskill
- UMIST staff
  - WS Truscott
  - R Sloan [Arrived 14:35]

Approvals

- The minutes from the previous meeting were approved.
- Changes to the time plan were approved.

Research summary

- As the bias voltage applied to a Gunn diode increases, frequency decreases.
- As the bias voltage applied to a Gunn diode increases, the output RF power increases to a peak, then drops back.
- The actual values vary from device to device, and are optimisations are often performed experimentally.
- PLLs, injection locking and power combining were discussed.
- A simple variable power supply can be used for a single diode oscillator. A Gunn modulator would be a good design.
- For multiple diodes, multiple power supplies could be used, or alternative a single power supply with multiple individually tunable outputs would be acceptable.
- Fields required for diode comparison tables were discussed:
  - Price.
  - Availability.
  - Frequency.
  - RF power output.
- Possible circuits were provided to be discussed.
- A book reference for a discussion on InP vs GaAs was provided.
- Planar circuits are easier to manufacture than waveguides.
- Waveguide circuits are electrically simpler than planar circuits.
- Waveguides can be tuned more easily than planar circuits after manufacture.
- Planar circuits require much more design skill.
- Higher frequency applications usually use waveguide, mainly because of it's intrinsic heat sinking properties.
- The Q factor in waveguides is higher than for planer circuits.

Mounting devices in planar circuits

- Since the ground plane is on the oppose site of the substrate to the microstrips, a hole must be drilled somewhere.
- A connection can be made from the ground plane to a pad on the top of the board, then a bond made from this pad to the diode.
- This connection will have an inductance which must be accounted for.
- Coplanar waveguide could be used. This is a track surrounded by ground tracks on a substrate.
- Microstrip tends to be used for 1–2 GHz applications, whereas coplanar waveguide is normally used for 10–20 GHz applications.
- Summary for mounting devices in planar circuits:
  - It can be done.
  - It's not easy.
  - e2v has expertise in this area.
  - It will always add an inductance.

Wilkinson power combiners

- Talk to R Sloan for more details.
- They could possibly be used in this project.
- They work best at one particular frequency.
- Combining them reduces bandwidth, but this should not be a problem in our narrow frequency project.

Modes

- For a circuit with four active components, there can be up to four modes.
- Even modes are in phase (eg using a see-saw as most people do).

- Odd modes are anti-phase (eg bounding both ends of the see-saw up and down, taking the pivot with you).

e2v Presentation

- The papers found on power combining should be mentioned whilst presenting relevant information.
- The presentation should last about 20 minutes.
- The various power combining methods should be presented along with advantages and disadvantages for each one.
- It showed we've done lots of work, and the reliability of the papers can be commented upon — the results will probably be correct, but the conclusions drawn may not be.
- State that we want to use waveguide, but will continue to develop a planar solution (time split, eg. 60/40), but if future developments necessitate, work on the planar circuit may be scaled back.
- Smart dress required.
- Suits suggested as a safe bet.
- There are some good references in e2v's application notes which could be commented on in the presentation.

Group identity

- MP Gaskill's name and logo suggestion was presented.
- Opinions were mixed, but the idea was generally accepted.

Risk assessments

- The microwave risk assessment was discussed.
- More about the biological heat effects needs to be included.

- The standard allowed power incident upon a person must be stated (mW/cm^2).
- From this, a minimum distance from the waveguide can be derived.
- Information can be obtained from Dr. Melanie Taylor, B floor, Granby Row side of the main building. Check the UMIST directory for more information.
- Two sets of risks be to be set up on separate forms.
  - One for risks to people.
  - One for risks to the progression of the project.
- Project risks include having mad supervisors, computer failure, device failure, critical path delay.
- It was suggested that we get out hands on as many diodes as possible, just in case they're required.
- Many microwave devices use Beryllium Oxide as a thermal conductor. This is very poisonous, and devices containing it must be disposed of properly. The packaging of such devices should never be damaged.
- We may need a label in the lab to warn of non-ionising radiation.
- "Gunn primed, do not enter" was suggested as an amusing example.
- Don't put up warnings for risks that don't exist, as someone may ban us from working in that area.

Device manufacture

- We should start designing a single device oscillator as soon as possible.
- WS Truscott likes the idea of a waveguide design.
- The circuit type may be changed later as more experience is gained.
- The main waveguide problem is that you are limited to using a box.
- Screws scan sliders can be used to change the properties of a box, but these can be difficult to make for small waveguides.

- Waveguide combining needs to be considered.
- Who will be designing and making the waveguide needs to be decided upon.
- Pre-made waveguides can be purchased, but with customisation in mind it may be better to design and build them ourselves.

Out of hours working

- Officially, the UMIST buildings are open each day until the library shuts.
- We can work in a lab as long as we are not doing something identified as dangerous.
- Out of hours passes can be obtained if there is a special case for them.

Resonant discs

- Will we be using or not?
- e2v will make some Gunn diodes with the discs attached, but they will be fixed in frequency.
- For power combining, frequency and phase must be locked.
- Each diode must be placed in its own resonant circuit.
- We could use a waveguide with a plate across the front to reflect most of the energy, but a hole to allow some through to be impressed upon the other diodes. This could, however, be difficult to manufacture.
- Alternatively, an open waveguide could be used with capped diodes as a resonant circuit.
- Allowing each circuit to be tunable is probably a good idea.

e2v presentation format

- The format was discussed

  1. Introduce the group.
  2. Present the problems, project aims, etc.
  3. Our understanding of Gunn diodes.
  4. InP vs GaAs.
  5. Waveguide vs planar circuits.
  6. Power combining techniques
  7. Conclusion and future plans.

- Start with the basics, then provide more details.
- Questions will be asked at the end of each section detailed above.
- Our current research areas will be a base for individual contributions to presentation content.
- Basing the information of the group bios, we should consider what information should go into each person's introduction for section 1.

Proposed actions

All	Provide content for the presentation to e2v:	
	JM Higginbotham	Sections 2 and 3.
	DP Headland	Section 6: Power combining, frequency and phase locking.
	RE Irwin	Section 5.
	MP Gaskill	Section 3: Power supplies.
	R Wan	Section 6: Diode biasing.
	AJ Nelms	Section 4.
MP Gaskill	Update the risk assessment with information discussed in this meeting, then mail WS Truscott with a copy of the updated assessment.	

MP Gaskill	Add “Power Combining Gunn Diode Oscillator” below the logo.
All	Try to attend the power combining seminar tomorrow, 12:30–13:30 in C53. Sandwiches will be provided afterwards.

Next meeting

Time	Tuesday, 28 October, 09:00
Place	D-floor coffee room

Meeting adjourned, 16:19.

Gunn Diode Oscillator Minutes

David Headland

2003-10-28 09:00

Attendance

- Fourth year students
  - DP Headland
  - AJ Nelms
  - RE Irwin
  - R Wan
  - JM Higginbotham
  - MP Gaskill

Approvals

- The minutes from the previous meeting were approved.

Dress code

- Dress code was decided upon.
  - Smart trousers.
  - Shirt and tie.
  - No jackets.

Presentation to e2v

- RE Irwin experienced problems reading the Powerpoint files on the university computers.
- It was decided that current sections should be combined in A19 after the formal meeting.
- Problems were experienced getting the logo to display properly inside the PPT files. Attempts will be made to convert the logo into either a vector or a bitmap image file.
- The content of the personal slides was discussed. The format was decided as follows:
  - 4th year: *degree course.*
  - *Interests and related work experience.*
  - *3rd year project.*
- The actual style of the slides will be discussed in A19 so proposed changes can be quickly implemented and commented upon.

Microwave risk assessment

- Based on information provided from the Occupational Health web site.
- A detailed risk summary has been produced.
- Warning signs will be required in the lab.
- Restricted access to the workspace will need to be established whilst working with the oscillators.
- The minimum safe working distance in a straight line from the waveguide to an eye has been calculated to be 2.8 m.
- Nobody should *ever* look down a waveguide.
- The rest of the body has much less strict distance requirements that the eye.

Project risks

- An example critical path analysis graph was presented.
- Project should be able to do similar analysis itself — this will be investigated over the next couple of days, and the results will be reported at Thursday's meeting.

Waveguide vs planar circuits

- A paper describing a method for waveguide power combining using an overmoded waveguide and a serial of individual waveguide oscillators was presented.
- Few papers describe in any detail the reasons for choosing waveguide over planar circuits or vice versa.
- Priestley's paper describes the designing of a planar circuit to overcome many of its problems. This does, however, require much more design skill than a waveguide-based oscillator.

Meeting time adjustment

- A motion was proposed to move the start of the Tuesday meetings to 10:00 to aid travel arrangements for certain people and reduce dead time for students with afternoon lectures.
- The motion was passed unanimously.

Proposed actions

All	Check assigned sections for any required modifications:	
	JM Higginbotham	Sections 2 and 3.
	DP Headland	Section 6: Power combining, frequency and phase locking.
	RE Irwin	Section 5.

	MP Gaskill	Section 3: Power supplies.
	R Wan	Section 6: Diode biasing.
	AJ Nelms	Section 4.
RE Irwin	Check with WS Truscott for travel arrangements.	
DP Headland	Bring in copies of driving license for insurance purposes.	
MP Gaskill	Present the risk assessment to R Sloan for approval and check for access to a working oscillator for testing purposes.	
MP Gaskill	Check what sign will be required for the lab.	
MP Gaskill	Mail a copy of the current logo and associated fonts to DP Headland	
DP Headland	Convert the logo into a more useful and portable format for inclusion in the presentation.	
AJ Nelms	Collate information gathered into a set of slides and mail to DP Headland for inclusion in the presentation.	
All	Provide possible questions to ask e2v Technologies.	
DP Headland	Provide the latest presentation on the web site, and keep up-to-date with any future changes.	
RE Irwin	Check the facilities on offer at e2v Technologies: computers and projectors.	
All	Provide suggestions for information to be added into the conclusion.	

Next meeting

Time	Thursday, 30 October, 14:00
Place	D-floor coffee room

Meeting adjourned, 11:49.

Gunn Diode Oscillator Minutes

David Headland

2003-10-30 14:00

Attendance

- Fourth year students
  - DP Headland
  - AJ Nelms
  - RE Irwin
  - R Wan
  - JM Higginbotham
  - MP Gaskill
- UMIST staff
  - WS Truscott
  - R Sloan

Approvals

- The minutes from the previous meeting were approved.

Presentation to e2v

- Possible Questions for e2v technologies:
  - InP vs GaAs — Are any InP diodes available?
  - Can we have any Gunn diodes for testing?
  - Ask about resonant caps.
  - Comments on the waveguide vs. planar approach.
  - Discuss heat dissipation problems.
  - Solicit any general practical advice.
  - Informally ask about our presentation technique to improve upon it for the formal presentation later on.
  - What tests would they make on a project such as this, and do they have any test equipment we could use to help us.
  - Would e2v be able to machine waveguides, and if so what information would they require from us.
  - Do e2v have any good device models they use during their own development.
- Suggestions for the summary slide:
  - One diode oscillator should be complete this calendar year.
  - Then we will progress to low-frequency power combining.
  - Work will then start towards high frequency power combining.
- Facilities at e2v Technology
  - WS Truscott has not checked.
  - He suspects that projectors and a computer will be available.
  - A copy of the slides should be printed for group members and e2v staff: 10 copies in total should suffice.
  - A copy of the time plan should also be included for e2v staff.
- Travel arrangements
  - Minibus will be hired.
  - AJ Nelms and DP Headland will be insured to drive.

- Lunch will be provided.
- The presentation style was discussed.
  - Each person should present their own introduction.
  - Two people should share the main body of the presentation.
  - All should participate in questions.

Administration

- The following stationery items have been purchased for use by the project group:
  - Stapler.
  - Staples.
  - Hole punch.

Microwave risk assessment

- The microwave risk assessment was signed by all.
- Access to the lab will be provided once everyone has a copy of the assessment.
- A waveguide oscillator is set up and working in the lab.
- The safety sign was agreed upon as “Non-ionising radiation”.
- The sign should only be put up when there is a risk.

Waveguides

- Fin line slots were discussed.
- The theory of waveguides was discussed.
- One important consideration is that the waveguide wavelength λ_g is larger than the free-space wavelength, λ.

Applications

- The two main applications for W-band radio are:
  - Car radar.
  - The intelligent shell.

Proposed actions

All	Meet tomorrow at 9:00 in A19 to finalise the presentation.
DP Headland	Check the location of e2v Technologies.

Next meeting

Time	Tuesday, 4 November 2003, 09:00
Place	UMIST to head to Lincoln

Meeting adjourned, 17:01.

Gunn Diode Oscillator Minutes

David Headland

2003-11-11 10:00

Attendance

- Fourth year students
  - DP Headland
  - AJ Nelms
  - RE Irwin
  - R Wan
  - JM Higginbotham [arrived 10:10]
  - MP Gaskill
- UMIST staff (at various points during the meeting)
  - WS Truscott
  - R Sloan

Approvals

- The minutes from the previous meeting were approved.

Second harmonic operation

- R Sloan demonstrated fundamental frequency and second harmonic operation to the group.
- The example given was a string oscillating between two fixed points for fundamental frequency (f_0) operation.
- Second harmonic ($2f_0$) operation was demonstrated as the string oscillating with the centre fixed as well.
- Second harmonic operation of Gunn diode oscillators is possible because of the current spike in a Gunn diode being so tight.
- Second and higher harmonics will be high power if the spike is infinitely sharp (a comb).
- To select the second harmonic, a filter must be designed to reflect back all frequencies except the second harmonic.
- Sub-harmonic locking can be used.
  - This involves injection locking at a lower harmonic than the one used for power output.
  - R Sloan suggested not to complicate matters by trying this.

e2v presentation

- Overall, the group was pleased with the outcome.
- Mick was worried about part of his presentation.
  - Extra knowledge and professional response compensated for this.
- The buildings were not as expected for a high-tech plant.
- It was suggested that we ask to borrow the 1000× model of the Gunn diode for our presentation.

Points made by e2v

- The help on capacitance and resonant discs was very useful.
  - Trial and error will be required for final tuning.
- Simulation would be more useful in certain aspects of the project than others:
  - Injection locking
  - Power combining
- The biasing circuit is important.
  - A power supply with four tunable outputs will be required.
- MP Gaskill knows of a company that may be able to help with machining in an emergency.
- Circular waveguides were discussed
  - Can use used, but they are lossy.
  - The waves will propagate in any orientation.
  - Can be used as a backup idea.
  - Concentrate on rectangular waveguide.

New project aims

- Power combining.
- Use waveguide rather than planar circuits.
- Use the diodes in second harmonic mode.
- Use GaAs Gunn diodes.
- Aim for the highest achievable power and frequency without set limits.

New tasks

- Investigate the effects of varying the resonant caps.
- Investigate methods of combining the diodes
  - Four diodes in one waveguide.
  - Two waveguides with two diodes each and an overmoded waveguide.
  - Four single-diode waveguides and an overmoded waveguide.
  - One waveguide operating in fundamental mode and one at the second harmonic.

List of requests to e2v

- Example target specification.
- Provision of a ready-made Gunn diode oscillator.
- Provision of the Gunn diodes themselves.
- Ask about borrowing the scale model for the presentation in February 2004.
- Request photographs:
  - Model of the Gunn diode.
  - The semiconductor laboratories.
  - The lest lab with the electron microscope.
  - Philip Norton's test area.

Task assignment

- MP Gaskill presented a draft task split for the interim report.
- This was commented upon by the group.
- Specifications will be required to designs a single oscillator.

  - This should be discussed on Thursday.
  - This will require the diodes from e2v.

- The LyX CD was made available.

Proposed actions

RE Irwin	Bring the rough guide sketch to Thursday's meeting.
RE Irwin	Email our requests to e2v.
RE Irwin	Email the American company with a request for a sample of InP Gunn diodes.
All	Read all proposed papers by WS Truscott for Tuesday.
All	Look at the proposed task split in the report with a view to making changes and task assignment on Thursday.
MP Gaskill	Mail DP Headland with the interim report task split.
R Wan	Mail DP Headland with group photographs from Lincoln.
DP Headland	Place the task split and photographs on the web site.

Next meeting

Time	Thursday, 13 November 2003, 14:00
Place	D floor coffee room

Meeting adjourned, 11:43.

Gunn Diode Oscillator Minutes

David Headland

2003-11-13 14:00

Attendance

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

Approvals

- The minutes from the previous meeting were approved.

Interim report proposal

- The draft proposal was discussed.
- Individual sections can be written in any format.
- DP Headland will collate sections to create LaTeX source with LyX.
- Deadlines:
  - All section submitted for collation: 15 December 2003 AM.
  - Submission of collated document for proof reading: 16 December 2003 AM.
  - Submission of changes to create final documents: 17 December 2003 AM.
  - Print document: 18 December 2003 AM.
  - Document submission deadline: 19 December 2003.
- Supervisors suggest flexibility in who is writing report sections.
- The main delay points were identified as:
  - Waveguide machining time.
    - Suggested getting a large section of waveguide machined.
    - It can be chopped up and used as needed.
  - The test equipment may not always be available.

Tasks split

- Design a single diode oscillator before Christmas.
  - JM Higginbotham.
  - R Wan.
  - MP Gaskill.
- Learn to use test equipment, thoroughly test and document the existing oscillator.
  - Tests to perform.

    - Spectrum analysis.
    - Power measurements.
    - Voltage vs. frequency relationship (should be positive).
    - Phase noise (target is 75-80 dB/Hz at 100kHz offset).
  - Members performing tests.
    - AJ Nelms.
    - DP Headland.

- Design and simulation of the bias choke effects on the oscillator.
  - RE Irwin.
- Electromagnetic analysis of the waveguide.
  - Unassigned.
- The supervisors commented on this split.
  - Tasks should be available for when delays are in place.
  - This can be documentation or information assimilation.

Photocopier account

- A photocopier PIN number was made available.
- Details were given to all members at the time.

Phase noise

- Very important in any communications system.
- Research into QPSK was suggested.
- Phase errors will introduce errors in determining the transmitted signal.
- If the local oscillator is noisy, errors can also be introduced.
- Phase noise is a measure of the steepness of the power vs. frequency slope.

- Look for a paper by Leeson from the 1960s that describes this. The relationship is along the lines of

$$L(f) \propto \frac{1}{PQ}$$

Radial discs

- A radial disc acts like a capacitor at low frequencies, and an inductor at high frequencies.
- The frequency when the components are matched is the resonant frequency.

Second harmonic waveguide

- Using a second harmonic, the first harmonic will be attenuated quickly.
- Positioning devices close together there may still be enough first harmonic power to allow injection locking.
- This can be an advantage, as if the coupling is too strong there may be two solutions to the injection locking equation.
- Building on WS Truscott's explanation of wave propagation in a waveguide:
  - λ_G increases as f drops.
  - As $f \to f_{\text{cutoff}}$, $\lambda_G \to \infty$.

Miscellaneous points

- R Sloan tried to get us all to learn HFSS to some degree.
- Web of Science allows you to provide details of one paper and get forward and reverse citation lists for that paper.

Related paper

- "A wideband BackShort-Tunable Second Harmonic W-Band Gunn Oscillator" by H Barth was discussed
- WS Truscott thought that this paper was very useful to our project.
- It's very encouraging, it shows that similar was has been undertaken.
- It was suggested that everyone get hold of this paper and read it.
- The fact that the paper is 22 years old was discussed.
  - Much work was done in this area for defence in the 1980s.
  - Funding was withdrawn as the cold war ended.
  - This doesn't mean to say that the work is incorrect or has been disproved.
- We should find out:
  - Has anyone improved on it?
  - Has anyone disproved on it?
- We should talk to e2V, ask them where does the varactor diode go with respect to the radial disc. This will help give insight into the coupling of the devices.

Test equipment tutorial

- Spectrum analyser will work with mixers to 110 GHz.
- Need to order a rotary vein attenuator from Flann in Bodmin.
- Session organised for AJ Nelms and DP Headland.
- Meet Keith Williams in the Agilent lab at 10:00 on Thursday 20 November.

Proposed actions

All	Read up on quadrature phase shift keying (QPSK).
All	Read the paper by H Barth.
All	Look up and read the paper on phase noise by Leeson.
All	Decide upon a time for R Sloan to organise HFSS simulations and mail him with it.
AJ Nelms	Start learning to use the test equipment.
DP Headland	Start learning to use the test equipment.
MP Gaskill	Start designing the single Gunn diode oscillator.
R Wan	Start designing the single Gunn diode oscillator.
JM Higginbotham	Start designing the single Gunn diode oscillator.
RE Irwin	Look into the dimensions of resonant discs.
Supervisors	Check for any existing suitable waveguides.

Next meeting

Time	Tuesday 18 November 2003, 10:00.
Place	D floor coffee room

Meeting adjourned, 17:00.

Gunn Diode Oscillator Minutes

David Headland

2003-11-18 10:00

Attendance

- Fourth year students
  - DP Headland
  - AJ Nelms
  - RE Irwin
  - R Wan
  - JM Higginbotham
  - MP Gaskill

Approvals

- The minutes from the previous meeting were approved.

H Barth paper

- The origin of the maths used on the paper is explained.
- We need to find out why $\lambda_g(f_0) = 3\lambda_g(2f_0)$.
- Citation checks report that this is the start of work into second harmonic power combining oscillators.
- This paper is a good start for the project.

Resonant discs

- If anyone comes across information on resonant discs and their design, let RE Irwin know.
- Formulae describing the disc diameter and thickness are not known, although both parameters affect the resonant frequency of the system containing the disc.

Single diode oscillator design

- Three people is probably more than required.
- A thesis for X-band combining was presented.
- An X-band power combining paper was presented.
- Mathematics for calculating f_{cutoff} were demonstrated.
- A paper showing example dimensions was presented.
- JM Higginbotham will leave the design team and assist RE Irwin with resonant disc design and HFSS simulation.

Testing

- Thursday morning is now not good for Keith Williams.
- DP Headland will email him to arrange a new time.
- Modules for testing are present in the lab.
- All items removed from the lab must be signed out and back in again.

Fields in a waveguide

- Electric and magnetic fields inside a waveguide were drawn by R Sloan.
- The HFSS simulation session for RE Irwin and JM Higginbotham will be organised on Thursday.

Report task split

- Main body deadline moved forwards by one week to 8 December 2003.
- We should ask R Sloan and WS Truscott to check the report before final printing and submission.
- The task assignment was discussed and modified.
- The tasks required to complete the interim report have been assigned as follows:

Executive summary

RE Irwin	Executive summary.

Introduction

AJ Nelms	Aims and objectives.
RE Irwin	Reasons for the project.
MP Gaskill	Sections: Building.
JM Higginbotham	Sections: Simulation.
DP Headland	Sections: Testing.
R Wan	Sections: Research.
All	Basic summary overview paragraph for each chapter. Each section written should have a summary paragraph for this section.
JM Higginbotham	Existing devices.
RE Irwin	Team introduction.

Main Body

R Wan	1: Overview of Gunn diodes.
MP Gaskill	2: Health and Safety.
JM Higginbotham	3: Simulations.
AJ Nelms	4: GaAs vs InP.
RE Irwin	5: Waveguide/Planar circuits.
AJ Nelms	6: Biasing
RE Irwin	7: Harmonic operation.
DP Headland	8: Power combining and injection locking.
JM Higginbotham	9: Thermal requirements.
DP Headland	10: Commercial device testing results and findings.
AJ Nelms	11: Test plan.
MP Gaskill	12: Building a single device oscillator.
JM Higginbotham	13: Conclusion and summary.
Collation only	Appendices: Design requirements, risk assessments, relevant literature.

Summary

DP Headland	Progress against the time plan.
All	Proposed changes to time plan - should be reported as needed by each sub-team.
All	Describe progress of each section and describe any problems observed.

Additional sections

All	Provided references and cite where appropriate.
AJN, DPH	Tests made and findings - raw results.
RW, MPG	Circuits, drawings, etc.
RE Irwin	Block diagram.

CD Appendix

DP Headland	Project plan.
DP Headland	Meeting minutes.
MP Gaskill	Financial accounts.
DP Headland	Presentation slides.

Proposed actions

DP Headland	Provide the format for BibTEX references.
All	Read appendix D in the project guidelines before starting to write report sections.
MP Gaskill	Update the report task split and mail a copy to the group list.
All	Check the documentation task assignment for possible problems for Thursday.
DP Headland	Mail Keith Williams to re-arrange the tutorial for microwave test equipment.
All	Consider appropriate risks for out-of-hours working.

Next meeting

Time Thursday 20 November 2003, 14:00.

Place D floor coffee room.

Meeting adjourned, 11:40.

Gunn Diode Oscillator Minutes

David Headland

2003-11-20 14:00

Attendance

- Fourth year students
  - DP Headland
  - AJ Nelms
  - RE Irwin
  - R Wan
  - JM Higginbotham
  - MP Gaskill
- UMIST staff
  - WS Truscott
  - R Sloan

Approvals

- The minutes from the previous meeting were approved.

Bias choke operation

- R Sloan draw pictures to demonstrate the bias choke in a waveguide.
- The thick sections are equivalent to parallel capacitances to ground.
- The thin sections are equivalent to serial inductances.
- The DC bias is supplied from the far end of the arrangement.
- DC passes through to the diode.
- Higher frequencies are attenuated.
- For further information, a book on filters by Matthaei, Young and Jones (1956) was suggested.

Resonant caps

- No formula for calculation is available.
- All current work is empirical.
- Concentrate on the choke design.
- Empirical work is okay for this project report, as it demonstrates work within current engineering standards.
- JM Higginbotham and RE Irwin pooled information.
- Research matched Philip Norton's suggestions.
- The plan is to make several chokes or various coarse measurements and see which work best.
- The best designs can then be tuned.
- Simulation in HFSS will be carried out.
- A fixed wall to screw into the waveguide could be made to house the choke.
- This would allow different sized chokes to be used in one waveguide.
- A solid dielectric could be used around the choke.

Team meal

- The possibility of a subsidised team meal was mentioned.
- It could be set up as a team-building exercise.
- R Sloan thinks this is a good idea.
- WS Truscott suggested an Indian buffet near Levenshulme.
- The evening of Thursday 11 December was suggested.
- We should mail the supervisors to arrange this.

HFSS simulations

- An email should be sent to R Sloan to organise this.
- He will then arrange a suitable time and material for tuition.

Report task split

- This was discussed with WS Truscott.
- We may have to re-shuffle sections as the report progresses.
- This project can not be split to one person per module.
- It was suggested that we may want to have a keep the read material separate from planned and completed work in the report.
- Question: Should we have sections for research, completed work and planned work?
  - It doesn't matter.
  - Make it easy for the reader to see what we have done.
  - If you don't do this, the information can easily get lost.
  - Organise the report for impact.
- Contents pages can be submitted to the supervisors so they can check the structure.
- There probably won't be time for them to check the document itself.

Presentation

- We tried to present ourselves to e2v — this worked well.
- We may not want to do individual introductions at the formal presentation in February.
- Check the mark scheme.
- All presentation rules must be adhered to.
- Our presentation to e2v was well matched to the situation.
- Most of the marks for the formal presentation are for preparation and delivery.
- Technical content is worth only 20%.
- It was suggested that 2–3 people talk in February.
- All people must be prepared to answer questions.
- Questions will be asked of everyone.
- Question handling is worth 20%.
- It is suggested that at the end of the report, people's knowledge areas are summarised to allow people asking questions to target them to balance the load.
- More diagrams might be useful.
- The room at e2v was small — we may need to project our voices more at UMIST.
- Checking the room before the presentation is advisable.
- Time keeping is very important.
- People who will be present:
  - All project teams.
  - All project supervisors.
  - Two independent markers.
  - Industry representatives.

- If we have a waveguide it is suggested that we pass it around.
- This would help to give an idea of the size we are working at.

Mark scheme

- The mark scheme was discussed.
- The HOTFET team left some things quite late.
- Forward planning would be very helpful.

Bias choke manufacture

- Manufacturing can be done at UMIST.
- The control systems workshop is the best place.
- How long it takes will depend on the workshop's workload.
- The workshop is on F floor above the tomography department.
- Roy Moody does the supervising there.
- We must check all work to make sure it matches the specification.
- We will need tools for accurate measuring.

Waveguide design

- Both rectangular and circular back shorts will be made.
- When the back short is in the correct position is will be glued into place.
- For the guide wavelength (for the second harmonic):

$$\begin{aligned} a &= 2.54\,\text{mm} \\ b &= 1.27\,\text{mm} \\ \lambda_c &= \frac{1}{\sqrt{\left(\frac{m}{2a}\right)^2 + \left(\frac{n}{2b}\right)^2}} \end{aligned}$$

For TE_{10} (dominant mode), $m = 1$, $n = 0$:

$$\begin{aligned}
\lambda_c &= \frac{1}{\sqrt{\left(\frac{1}{5.08}\right)^2}} \\
f_c &= \frac{c}{\lambda_c} \\
&= \frac{3 \times 10^8}{5.08 \times 10^{-3}} \\
&= 59.1\,\text{GHz} \\
\lambda_G &= \frac{\lambda_0}{\sqrt{1 - \left(\frac{\lambda_0}{\lambda_c}\right)^2}} \\
\lambda_0 &= \frac{c}{f_0} \\
&= \frac{3 \times 10^8}{87 \times 10^9} \\
&= 3.45\,\text{mm} \\
\lambda_G &= \frac{3.54}{\sqrt{1 - \left(\frac{3.45}{5.08}\right)^2}} \\
&= 4.70\,\text{mm}
\end{aligned}$$

Postgraduate passes

- A risk assessment must be produced.
- Since lab access is not likely, base it on the computer use assessment.

Proposed actions

DP Headland	Create an out-of-hours working risk assessment.
RE Irwin	Return the microwave bible on Monday.
All	Continue working on your own task sections.
All	Start work on the interim report.
JM Higginbotham	Mail R Sloan or WS Truscott regarding workshop access.

JM Higginbotham Mail R Sloan to arrange HFSS tuition times.

DP Headland Mail the supervisors to arrange team building meal.

Next meeting

Time Tuesday 25 November 2003, 10:00.

Place D floor coffee room.

Meeting adjourned, 16:12.

Gunn Diode Oscillator Minutes

David Headland

2003-11-25 10:00

Attendance

- Fourth year students
  - DP Headland
  - AJ Nelms
  - RE Irwin
  - R Wan
  - JM Higginbotham
  - MP Gaskill

Approvals

- The minutes from the previous meeting were approved.

Bias choke operation

- Equivalent circuits have been found.
- Work should be started on the values by Thursday.
- More research was undertaken.
- Comparisons with transmission lines have been made.
- Waveguide impedance is normally measured rather than calculated.
- May want a transmission lines section in the report.

Waveguide design

- Design finished.
- Drawings have been created.
- Design team will go to the workshop and discuss fabrication.
- The bias choke hole can be drilled later to any size.
- The heating problem was discussed.
  - Water cooling should be used to cool the waveguide.
  - De-ionised water should be used to avoid corrosion.
  - A risk assessment for water cooling needs to be drawn up.
- Alignment holes were discussed for attachment to other devices.
- Dimensions for the holes are in the Flann catalogue.

Interim report

- After section 5, add a new section:
  - Title: "Radial line transformers".
  - Author: JM Higginbotham.
  - Length: approximately 3 pages.
- A glossary should be added as an appendix.
- Everyone should provide relevant entries for the glossary.
- The content of the report sections was discussed.
- R Wan will now be the author for the progress against the time plan section.
- We should check with the supervisors about what sort of block diagrams to include in the report.

Waveguide machining

- Machining facilities for the waveguide were discussed.
- It's unlikely that a waveguide could be manufactured before December.
- January or February is probably the earliest target.

Out of hours working

- Put the security phone number on the risk assessment.
- Point out that there is an internal phone in A19b.

Power supply

- An emitter follower stage was suggested for oscillations at DC.
- It was suggested that switched mode supplies are not used.
- It would be good to have a stop voltage set on the PSU.
- The is a possibility of using microprocessors to control multiple outputs on the power supply.
- Uses for the microprocessor should be considered.

Formal presentation

- Week 14 is available for full-time project work.
- Changes can be made to the presentation during this time.
- Some time should be used for rehearsals.
- Major changes and additions should be made in advance.

Device testing

- Tests to be performed were discussed.
  - Frequency vs. bias voltage.
  - Power output.
  - Phase noise.
- The function of a vector network analyser should be established.
- Further tests should be conducted to draw a full hysteresis loop for a Gunn diode.

Proposed actions

AJN, DPH	Continue testing the current oscillators.
All	Continue work on the interim report.
JM Higginbotham	Read the microwave bible.
RE Irwin	Contact the Narwab restaurant.
MPG, JMH, RW	Discuss fabrication with Roy Moody.
RE Irwin	Mail e2v with request for more Gunn diodes and power supply queries.
DP Headland	Modify and print the out-of-hours working risk assessment.

Next meeting

Time	Thursday 27 November 2003, 14:00.
Place	D floor coffee room.

Meeting adjourned, 11:11.

Gunn Diode Oscillator Minutes

David Headland

2003-11-27 14:00

Attendance

- Fourth year students
  - DP Headland
  - RE Irwin
  - R Wan
  - JM Higginbotham
  - MP Gaskill
- UMIST Staff
  - R Sloan [Until 15:50]
  - WS Truscott [From 16:00]

Apologies

- AJ Nelms

Approvals

- The minutes from the previous meeting were approved.

Interim report

- A web site section was suggested in the report handbook.
  - DP Headland will write this section.
  - PHP source can be included as an appendix.
- Block diagrams were discussed.
  - The type is not important.
  - They should provide a simplified view of the project.
  - Project guidelines are not set in stone.
  - If the diagrams suggested don't fit, don't use them.
  - We could use circuit equivalents as block diagrams.
  - They should convey concepts without any great detail.
- Marks will be lost for repetition or contradiction.
- Avoid excessive use of "I" or "we".
- Be consistent with tense.
  - Proposed work should be written in the future tense.
  - Current work can be written in the continuous present tense.
  - Completed work could be written passively.
  - If the passive voice is too complicated, use of "I" or "we" is allowed.
- Referencing was discussed.
  - The Harvard referencing style was clarified.

Manufacture

- Drawings have been submitted to the workshop.
- The work cannot be done immediately.
- January 2004 was set as a provisional target date.

- Some work has already started.
- It is suggested that for time reasons drawings are sent to the supervisors for them to suggest changes to reduce machining time.
- MP Gaskill has some machining experience.
- It was suggested that the waveguide height is reduced to reduce second harmonic modes.

Out of hours working

- Changes were suggested to the risk assessment.
- The new assessment should be printed for supervisor approval.

Testing

- Power measurements were discussed:
  - Waveguide to air transfer is about 90% efficient.
  - Assume 100% efficiency.
  - The aperture size can be calculated.
  - Gain can then be calculated.
  - A book was lent to DP Headland to help with this.
- Spectrum analysis:
  - It was suggested that we look for the fundamental frequency emitted from the waveguide.

Transmission lines

- Z is impedance.
- $Z = R + jX$ (R is resistance, X is reactance).
- Y is admittance.

- $Y = G + jB$ (G is conductance, B is susceptance).
- Transmission lines can be used to transform impedances.

Project specifications

- RE Irwin has mailed Nigel Priestley.
- A copy of the reply has been sent to the mailing list.
- The target frequency has been defined as 82–92 GHz.
- 87 GHz should be used in calculations.
- TBC: Terahertz bayonet connector.

Attenuators

- R Sloan's comments:
  - Need to be ordered from Flann.
  - Rotary vein attenuators would be the best choice, but are expensive.
  - We should organise quotes and present them to the supervisors.
- WS Truscott's comments:
  - We cannot afford attenuators.
  - We should try to arrange to borrow them from e2v.

Project meal

- Nawaab has been contacted.
- Booking will be necessary for groups of over 15 people.
- It has been integrated into the MMD Christmas party.
- Price is £10/head.
- Drinks are extra.

Proposed actions

All	Continue work on the interim report.
JM Higginbotham	Create a block diagram from the simulation.
DP Headland	Locate the diode in e2v's aluminium oscillator.
R Wan	Finish design drawings.
DP Headland	Update the report task split.
MP Gaskill	Create a block diagram for the fabrication process.
RE Irwin	Contact T York regarding the report format.

Next meeting

Time	Tuesday 2 December 2003, 10:00.
Place	D floor coffee room.

Meeting adjourned, 16:55.

Gunn Diode Oscillator Minutes

David Headland

2003-12-02 10:00

Attendance

- Fourth year students
  - DP Headland
  - RE Irwin
  - R Wan
  - JM Higginbotham
  - MP Gaskill

Approvals

- The minutes from the previous meeting were approved.

Interim report

- Diagram crediting was discussed.
  - Copied diagrams should should have references cited as if for text.
- The time plan was discussed.
  - The latest PDF copy is missing labels.
  - DP Headland will correct this.

- Sections can be submitted by any means.
- Email submission is preferred.
- The bias choke was discussed.
  - Dimensions depends on the waveguide.
  - Dimensions are critical to oscillation frequency.
  - Smaller dimensions generally lead to higher frequencies.
  - The official name for the reports will be “radial line transformer”.
- Chapters should run on from each other in the report rather than having blank leading balance pages.
- A basic overview should be given in introductory sections.
- Details should not be given in introductory sections, but future sections should be referred to. Please mark references both within and external to the report so they then can be correctly added into the LyX document.

Report proof reading

- After compilation and typesetting, the document will be placed on the web site.
- The URL will be distributed for proof reading.
- This will help people with quota-based mail systems.

Waveguide design

- A diagram was shown to WS Truscott.
- A time for a meeting was arranged between MP Gaskill and WS Truscott.
- Simplifications to the diagram will be suggested.

Attenuator

- RE Irwin will contact e2v to request an attenuator.
- Required attenuators are:
  - W-band.
  - 10 dB and 20 dB attenuation.
  - Suitable for their waveguide flange (R Wan has the official name for this, if required).
- Any other unused equipment they think would be useful will be gratefully received.

Report reorganisation

- The two first testing sections are mainly duplicated of each other.
- The second section will be removed and combined with the first.
- The remaining testing section will be used as a plan for future tests.
- AJ Nelms will take on the testing reporting.
- DP Headland will concentrate on other sections and compilation.
- Testing reporting should go into quite a bit of detail.
- Assume knowledge of the equipment, but not of the project.
- Future tests should include:
  - Spectrum analysis.
  - Phase noise.
  - Testing for the fundamental frequency.
  - Power measurements (power meter and attenuator).
- We should find out what a vector network analyser is for.
- Tests described above should be made on the single device oscillator.
- Tests can be extended for the four-device power combining oscillator.

Laptop loan

- RE Irwin requires a laptop to use over the weekend for the project report.
- R Wan offered to loan an iBook.
- The offer was accepted.

Formal presentation

- Some section can be kept:
  - Introduction
  - Waveguide vs. planar.
- Most should be re-written.
- Some members could work on this whilst the report is being compiled.
- Exact details will be decided upon at a later date.

Proposed actions

All	Continue work on the interim report.
DP Headland	Produce a PDF version of the time plan with labels.
RE Irwin	Write to e2v requesting an attenuator and more diodes.
R Wan	Lend laptop to RE Irwin.
DP Headland	Adjust interim report task split to account for recent changes.
AJN, DPH	Continue testing in detail, obtain power readings and look for RF power at the fundamental frequency.

Next meeting

Time Thursday 4 December 2003, 14:00.

Place D floor coffee room.

Meeting adjourned, 11:05.

Gunn Diode Oscillator Minutes

David Headland

2003-12-04 14:00

Attendance

- Fourth year students:
  - DP Headland.
  - R Wan.
  - JM Higginbotham.
  - MP Gaskill.
- UMIST Staff:
  - R Sloan.
  - WS Truscott.

Apologies

- RE Irwin.

Approvals

- The minutes from the previous meeting were approved.

Simulation labs

- The email about ADS labs was discussed.
- Some people have not received the email.
- RE Irwin and DP Headland will not be able to attend due to tomography module reorganisations.
- The matter was discussed further with R Sloan.
- Proposed checks were discussed.
- RF power going up the radial line transformer is important.
- The usefulness of HFSS was questioned for certain situations.
- Models with the radial line transformer were suggested.

Waveguide fabrication

- A W-band waveguide flange combining the diode and the backshort has been designed.
- Different possibilities were discussed.
- A diagram of possibilities was shown.
- Tolerances in manufacture of waveguides are ± 2 mils.
- The British Standards suggest a surface finish of 6–3 μm for waveguides, which refers to the roughness of the surface.
- Further discussion was entered into with WS Truscott.
- 3 μm is achievable in the UMIST workshops.
- Three main points for the finish were decided upon:
  - The two halves to be clamped must be well finished.
  - The inside of the cavity must be well finished.
  - The outside surface does not matter as much.
- Fabrication methods were discussed.
- Adding channels near the cavity was suggested as future work.

Backshort

- The backshort in the e2v waveguide contains a filter.
- R Sloan suggest just doing a plain backshort.
- Adjusting the backshort position is critical, and may required specialised machinery.
- e2v uses specialised tools for this.
- A fixed radial line transformer with an adjustable backshort was decided upon.
- Keeping the initial design simple was suggested.
- Alternative approaches may be required for power combining.
- Further discussion was entered into with WS Truscott.
- The first section would normally be $\frac{\lambda}{4}$ long.
- Since we are using harmonics, our target will probably by closer to $\frac{\lambda}{6}$.
- Calculations must be done.
- It was suggested that three diode combining should be mentioned to the workshops.

Waveguide drawings

- Drawings were discussed with R Sloan.
- Dimensions should be placed outside the objects with construction lines indication where they apply.
- Hole dimensions were discussed.

Interim report

- A list of achievements was discussed for the summary section.
- Clarification was provided of the tests performed.
- The future work section was discussed.
- Suggestions for future work were provided.
- Tests were suggested by e2v and listed in the minutes for the visit to Lincoln.

Power supply

- The power supply was discussed.
- e2v do make power supplies.
- Circuit diagrams are available.
- Ours could be based on a e2v design but with multiple outputs.

Vector network analyser

- The function of the device was discussed.
- It measured the S parameters of forward and reflected waves.
- Will effectively measure the input and transfer impedances.
- Will output power and phase reflected (ideally zero).
- Will apply waveguide impedance corrections if required.

Power estimates

- Power estimates for tested devices were discussed.
- The antenna gain will be approximately 10 dB (1).
- Power will be spread over a sphere's surface if radiating isotropically.
- For a waveguide, this will not be true, so calculating the effective aperture of the antenna will be required.

P drive problems

- Problems with the P drive were discussed with WS Truscott.
- Help from ISD has been requested.
- The suggestion was made to talk to ISD face-to-face.

Group meal

- A reminder was made of the group meal next Thursday.

Proposed actions

All	Main focus: Continue work on the interim report.
DP Headland	Send mail about ADS lab to MP Gaskill.
AJ Nelms	Provide quantitative measurement of the air gap used in testing.
DP Headland	Mail R Sloan regarding out of hours working.

Next meeting

Time Tuesday 9 December 2003, 10:00.

Place D floor coffee room.

Meeting adjourned, 15:27.

Gunn Diode Oscillator Minutes

David Headland

2003-12-09 10:00

Attendance

- Fourth year students:
  - RE Irwin.
  - DP Headland.
  - R Wan.
  - JM Higginbotham.
  - MP Gaskill.

Approvals

- The minutes from the previous meeting were approved.

Interim report

- Half of the introductions are currently written.
- Binding was discussed.
  - Comb binding was suggested.
  - Facilities are available in the UMIST stores.
- A draft print should be created with two pages per printed side, duplex.

- Changes can be made on copies of this draft.
- A request for "!here" positioning on a block diagram was made.
- Proof reading should be for discussion and changes on Thursday.
- Be aware of the approaching exams, take time to prepare.
- Citation positioning was discussed.
- A mistake in one of the references was pointed out.
- Encouragement was received from the project manager.

Formal presentation

- It would be a good idea to start on a structure to the presentation.
- Top priority goes to the report.
- MP Gaskill will make a start producing a skeleton presentation.

Waveguide fabrication

- MP Gaskill has spoken to the machinist.
- New drawings were submitted.
- Students are not permitted to use the machines.
- He will try to complete the task by mid-January, but did not sound confident.
- e2v may be able to help with the machining.
- Problems should be mentioned to the supervisors on Thursday.

Group meal

- A reminder was made of the group meal next Thursday.
- Group members meet outside the restaurant on Stockport Road at 6:00.

Proposed actions

All	Proof read the report.
RE Irwin	Submit sections for inclusion in the report.
R Wan	Submit section summary for inclusion in the report.
DP Headland	Mail URL of Mozilla Firebird to AJ Nelms.
AJ Nelms	Submit remaining section for the report.
DP Headland	Correct the erroneous reference.
RE Irwin	Mail e2v about waveguide fabrication and attenuators.
DP Headland	Print a draft copy of the report after finishing compilation.

Next meeting

Time	Thursday 11 December 2003, 14:00.
Place	D floor coffee room.

Meeting adjourned, 11:12.

Gunn Diode Oscillator Minutes

David Headland

2003-12-11 14:00

Attendance

- Fourth year students:
  - RE Irwin.
  - DP Headland.
  - R Wan.
  - JM Higginbotham.
  - MP Gaskill.
- UMIST staff
  - WS Truscott (at times)

Approvals

- The minutes from the previous meeting were approved.

Interim report

- The deadline for writing sections has been set to the end of Saturday.
- Changes to be made as a result of proof reading were discussed, and will be attached to these minutes in the paper file in the form of an annotated draft report copy.

- The future work section was discussed with WS Truscott.
- The approximate power calculation was discussed with WS Truscott.

Group meal

- Facilities at the restaurant were discussed.
- The meeting time was clarified: 6:00 at the Nawaab.

Proposed actions

All	Proof read any new revisions of the report as announced.
DP Headland	Commit the current changes to the report.
RE Irwin	Mail in the executive summary.
JM Higginbotham	Write the future work section and the discussed paragraph.
REI, DPH	Meet at 9:30 AM on Monday to make grammatical changes.

Next meeting

Time	Tuesday 16 December 2003, 14:00.
Place	D floor coffee room.

Meeting adjourned, 16:25.

Gunn Diode Oscillator Minutes

David Headland

2003-12-16 10:00

Attendance

- Fourth year students:
  - RE Irwin.
  - DP Headland.
  - R Wan.
  - JM Higginbotham.
  - MP Gaskill.
  - AJ Nelms

Approvals

- The minutes from the previous meeting were approved.

Waveguide manufacture

- Problems with the UMIST workshop were discussed.
- The workshop is unable to create the waveguide.
- e2v is the best choice from here.
- MP Gaskill has a friend who owns a machining shop.

  - The workshop uses spark erosion.
  - URL: http://www.wirexprecision.com/
  - MP Gaskill will ask if our work could be done there.

Radial line transformer

- The design of the radial line transformer was discussed.
- R Sloan should be consulted for advice.

Interim report

- The current state of the report was discussed.
- The deadline for changes was set to 17 December, 00:00:01.
- Pages that need printing in colour were marked.
- Personal copies were discussed:
  - Several options available:
    * Print nine copies now.
    * Print three copies then photocopy.
    * Print copies later from the CD (Appendix A).
  - Four copies will be printed now.
  - Further copies can be made at a later date.
- The report will be printed tomorrow.
- If all is well at the start of Thursday's meeting, the report will be bound and submitted immediately.
- Future time plan changes are documented in the report.

Formal presentation

- People should start thinking about the structure.
- Each person will concentrate on their sections from the report.

Miscellaneous

- Make sure a shirt and tie is available for the presentation.
- The time plan will get revised after the presentation.

Proposed actions

All	Submit and changes to the report by the end of today.
DP Headland	Place the first 25 pages of the report online for inspection.
JM Higginbotham	Speak to R Sloan regarding the radial line transformer.
DP Headland	Print four copies of the report.
RE Irwin	Call e2v regarding waveguide manufacture.
DP Headland	Burn four copies of appendix A.
MP Gaskill	Discuss the waveguide with Wirex Precision.

Next meeting

Time	Thursday 18 December 2003, 14:00.
Place	D floor coffee room.

Meeting adjourned, 10:33.

Gunn Diode Oscillator Minutes

David Headland

2003-12-18 12:15

Attendance

- Fourth year students:
  - RE Irwin.
  - DP Headland.
  - R Wan.
  - MP Gaskill.
  - AJ Nelms

Apologies

- JM Higginbotham

Approvals

- The minutes from the previous meeting were approved with one change:
  - MP Gaskill's friend owns the machining business.

Interim report

- Wire binding was arranged with the UMIST print shop at the rate of $4 \times £2 = £8$.
  - A receipt was obtained.
  - R Sloan or WS Truscott should be contacted about reclaiming the cash.
- The quality of the report was discussed and found acceptable.
- A budget estimate could have been included but wasn't.
- Report submission was attempted.
  - Dr. York was out at lunch when we attempted to submit the report.
  - RE Irwin will try to submit the report after lunch.
  - Dr. York's extension was found to be 4729.

Formal presentation

- A skeleton was presented.
- A copy of the initial suggestion is attached.
- People should consider preferences.
- Think about content over the Christmas break.

Waveguide manufacture

- RE Irwin will push e2v about the waveguide manufacture.
- No response has been received yet from MP Gaskill's contact.
- The power combining design should be started immediately after the Christmas break.

Proposed actions

All	Concentrate on revision over the holidays.
RE Irwin	Contact e2v regarding waveguide manufacture.
All	Check the proposed presentation structure for potential changes and preferences.
RE Irwin	Submit the interim report.
All	Consider actual content for the formal presentation.

Next meeting

Time	Monday 26 January 2004, 12:00.
Place	D floor coffee room.

Meeting adjourned, 13:00.

Gunn Diode Oscillator Minutes

Mick Gaskill

2004-01-26 12:30

Attendance

- Fourth year students:
  - AJ Nelms
  - R Wan.
  - JM Higginbotham.
  - MP Gaskill.

Apologies

- RE Irwin.
- DP Headland.

UMIST Staff

- WS Truscott
- R Sloan

Approvals

- The minutes from the previous meeting were approved.

Old business

- Interim report discussed briefly with Dr.Truscott — some minor problems in report will give feedback before presentation — will be marking with Dr. Sloan on Wednesday.
- Ray from the workshop on D-Floor has started machining the first oscillator.
- No progress from e2v, known.

New Business

- (a) Discussion of progress against time plan, R.Wan has said this must change and is detailed in the interim report.
  - Possible areas for development is the power supply unit AJ Nelms suggested a possible design (1.5 A 0-8 V) but still requires four separate controls. R Wan can provide a solution for this later.
  - JM Higginbotham has been provided with the information for calculating the radial line transformer.
- (b) Discuss approach to presentation — each person will have five minutes to discuss their area of expertise.
  - Presentation similar to e2v presentation.
  - Questioned whether we still require the Gunn model from e2v.
  - Flow of the presentation will be of a top-down approach — design, simulate, build, test.
  - It was stressed not to go into much detail, as time is limited.
  - Slides should be prepared in Word then its easier to copy and paste into PowerPoint.

Proposed actions

JM Higginbotham	Calculate the size of the radial line transformer/slides simulating.

AJ Nelms	Prepare slides on testing.
R Wan	Prepare slides on introduction.
MP Gaskill	Prepare slides on building.
RE Irwin	Have information ready for waveguide.
DP Headland	Have information ready for power combining/2nd harmonics.

Next meeting

Time	Wednesday 28 January 2004, 10:00.
Place	D floor coffee room.

Meeting adjourned, 14:00.

Gunn Diode Oscillator Minutes

David Headland

2004-01-28 10:00

Attendance

- Fourth year students:
  - AJ Nelms
  - R Wan.
  - JM Higginbotham.
  - MP Gaskill.
  - DP Headland.
  - RE Irwin.
- UMIST Staff
  - R Sloan (at times).

Approvals

- A grammatical error in the previous minutes was corrected.
- The rest of the minutes from the previous meeting were approved.

Waveguide manufacture

- RE Irwin has been in contact with e2v about the waveguide manufacture.
- e2v have questions for the design team.
- They need to clarify reasons for the size change.
- Some aluminium guides are ready made, they may be suitable.
- Ray from the D floor workshop has said he can make the guides.
- We will ask for both, then may get at least one.
- MP Gaskill should confirm the waveguide design with e2v by telephone.

Presentation

- Arrangements should by made with T York to book the computer and projector as soon as possible.
- Collaboration with other groups was suggested for the practise.
- e2v Technologies have been invited to the presentation.
- The dress code is shirt and tie.
- Cameras should be present in case of relevant photo opportunities.
- 3–6 slides were suggested per person, totalling five minutes each.
- The detail level is important — enough to explain, but not to bore.
- Presentation task split
- The task split was discussed.
- The following sections have been decided upon (in approximate order):
  - RE Irwin:
    * Team introduction: As for the previous presentation. All aural introductions will be done by Ruth this time.

  - R Wan:
    * Uses of Gunn diodes.
    * Overview of Gunn diodes: The Gunn effect, demonstration with the model, band structure, reasons for oscillation.
    * Waveguide choice.
  - DP Headland:
    * Power combining and injection locking: Phase locking, etc.
    * Second harmonic operation: Guide wavelength, base on Ruth's report section.
  - JM Higginbotham:
    * Radial line transformer: Summarise report, filtering harmonics.
    * Simulation: Reasoning, limitations, software, graphs (possibly video) or simulations, future possibilities.
  - MP Gaskill:
    * Building: Aims and objectives, research, construction, problems, future work.
  - AJ Nelms:
    * Testing: What and why, results graph and comparison to expected data, future testing.
  - RE Irwin:
    * Summary: Needs the rest to be complete before it can be constructed. Emphasise past, present and future work.
  - All:
    * Questions must be answered after the formal presentation.

- Collation of individual sections will take place on Friday from 10:00 in A19.
- It was suggested that work should take place in Word to be pasted into PowerPoint to work around a bug in PowerPoint.

Elected positions

- The elected positions were discussed.

- Current positions should stay as they are until after the presentation.
- At this point, possible changes will be discussed again.

Task list

- Following T York's email, a task list must be created.
- This refers to the self appraisal documented in the handbook.
- This will be worked on after the practise on Wednesday afternoon.

Proposed actions

DP Headland	Mail T York to arrange a session to practise the presentation.
MP Gaskill	Talk to e2v Technologies by telephone regarding waveguide design.
AJ Nelms	Talk to T York regarding the possibility of having to miss the presentation.
MP Gaskill	Investigate slide templates.
MP Gaskill	Bring in a laser pointer.
All	Consider material for the self-appraisal.
MP Gaskill	Check the PowerPoint version on the presentation computer.
JM Higginbotham	Talk to R Sloan about problems with the radial line transformer.
RE Irwin	Inform R Sloan that we will be in A19 on Friday morning.
MP Gaskill	Inform WS Truscott that we will be in A19 on Friday morning.
All	Prepare slides ready for collation on Friday.

Next meeting

Time Friday 30 January 2004, 10:00.

Place A19 laboratory.

Meeting adjourned, 11:19.

Gunn Diode Oscillator Minutes

David Headland

2004-01-30 10:00

Attendance

- Fourth year students:
  - AJ Nelms
  - R Wan.
  - JM Higginbotham.
  - MP Gaskill.
  - DP Headland.
  - RE Irwin.
- UMIST Staff
  - WS Truscott (12:00–12:30).

Approvals

- The minutes from the previous meeting were approved.

Waveguide manufacture

- The UMIST workshops are passing the waveguide manufacture between people.
- It is unlikely that anything will come of this.

- MP Gaskill faxed N Priestley the paper regarding waveguide design.
- N Priestly will read it and get back in touch if there are any problems.
- Otherwise, manufacture will start.

Report Comments

- WS Truscott provided the following comments on the interim report:
- Always be quantitative where possible. For example:
  - Low cost $\rightarrow$ 10p or £25.
  - Low voltage $\rightarrow$ 2 V or 2 μV.
- Some equations have been used without full understanding.
- Problems were introduced whilst translating to LaTeX.
- It was suggested that a copy of the presentation should be sent to R Sloan and WS Truscott so that they can check factual claims such as formulae.
- Low resolution images were used in places where taken from books. Try to re-draw where possible.
- Be more careful with crediting pictures taken from elsewhere — always credit directly below the picture in question.
- A critical review of the current literature was expected but not found.
- A chronology of developments by others was expected.
- For the Barth paper, a list of things that were specified and those left for us to find out should have been presented.
- Suggested presentation format:
  - Introduction
  - GaAs vs InP
  - What has been done on power combining
  - Second harmonic power combining.

- Concentrate on information for power combining rather than explaining Gunn diode operation.
- If possible explain how much power is present in the fundamental frequency and second harmonic (nobody knows for sure).
- Make sure not to confuse $I-V$ curves any velocity-electric field curves.
- Emphasise differences with the Barth paper.
- Emphasise particular challenges with the project.

Presentation decisions

- R Wan's section will have to be re-written based on WS Truscott's comments.
- RE Irwin will be doing aims and objectives after the introduction.

Social event

- Lunch will be available for those wishing to attend before Monday's meeting.
- Time: 12:00.
- Place: The Number 1 Oriental Buffet, Whitworth Street.
- Meet: By the main entrance of UMIST on Sackville Street.

Proposed actions

All	Tweak slides if required: Deadline: 23:59:59 2004-01-31.
All	Prepare oral presentation for Monday's meeting.

Next meeting

Time Monday 2 February 2004, 14:00.

Place D floor coffee room.

Meeting adjourned, 13:05.

Gunn Diode Oscillator Minutes

David Headland

2004-02-02 14:00

Attendance

- Fourth year students:
  - R Wan.
  - JM Higginbotham.
  - MP Gaskill.
  - DP Headland.
  - RE Irwin.

Apologies

- AJ Nelms.

Approvals

- The minutes from the previous meeting were approved.

Radial line transformer

- The radial line transformer and radial disc functions were discussed.
- The Gunn diode has an associated capacitance.

- The radial line transformer has two functions:
  - Spreading the electric field out to fill the waveguide.
  - Be an inductor to act as a resonant circuit for the oscillator.
- If using the fundamental frequency to resonate, the radial line transformer must be used to extract the second harmonic.

Formal presentation

- Slide numbers need adding.
- Hand-outs need creating.
  - Copy of the slides with an area for notes.
  - Time plan attached.
- Shadows under text have appeared and need removing.
- Changes to slides were discussed and marked for change after the meeting.
- Summary section was discussed. Suggested items:
  - Not used: Research, simulation, building, testing, proposed work.
  - What we have done.
    - Research: based on the Barth paper. Mention differences.
    - Simulation: Waveguide, software, radial line transformer.
    - Testing: Commercial model, development of the plan.
    - Building: Designs and manufacture.
  - Leave the current state out, that should be obvious from other sections.
  - What we're going to do should be split into four sections as above.

Proposed actions

All	Tweak slides if required: Deadline: 23:59:59 2004-02-03.
All	Finish all preparations for the presentation.
JM Higginbotham	Provide photograph for one of the slides.

Next meeting

Time Wednesday 4 February 2004, 12:00.

Place D floor coffee room.

Meeting adjourned, 17:10.

Gunn Diode Oscillator Minutes

David Headland

2004-02-12 10:00

Attendance

- Fourth year students:
  - AJ Nelms
  - R Wan.
  - JM Higginbotham.
  - MP Gaskill.
  - DP Headland.
  - RE Irwin.

Approvals

- The minutes from the previous meeting were approved.

Waveguide manufacture

- MP Gaskill called P Norton last Friday as requested.
- P Norton had not spoken to N Priestley at that point.
- It was suggested that we not bother with water cooling.
- A standard heatsink from RS was suggested for cooling.

- The position of the diode within the waveguide can alter useable RF power by $\pm 10\,\mathrm{mW}$.
- P Norton called MP Gaskill back on Wednesday.
- They don't think our design will work because of backshort problems.
- Suggestions were made for improvement:
  - Split the backshort away from the main waveguide.
  - Make up about four backshorts to test them.
  - Use circular backshorts.
- Drawings are being produced to be sent to e2v tomorrow.
- Shims could be used for adjusting the waveguide length.
- 0.5 mm was suggested as a good shim thickness.
- We will ask e2v to make the shims along with the waveguide.
- Tolerances have been changed to 0.02 instead of the BS 0.05.
- We could build the waveguide in section to test with 2, 3 and 4 diodes.
- A single section could also be built for the final design.

Elected positions

- A vote was taken on whether to change any of the elected positions.
- It was unanimously decided that they should remain as they are:

Manager:	RE Irwin.
Auditor:	MP Gaskill.
Secretary:	DP Headland.

Power supply

- Power supply issues were discussed.
- We may not need to individually bias each diode, but we will not know until tests have been performed.
- Required features were discussed:
  - A maximum voltage limiter. This can be constant across all outputs.
  - Current limitation is not required.
  - Small would be preferable.
  - Digital control would be nice for smooth adjustments, but not required.

Time planning

- Points to consider were listed.
- A time plan check should be added to all future agendas before the "any other business" section.
- The manager is responsible for checking status with the plan.
- A new time plan was developed for this semester.

Simulation

- JM Higginbotham has been progressing.
- New waveguide dimensions were discussed for simulation.
- All members were invited for a demonstration if required.
- It was suggested that at some point in the future, we present our findings and methods internally to help give an understanding of the "big picture" to the whole group.

Proposed actions

MP Gaskill	Complete waveguide drawings and send to e2v and JM Higginbotham.
RE Irwin	Chase up the supervisors for feedback.
JM Higginbotham	Ask R Sloan to clarify waveguide dimensions.
RE Irwin	Measure e2v's power combining waveguide oscillator.
R Wan	Check MP Gaskill's calculations on the waveguide drawings.
RE Irwin	Look into re-claiming cash for the report binding (£8.08).
JM Higginbotham	Continue working on the simulation with R Sloan where required.
DP Headland	Research hot electron injection.
R Wan	Look into voltage references set digitally.
AJ Nelms	Research power supply circuits.

Next meeting

Time	Thursday 19 February 2004, 10:00.
Place	D floor coffee room.

Meeting adjourned, 12:18.

Gunn Diode Oscillator Minutes

David Headland

2004-02-19 10:00

Attendance

- Fourth year students:
  - AJ Nelms.
  - JM Higginbotham.
  - MP Gaskill.
  - DP Headland.
  - RE Irwin.
- UMIST Staff
  - WS Truscott from 11:07.

Apologies

- R Wan.

Approvals

- The minutes from the previous meeting were approved.

Power Supply

- AJ Nelms and R Wan are meeting this afternoon to progress here.
- Plans for the power supply have been produced.
- Designs are suitable for 1.5 A current per channel.
- PCB design is preferred for the finished design.
- The design eliminates the need for a voltage limiter as it is set digitally.
- A 6 A, 10 V PSU was suggested for the main supply.
- WS Truscott suggested capacitors between the output and ground. Ones at the device will also be required because of the inductance of supply leads.
- Using a pre-regulated voltage was suggested.
- Check for a PSU brick with the required voltage and current.
- Check with Ian regarding voltage regulation.
- Regulating each channel individually may be cheaper and easier.
- Four 2 A PSUs may be cheaper than a single 8 A PSU.

Simulation

- All was going well simulation the radial line transformer until rejection at the second harmonic was checked.
- Dimensions were altered to try give give >5 dB rejection.
- JM Higginbotham will talk to R Sloan and WS Truscott to try to find a solution.
- This needs to be sorted out quickly.
- WS Truscott recommends spending a lot of time on simulations.
- It was suggested that difficult problems are set going to be calculated over the weekends.

- More stages may be required on the radial line transformer to produce a more complex transformer.
- Model an existing filter and see how that works.
- Another person may need assigning to simulation.

Waveguide design

- Drawings have been changed by R Wan and JM Higginbotham.
- Designs have been submitted to e2v Technologies.
- The backshort is now circular to allow for greater tuning of the second harmonic.
- Individual Q factors have been calculated, but need to be combined.
- The losses in each section have been calculated.
- It has been suggested that the waveguide be simulated as a transmission line.
- The power combining waveguide was measured.
  - The device has similar length:width ratios to ours.
  - The device is designed to operate at a slightly higher frequency.

Progress with e2v

- MP Gaskill has spoken to P Norton.
- e2v Technologies are currently in the process of building the device.
- A long section is being made and will be cut into the required lengths.
- Liaise with R Irwin to limit calls to e2v to ≤ 2 per week.

Carrier energy raising

- Hot electron injection was discussed.
  - Papers were shown.
  - The summary was presented and explained.
- Graded gaps were discussed.

Interim report feedback

- Comments from the markers were copied and distributed.
- There were problems deciding what level to write at.
- We have to show that we're working professionally at a challenging project, yet were are managing to succeed.
- Use comments here to influence the final report.
- Make brief references to things that are well known.
- Start with a brief history of Gunn diode developments.
- To make the biggest improvements:
  - Alter the weighting of certain areas.
  - Change the writing style.
- WS Truscott will try to find an example report written in a good style.
- Getting facts right is very important in the final report.
- Good project reports state the final result. Bad ones describe a journey with many problems.
- Persuade the readers that the project is cutting edge:
  - The most relevant paper was written in 1981.
  - Power combining was dropped because InP was seen as better.
  - Research in 1982–2003 concentrated on InP, which has since been determined to be commercially infeasible.
  - We can improve on Barth's design with new simulation tools.

Marks assignment

- Individual mark assignments were discussed.
- Marks have not been decided upon yet.
- WS Truscott will discuss with R Sloan to come to an agreement.
- The individual mark adjustment value does not have to be an integer.

Forthcoming events

- There is a postgraduate open day on 3 March.
- There is a terahertz programme meeting in Cambridge on 2004-03-31.
- We may want to prepare a poster for this event.
- The poster could be used as a basis for the one in the demonstration.

Proposed actions

DP Headland	Post research on hot electron injection to the web site.
MP Gaskill	Call N Priestley to check the build status.
JM Higginbotham	Talk to R Sloan and WS Truscott regarding radial line transformer problems at the second harmonic.
AJN, RW	Meet to continue PSU design.
DP Headland	Research Gunn diode history and produce document.
AJ Nelms	Send a copy of the circuit diagram to DP Headland.
RE Irwin	Measure the radial line transformer and its cavity.
DP Headland	Reclaim the cost of binding the report from UMIST.

Next meeting

Time Thursday 26 February 2004, 10:00.

Place D floor coffee room.

Meeting adjourned, 12:42.

Gunn Diode Oscillator Minutes

David Headland

2004-02-26 10:00

Attendance

- Fourth year students:
  - AJ Nelms.
  - JM Higginbotham.
  - R Wan.
  - DP Headland.
  - RE Irwin.
- UMIST Staff
  - WS Truscott (10:15–10:30, 11:50–12:05).

Apologies

- MP Gaskill.

Approvals

- The minutes from the previous meeting were approved.

Power Supply

- The data acquisition board used by R Wan in his third year project is currently in use elsewhere.
- T York has been mailed to request borrowing another one.
- Alternative reference voltage sources were discussed:
  - A PWM controller implemented by a PIC with a low pass filter.
  - Using a standard analogue potentiometer as coarse control with a digital potentiometer for finer control, although automated ramping will not be possible here.
  - An FPGA in combination with a DAC.
- An old PSU without a cover has been found which could be used as the source for our circuit. It is rated at 6 A, 10 V.
- I Hawkins provided the group with an ISA8 DAQ card.

Feedback from directors

- WS Truscott has not been able to contact R Sloan to agree on feedback.
- Directors will arrange individual interviews with group members.

Progress with e2v

- WS Truscott will contact e2v to check on build progress.
- R Sloan and WS Truscott will concentrate on getting us some hardware to test.
- An oscillator will be available by 2004-03-07.
- If HFSS suggests that a particular radial line transformer design is good, we can get the designs to e2v in time for them to make them with the rest of the oscillator.

Simulation

- We will need to compare experimental results with simulated theoretical results.
- To do this, we will need lots of simulation data.
- Radial line transformer simulation is currently on hold as the results don't make sense. Help will be sought from supervisors.
- Work has continued with WS Truscott on the radial resonant disc.
- The disc operates at the fundamental frequency.
- Different sizes are being tried to find the optimum design.
- The column above the disc affects the second harmonic.
- e2v's waveguide and radial line transformer will be modelled.
- The model will be compared to the experimental results to check the accuracy of the simulations in general.

Gunn diode history

- Talking to Prof. Missous has been suggested for details.
- He has a lot of knowledge of the history.
- He could probably point us in the direction of good sources.

Final report

- Positive and negative comments about the interim report have been marked.
- Considering this, a preliminary breakdown of sections for the final report has been created.
- Chapters that end up having a lot of information in them can be split into multiple chapters if required.

- Sections should be submitted as soon as they are complete.
- Deadline for all sections is Friday 2004-04-02.

Preliminary task split

Executive Summary	Aims of the project, motivation, progress compared to plan (1 Page, do this last).
Introduction	Summary of the Interim Report including block diagrams (RUTH). Minor changes to project since R1.
Chapters	Main body:

1. Management — including safety, auditing, website etc.
2. Overview of research/history of the Gunn diode (DAVE).
3. Individual device system — design, simulation, testing, optimisation.
4. Multiple device system — design, simulation, power supply, heat sinking testing, optimisation.
5. Conclusion — Summary of testing, project to date and future objectives (for *this* design), progress against plan.
6. Other designs/future work — hot electron injection etc.

   Key Points for each Chapter:

   - Summary of work/findings from R1
   - Module Definition
   - Progress

Appendixes — Attached as a CD:

- Project plan - chart
- Minutes of meeting
- Financial Accounts - costs
- Design Documents

Long-term tasks

- Tasks should be retained with the following additions:

  R Wan: Heat sinking.

  MP Gaskill: Work with the testing team for optimisation.

Proposed actions

DP Headland	Ask G Blackman if there is a DAQ board available.
R Wan	Ask T York if there is a DAQ board available.
DP Headland	Discuss Gunn history with Professor Missous.
All	Mail possible times for interviews to the UMIST mailing list at `gunn-umist@winterwolf.co.uk`.
AJN, REI, DPH	Design a PCB once the bias circuit is finalised.
AJN, RW	Continue work of the PSU and bias circuit.
All	Start work on the report where possible.
RE Irwin	Mail the report task list to DP Headland for publication.
DP Headland	Check `gunn.winterwolf.co.uk` for AAAA records.

Next meeting

Time Thursday 4 March 2004, 10:00.

Place D2c coffee room.

Meeting adjourned, 12:12.

Gunn Diode Oscillator Minutes

David Headland

2004-03-04 10:00

Attendance

- Fourth year students:
  - AJ Nelms.
  - JM Higginbotham.
  - R Wan.
  - DP Headland.
  - MP Gaskill.
- UMIST Staff
  - WS Truscott (10:00–10:15, 12:00–12:13).

Apologies

- RE Irwin.

Approvals

- The minutes from the previous meeting were approved.

Power Supply

- This afternoon the 6 V 10 A power supply will be tested.
- A case needs to be made in the D floor workshop.
- The workshop may have holy or slotted metal to allow venting.
- Software is working for one output.
- Multi-output operation is being worked on.
- Bias circuitry is not suitable for 6 V operation.
- Bias circuitry should work without current limiting.
- Desired features for the software were discussed:
  - Individual diode biasing.
  - Individual diode switching on/off.
  - Ramping voltages up over time.
  - Current monitoring.
- Electrolytic capacitors may fail over time.
- Re-anodising has been suggested.
- This will be performed this afternoon.
- The workshop will PAT test the PSU on request.
- It was suggested that an IEC cable is added to the case for the PSU.

Simulation

- WS Truscott has helped with suggestions.
- The filter circuit is on hold.
- The resonant disc is causing problems, work continues.
- P Norton has made a radial line transformer for our oscillator.
- We can compare our simulated design with P Norton's.

Building

- The new device needs testing as soon as it arrives.
- Spacing between the diodes was discussed.
- The spacing will be a function of λ.
- MP Gaskill will phone to check progress.
- Drawings for the multiple device oscillator will be sent as soon as possible after testing the single device oscillator.

Final report

- The task split for the final report has been organised as follows:
  - Executive summary
    - Aims, motivation, progress compared to the plan: *Ruth*.
  - Introduction
    - Summary of interim report including block diagrams: *Ruth*.
    - Minor changes to the project since R1: *All*, *Ruth* to compile.
  - Body chapters
    - Management
      - Safety: Statement of changes: *Mick*.
      - Auditing: Finances: *Mick*.
      - Web site: *Dave*.
    - Overview
      - Research/Gunn history: *Dave*.
    - Single device oscillator
      - Design: *Mick*.
      - Simulation: *Jamie*, *Ruth*.
      - Testing: *Andrew*, *Dave*.
      - Optimisation: *Mick*.
    - Multiple device oscillator
      - Design: *Mick*.

        - Simulation: *Jamie*, *Ruth*.
        - Power supply: *Ray*, *Andrew*.
        - PCB: *Dave* (if required).
        - Testing: *Andrew*, *Dave*.
        - Optimisation: *Mick*.
    * Conclusions
        - Testing summary: *Andrew*, *Dave*.
        - Progress to date WRT time plan: *Ruth*.
        - Future objectives for this design: *Ruth*.
    * Other designs/future work
        - Hot electron injection: *Dave*.
        - Other information: *Ruth*.

- Key points for each chapter:
  - Summary of work/findings from R1.
  - Module Definition.
  - Progress.
- Appendixes (attached as a CD):
  - Project plan: *Dave*.
  - Minutes of meeting: *Dave*.
  - Financial accounts: *Mick*.
  - Design Documents: *Mick*.

Individual marks

- Suggested marks will shift percentages by ±2–3%.
- The marks shifting applies to the interim report and presentation.
- WS Truscott will provide us all with a copy of the mailed document to sign and return to T York.

Out of hours working

- Passes not required for normal hours working over Easter.
- K Williams will want to supervise all measurements.
- No passes required for supervised work.
- May be useful to get second opinions, too.
- Need to collect enough data to draw conclusions and suggest possible improvements.
- WS Truscott suggested thinking about the required props for the demonstration.
- Order required items soon to guarantee availability.

Proposed actions

DPH, AJN	Test the new and old oscillators with the attenuator as soon as they are available.
MP Gaskill	Check oscillator arrival and inform DP Headland and AJ Nelms.
R Wan	Send mobile phone software to MP Gaskill.
DPH, AJN	Test PSU and bias circuit.
JM Higginbotham	Continue work on the simulation.
AJN, DPH	Check and re-anodise PSU electrolytic capacitors.
R Wan	Make changes to the bias circuit software.
MP Gaskill	Ask e2v for the size of the pins for simulation.

Next meeting

Time Thursday 11 March 2004, 10:00.

Place D2c coffee room.

Meeting adjourned, 12:13.

Gunn Diode Oscillator Minutes

David Headland

2004-03-11 10:00

Attendance

- Fourth year students:
  - AJ Nelms.
  - JM Higginbotham.
  - R Wan.
  - DP Headland.
  - MP Gaskill.
  - RE Irwin.

Approvals

- One typo in the minutes from the previous meeting was corrected.
- The rest of the minutes were approved.

Power Supply

- Work carried out last Thursday was discussed.
- The power supply should be tested under load if possible.
- Current measurement has been implemented in software.

- Problems have been experienced in coding a ramp.
- Current ramp time is less than 1 μs.
- Low ohmic resistors need to be specified and purchased.

Simulation

- Previous model has been found to be unsuitable.
- A new model has been started.
- Current model simulates in about 1 hour.
- Simulations are being left to run overnight.
- The results produced are more useful.
- A likely resonant frequency has been found.
- Radial line transformer simulation take approximate 30 minutes.
- Good results have been obtained with a single disc.
- Work will start on >1 disc.
- The model is being built up in steps to help understanding.
- It may be worth looking into simulation on Eric if this is possible.

Manufacture

- Last week, MP Gaskill spoke direct with Bernard from e2v.
- The design is almost complete.
- They are waiting on a tool from Switzerland.
- P Norton has passed on relevant dimensions for the housing.
- Bernard and P Norton suggested a visit to e2v to help with the design and manufacture of the multiple device oscillator.
- Drawings should be sent before Easter.
- A visit could be arranged after the Easter holidays.

Finances

- Costs have been split up.
- A copy of the schedule has been handed out.
- This should be filled in and handed in to MP Gaskill next week.
- In the facilities section, roughly break down resources used.

Final report

- Single diode design section complete.
- Multiple diode design section is generally changes.
- It may be suitable to merge these sections into one.
- Something should be put in the report about trying to find alternative manufacturing facilities.

Demonstration

- An ideal list of resources for the demonstration was complied:
  - Computer, including:
    - HFSS.
    - LCD panel.
    - Network connection.
  - Computer, including:
    - ISA8 slot for the DAQ card.
    - LCD panel.
  - Oscillators for demonstration:
    - Single device.
    - Multiple device.
    - Commercial devices.
    - PSU.

    - Biasing circuitry.
    - Attenuator.
    - Mixer.
    - Spare Gunn diodes.
  - Large scale Gunn diode model.
  - A laminated copy of the paper by H Barth.
  - Records:
    - Minutes.
    - Agendas.
    - Plans.
    - Log books.
  - Name badges.
  - Poster.

Miscellaneous

- An Accenture presentation is scheduled for Tuesday next week. It has been suggested that we all attend.

Proposed actions

REI, JMH	Continue simulation.
AJN, REI, DPH	Take measurements for the PSU case.
All:	Fill out the financial schedule form.
DP Headland	Mail AJ Nelms for circuit diagrams.
MP Gaskill	Work on documentation for the final report.
DPH, AJN	Work on developing the PSU hardware.
R Wan	Work on the PSU software.
RE Irwin	Talk to WS Truscott regarding device problems.
DP Headland	Find out if the attenuator flanges are here.
RE Irwin	Look into the teamwork award.

Next meeting

Time Thursday 18 March 2004, 10:00.

Place D2c coffee room.

Meeting adjourned, 11:17.

Gunn Diode Oscillator Minutes

David Headland

2004-03-18 10:00

Attendance

- Fourth year students:
  - AJ Nelms.
  - JM Higginbotham.
  - R Wan.
  - DP Headland.
  - MP Gaskill.
  - RE Irwin.

Approvals

- The minutes from last week's meeting were approved.

Budget allocations

- Budget allocation forms were submitted to MP Gaskill.

Power supply

- Power supply testing was discussed.

- The wiring of the switch and polarity of cables needs checking.
- The PSU case was discussed and demonstrated.
- A suggestion was made to blank the bottom slot on the AT case.
  - The idea was rejected.
  - Leaving it free would allow air from over the heatsinks then out through the AT PSU extractor fan.
- Work on the software is continuing.
- A circuit for reference voltages has been set up and is being tuned.
- Tests will be made with the AT PSU.
- Current limiting will require a $\frac{1}{3}\,\Omega$ high power resistor.
- Three $1\,\Omega$, 11 W resistors in parallel were suggested.

Simulation

- Many problems are being encountered.
- The simulation does not match up with the theory.
- Time will be booked with R Sloan to try to provide suggestions.
- WS Truscott suggested writing a mini report on the current simulation situation.
- RE Irwin's simulations are progressing well.
- She has developed a good knowledge of the radial line transformer and the relationship between its shape and resonance.
- Work is being carried out to determine if there is an advantage to having more than one notch in the radial line transformer.

Manufacture

- MP Gaskill talked to Bernard during the week.
- He has included a spring for tensioning the radial line transformer.
- Gunn diode housing calculations were submitted to DP Headland.
- Bernard has all required parts from P Norton.
- P Norton will fit all parts to the housing.
- A meeting with e2v at the start of next week has been suggested.
- MP Gaskill will arrange this meeting today.

Team working

- The team working prize forms have been filled in.
- Information from the Accenture presentation has been considered.
- A large amount of details has been included.
- The demonstration was discussed.

Test equipment

- Progress with the waveguide extensions was discussed.
- WS Truscott has not talked to the workshop.
- WST, AJN and DPH will visit the workshop after the meeting.
- The attenuator was discussed.

Issues log

- The idea of an issues log was discussed.
- One should be created based on issues raised in previous minutes.
- The log should be updated in real time from now on.
- This should be included in the final report.

Final report

- Search for "power combing" in the final report.
- The report sections are due in on or preferably before 2 April 2004.

Proposed actions

All	Attend meeting for e2v questions if possible: 2004-03-22 12:00.
MP Gaskill	Arrange the e2v meeting and mail the date to the list to solicit candidates.
JMH, REI	Create a mini report of the simulation progress.
JM Higginbotham	Book simulation time with R Sloan.
AJN, RW, DPH	Design PCB.
RE Irwin	Mail team working document to the list.
All	Mail RE Irwin with changes to the team working document.
RE Irwin	Include liaison with e2v in the final report.
DP Headland	Create an issues log based on past issues.
DPH, AJN	Arrange the first week of Easter for project work.
RE Irwin	Talk to Tuesday's lecturers regarding e2v visit.

Next meeting

Time Thursday 25 March 2004, 10:00.

Place D2c coffee room.

Meeting adjourned, 11:48.

Gunn Diode Oscillator Minutes

Mick Gaskill

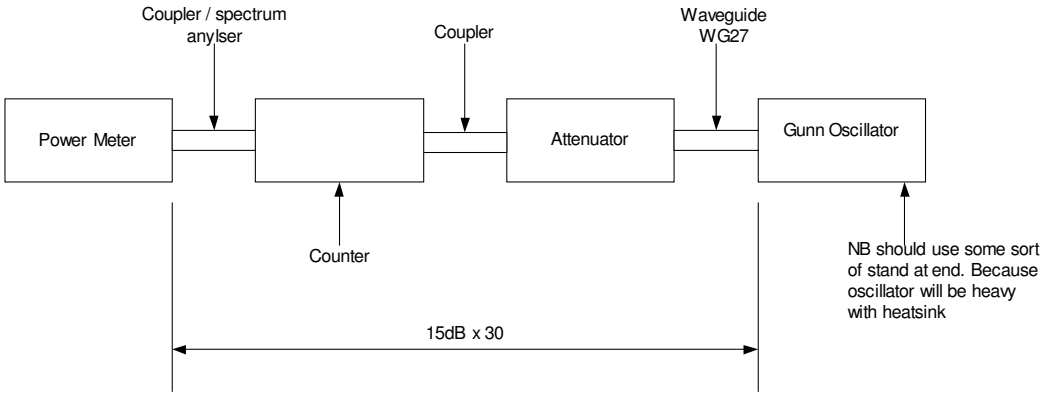
2004-03-23 09:35

Attendance

- Fourth year students:
  - JM Higginbotham.
  - AJ Nelms.
  - MP Gaskill.
- e2v personnel:
  - Nigel Priestley.
  - Philip Norton.
  - Bernard Whitworth.

Testing laboratory

* Phil Norton explained the test equipment he was using and a sketch was made.



- Phil had an accurate power supply — it is important to take account of volt drop.
- The oscillator has a $1\,\mu$F capacitor mounted at the biasing point this can be between 1–$10\,\mu$F. The leads connecting from the oscillator to the supply should be short as possible to reduce any inductance.
- The connections to the oscillator were then soldered.
- The oscillator was then mounted on the waveguide WG27 but not tightened. The power was then switched on, the oscillator was then firmly secured by tightening the screws individual, constantly looking at the power meter. This is to gain the optimum power output and reduces any air gaps, note that losses can be as much as 20 mW!
- The initial frequency was 85.8991 GHz with 35 mW of power, using 5.402 V and taking 0.785 A.
- Phil mentioned using the "frequency pushing method". This means to alter the frequency of the Gunn while keeping the power flat over that region.
- At this point Phil explained that it would be a important to take some measurements on this working system before the team got their hands on it.
- The parameters taken were voltage, current, frequency, power, over different backshort distances. It was suggested that these figures could be used in the report testing section. A plot of power versus voltage would be interesting. A set of Vernier were used to measure the backshort distance.

Backshort (mm)	Bias (C)	Current (A)	Power (mW)	Frequency (GHz)
13.0	4.5	0.776	21.5	85.69
13.0	5.0	0.773	16.5	85.83
13.0	5.5	0.771	12.0	85.94
13.0	6.0	0.772	9.0	86.00

Backshort (mm)	Bias (C)	Current (A)	Power (mW)	Frequency (GHz)
13.5	4.5	0.771	4.0	85.63
13.5	5.0	0.770	5.0	85.80
13.5	5.5	0.770	5.0	85.91
13.5	6.0	0.771	6.0	85.98

Backshort (mm)	Bias (C)	Current (A)	Power (mW)	Frequency (GHz)
14.0	4.5	0.775	16.0	85.62
14.0	5.0	0.773	19.0	85.79
14.0	5.5	0.773	19.0	85.90
14.0	6.0	0.773	17.0	85.96

Backshort (mm)	Bias (C)	Current (A)	Power (mW)	Frequency (GHz)
14.5	4.5	0.771	7.0	85.59
14.5	5.0	0.769	5.5	85.76
14.5	5.5	0.770	10.0	85.87
14.5	6.0	0.771	11.5	85.94

Backshort (mm)	Bias (C)	Current (A)	Power (mW)	Frequency (GHz)
15.0	4.5	0.778	40.0	85.61
15.0	5.0	0.774	35.0	85.77
15.0	5.5	0.772	32.0	85.87
15.0	6.0	0.771	25.0	85.93

Backshort (mm)	Bias (C)	Current (A)	Power (mW)	Frequency (GHz)
15.5	4.5	0.768	5.0	85.52
15.5	5.0	0.766	4.0	85.69
15.5	5.5	0.776	4.0	85.80
15.5	6.0	0.768	4.5	85.87

- It was seen that not much variation of frequency versus backshort.

- During these tests it was noted that the device was getting hot, Phil stated that the could run to approximately 115°C. But this would result in a reduced power, therefore its important to keep the device cool.

- Phil then recommended it would be beneficially to the group to take the device apart and look inside and re-set it back up ourselves.

- Insulation is placed round the radial line transformer pin, a length of this tape was given to the group and is wrapped around a pencil. The tape $\varepsilon_r = 2.2$. As an estimate the length of tape to put round each radial line pin is $1\frac{1}{4}$ turns. A washer is on the top of the radial line transformer pin this is at ground potential. The dimension of the pin were approximately 2.5 mm diameter and 1.5 mm thick. A sketch was made.

- Andrew replaced the Gunn diode with an alternative, the diode sits within a housing and sits flat to the floor in the cavity, the flange of the diode sits on the floor of the waveguide.

- The Gunn diode was tweaked. Rotating the Gunn while connected to the supply is a way of optimising the potential output, although if the contact is loss with the radial line this can cause the Gunn diode to be destroyed if the contact is made back again instantly. Phil demonstrated this.

- The spring keeps the contact in position, this can be used to lock the diode at the highest power.

- Optimum performance was at 85.05 GHz with 50 mW of power, although he stated that he could not get the goal frequency 87 GHz. Phil stated that it was not the package design, it would likely to be the oscillator design. Mick provided a solution to the problem by having a extra shim that could be implemented, Bernard made one.

- It was suggested that a second harmonic backshort slide could be used to optimise the second harmonic frequency. Bernard had produce four different backshorts set at different lengths: 0 mm, 0.5 mm, 1.0 mm, 1.5 mm. These results showed that little was to gain from this line of design.

Distance (mm)	Power (mW)	Frequency (GHz)
0.00	44.0	85.68
0.50	45.0	85.70
1.00	45.5	85.74
1.50	25.5	85.61

- Phil showed the group of a second example of this sort of design produced by a old employee of e2v. This looked fairly similar although the spacing between the diodes has various numbers of shims at different sizes, this was to gain the optimum performance.

- Again Phil suggested that the paper by H.Barth was lacking the full truth.

- Jamie went to discuss the simulation he has been doing with Keith Newsome (senior engineer).

- Mick went to discuss with Bernard Whitworth (machinist) about some points with the manufacturing of the device.

- Bernard explained that he would be extremely busy with customers and would be unlikely be able to spend much time on this project. Mick suggested that we did not need the full version to be built a more feasible solution would be just to build the Gunn diode housings. He agreed this would reduce the turnover time although expressed that his other jobs were a priority but would be happy to do our work but Nigel would have the final approval.

- At this point we all met back up in the meeting room to discuss the days findings and actions required from both parties.

- It was suggested that it would be more feasible to aim for using two Gunn diodes as this would be solving the design requirements of power combining. Due to the performance of the single device it would be hoped to get about 80 mW with two. Then we could add on a third device if possible.

- A heatsink and fan was provided by Nigel for us to use.

- It was expressed that the Gunn diodes should be manufactured at very latest for the first week in May, Bernard and Nigel agreed that this job should be prioritised with the other impending customer jobs.

Proposed actions

RE Irwin	Send Nigel the exact detail of the time of demonstration and location as soon as its available, reminder to bring the full scale Gunn model.
MPG, JMH	Report back to team with findings.
MP Gaskill	Send details of the exact lengths of the Gunn diodes housing ASAP to Bernard.

Next meeting

Time	Thursday 25 March 2004, 10:00.
Place	D2c coffee room.

Meeting adjourned, 15:00.

Gunn Diode Oscillator Minutes

David Headland

2004-03-25 10:00

Attendance

- Fourth year students:
  - JM Higginbotham.
  - R Wan.
  - DP Headland.
  - MP Gaskill.
  - AJ Nelms (10:42).
  - RE Irwin (11:01).
- UMIST staff:
  - WS Truscott (10:50).

Apologies

- JM Higginbotham.

Approvals

- The minutes from last week's meeting were approved.

Power supply

- Everything apart from the PCB has been designed.
- PCB design is mainly complete but needs finalising.
  - Pad widths need defining.
  - Trace widths need defining.
- Estimated time plan for the power supply:
  - Submit the circuit design tomorrow.
  - Have components fitted by Easter.
  - Complete testing by the first week after the holidays.

e2v meeting

- A separate set of minutes was produced by MP Gaskill.
- Lots of help was obtained from Keith Newsome.
- We have requested a copy of the HFSS Gunn diode model.
- P Norton explained the function of the radial line transformer.
- The positioning of diodes within the housing was discussed.
- Diodes will be offset from centre to allow for more combinations.
- The offset will be $\frac{\lambda_g}{12}$.
- This was a major decision, and should be documented as such.
- Measurements of the radial line transformer must be made and sent to P Norton ASAP.
- Mechanical engineering have measurement specialists.
- They may be able to measure the pin to high accuracy and precision.

Simulation

- Simulated designs have been compared to e2v's designs.
- One notch gives -40 dB rejection.
- A singe notch resonates in the transformer cavity at 80–90 GHz.
- The second notch stops the resonating.
- This suggests a match between simulation and practical results.

Financial position

- The finances have been organised.
- Cumulative costs are as follows:
  - Physical oscillator materials: £200.
  - Including waveguide extensions: £400.
  - Overheads including stationery: £550.
  - Total cost including labour: £6500.

Proposed actions

All	Finish documentation and submit.
DP Headland	Look into the frequency pushing testing method.
MP Gaskill	Order some 3 mm threaded bar.
DP Headland	Change the typeface in the diagram in the e2v minutes.
RE Irwin	Send the radial line transformer dimensions to P Norton.
RW, AJN, DPH	Discuss connectors for the PCB.

Next meeting

Time Thursday 22 April 2004, 10:00.

Place D2c coffee room.

Meeting adjourned, 12:13.

Gunn Diode Oscillator Minutes

David Headland

2004-04-22 10:00

Attendance

- Fourth year students:
  - JM Higginbotham.
  - R Wan.
  - DP Headland.
  - MP Gaskill.
  - AJ Nelms.
  - RE Irwin.
- UMIST staff:
  - WS Truscott (11:30).

Approvals

- The minutes from the last meeting were approved.

Power supply

- The control PCB is now complete.
- Some components are in place, others need to be added.
- PSU needs testing, which will be started tomorrow.
- The expectation is that the PSU will work.

Manufacturing

- e2v have found that the power combining system is tricky to set up.
- Part of the team has been invited to Lincoln to perform tests and set the multiple device oscillator up correctly.
- P Norton will be asked for suitable times.

Testing

- Those going to e2v should take our own graphs and ask for e2v's analysis to compare with our own.
- Compare two and three diode combining efficiency.

Simulation

- A model similar to e2v's will be required for further progress.
- Their current model works in a planar circuit.
- K Newsome said that he would send the model of the diode.
- We should mail him to check the current status of this.
- Could use this model as extra work beyond our original specifications.

Future tasks

- Tasks still to perform for the project were discussed.
- The following list was created, along with finish times:

    1. Combine PSU and control hardware (23 April).
    2. Test PSU system (30 April).
    3. Test multiple device oscillator (7 May).
    4. Simulations (7 May).

5. Poster (4 June).
6. Demonstration preparation (8 June).
7. Self appraisal (10 June).

Proposed actions

JM Higginbotham	Mail K Newsome for the diode model.
MP Gaskill	Mail e2v to arrange a visit next week.
MPG, REI	Start on the poster and demonstration preparation.
AJ Nelms	Prepare for the e2v visit.
R Wan	Order components to finish the PSU.
RW, AJN	Test the PSU.

Next meeting

Time	Thursday 29 April 2004, 10:00.
Place	D2c coffee room.

Meeting adjourned, 11:58.

Gunn Diode Oscillator Minutes

David Headland

2004-04-30 10:00

Attendance

- Fourth year students:
  - JM Higginbotham.
  - R Wan.
  - DP Headland.
  - MP Gaskill.
  - AJ Nelms.
  - RE Irwin.

Approvals

- The minutes from the last meeting were approved.

e2v meeting

- Minutes from the e2v meeting were distributed.
- An overview of the progress of the meeting was given.
- A suggestion was made to remove the second harmonic waveguide from the oscillator as the waveguide extensions will do the same job. This is only applicable for the testing, as waveguide extensions are no used in production.

Power supply

- The PSU is not currently thoroughly tested.
- The S/H doesn't like negative inputs.
- Positive inputs will be given to the S/H and unity gain inverting amplifiers will be used after the S/H devices.
- The PSU is required for multiple device oscillator testing.
- Testing should start as soon as the PSU is complete.
- The situation will be reviewed on Thursday.

Project demonstration

- A high-level outline was created, distributed and discussed.
- The equipment list was discussed and modified.
- Deadline for the epilogue sections was set to mid day on 4 June 2004.

Poster

- The general layout has been completed.
- No content is currently in place. This will be added soon.
- Remember to include the supervisors' names on the poster.
- It was suggested that R Sloan's poster layout is used.

Simulation

- The model of the Gunn diode has been received from e2v.
- The backshort has been modelled.
- These will be included in the simulation section of the epilogue.

Possible paper

- R Sloan congratulated the group.
- He suggested that WS Truscott and himself could write a paper on the project.
- This could increase the marks for the group.
- We should suggest this to WS Truscott.

Team working competition

- We are through to the final four in the "UMIST academic" category.
- We have been invited to a meal where the winners will be announced:
  - Staff building at Manchester University.
  - Be there 17:00 for 17:30.
  - Meet outside Kro Bar at 16:50.
- The dress code is smart/casual.
- A buffet will be provided after the presentation of awards.
- The event is expect to end around 22:30.
- This issue should be raised again on Thursday.
- Reminder
- A referendum will be held on the UMIST/Manchester merger next Wednesday.
- Please **vote**!

Proposed actions

DP Headland	Re-format the e2v minutes and put on the web site.
RE Irwin	Invite WS Truscott and R Sloan to the awards evening.
JM Higginbotham	Continue simulations.
AJN, RW	Test and complete changes to the PSU.
RE Irwin	Continue work on the poster.
MP Gaskill	Continue work on the demonstration.

Next meeting

Time	Thursday 6 May 2004, 10:00.
Place	D2c coffee room.

Meeting adjourned, 13:12.

Gunn Diode Oscillator Minutes

David Headland

2004-05-06 10:00

Attendance

- Fourth year students:
  - JM Higginbotham.
  - R Wan.
  - DP Headland.
  - MP Gaskill.
  - AJ Nelms.
  - RE Irwin.
- UMIST staff:
  - WS Truscott (11:15)
  - R Sloan (11:15)

Approvals

- The minutes from the last meeting were approved.

Power supply

- Problems have been observed with the voltage dipping.
- Different programs have been tried with no success.
- It will be tried with a commercial oscillator, but it's not expected to work.
- A large capacitor will be tried to smooth this out.
- Take everything to the demonstration even if it isn't fully functioning.
- Take an oscilloscope to show the dip.
- Be ready to explain the dip if questioned.
- The computer can still be used to monitor the voltages.
- Get two computer controlled channels working if possible.
- The third channel can use a potentiometer on the reference.
- New PSU deadline has been set: Wednesday 2004-05-12.

Miscellaneous

- Required work on the project should stop 7 days before the first exam.

Simulation

- The Maltese cross model has been received and imported.
- It isn't solid at present.
- It's coordinated cannot be easily set.
- Assistance from WS Truscott will be sought.
- Perfect results are not expected from this model.
- We could model the final radial line transformer.
- This model could then be shown at the demonstration.

Demonstration

- Currently, MP Gaskill is trying to organise props.
- A name tag has been completed.
- This tag can be used as a template for other name tags.
- Simulation pictures will be required for the display.
- The format of the demonstration was discussed.
- Ideally, we would demonstrate a single diode oscillator followed by an n-diode oscillator.
- Practically, we may be better demonstrating the combining oscillator then replacing it with the single device oscillator whilst other areas of the project are being demonstrated.
- We could use e2v's commercial oscillator if required.
- We may want a computer running HFSS at the demonstration.
- Martin Edwards and Dave Armitage will be marking.
- They will mark well for engineering content.
- We will need to talk about how we managed e2v.
- It was suggested that a dummy demonstration takes place with the equipment on E floor.
- This trial will be useful for timing purposes.
- We will need to find out about calibration from K Williams.
- A good way to do sections of the presentation would be to have one person talking and another practically demonstrating.
- Interactions will show that both understand the process well.
- Power combining and simulation are ideal section candidates.
- 3–4 speaking parts was suggested as possibly optimum.
- It should be clear in the management section what everyone's primary role is.

- Questions are always asked on project management.
- Don't be afraid to cut parts that don't seem up to scratch.
- It's not a problem to say that certain parts couldn't be investigated as far as we would have liked because they were more involved that initially anticipated.
- Questions are likely to be asked on the functions of:
  - The resonant disc.
  - The radial line transformer post.
- Always have a strategy for failure.
- Try n times then skip it and come back if it's working before the end.
- Video can be used as a last resort.
- The markers will have seen previous presentations and reports.
- Starting with a working whole systems is a good idea.
- This can be taken to bits afterwards to show how things work.

Poster

- Example templates were distributed.
- The formats were discussed.
- The content has not been finalised but is being worked upon.
- Previous years' posters are kept by staff in B21.
- Check the contrast between colours rather than actual colours.
- Background pictures were suggested.
- Perhaps a photograph of the large scale Gunn diode model?

Awards ceremony

- Team working awards ceremony this evening.
- Meet outside Kro Bar near Dover Street at 4:50.
- Dress code is smart/casual.

Epilogue

- RE Irwin will post an example epilogue structure soon.
- This should be commented upon by all team members.

Testing

- We may be able to try to optimise the device configuration.
- The front diode is in a cavity stopped by the back diode.
- Comment upon this in the epilogue.
- The cavity length affect frequency, so will relative diode positioning.

Published paper

- There is a possibility of a paper being published based on the project.
- This would require graphs that tell a story.
- We would need to know:
  - What changes the frequency of each diode.
  - What frequency range locking occurs within.
- The team would publish the paper.
- Ana electronics letter would be preferred over a journal paper.
- Letters take less time to be approved than papers.

- Feedback from letters is either a will or won't publish.
- Can state something like "a paper is in preparation on the basis of the project" in the epilogue.
- We probably would get many extra marks for this.
- If we are in a position to do this, we should do so, but should not spend a disproportionate amount of time on it.

Closing the project

- The project must be closed after the demonstration.
- Simulations should be burned to CD.
- WS Truscott and R Sloan should receive a copy each.
- We can keep the equipment if we need it for writing the paper.
- When finished, equipment should be returned to WS Truscott.
- UMIST will keep the equipment until the no longer need it.
- After that, it will be returned to e2v for their own use.

Proposed actions

RE Irwin	Mail the draft epilogue structure in.
DPH, AJN	Try testing the multiple device oscillator with two PSUs.
MP Gaskill	Check the presentation board sizes.
JM Higginbotham	Send interesting simulation pictures to MP Gaskill.
DPH, AJN	Check with K Williams about the calibration process.
R Wan	Acquire a digital camcorder for critical tests.
DP Headland	Sort out whiskey at ≈£10/bottle.
R Wan	Send a photo in for inclusion on the project web site.

DP Headland	Look into getting aluminium foil for shims.
All	Start thinking about what to say in the demonstration.
DPH, AJN	Check that we can have test equipment for the demo.
DPH, AJN, RW	Continue testing the PSU: D floor lab, 1:30 Monday.
MP Gaskill	Provide mechanical drawings for the demonstration.
RE Irwin	Ask Pauline Bradshaw for poster templates.

Next meeting

Time	Thursday 13 May 2004, 10:00.
Place	D2c coffee room.

Meeting adjourned, 12:33.

Gunn Diode Oscillator Minutes

David Headland

2004-05-13 10:00

Attendance

- Fourth year students:
  - JM Higginbotham.
  - R Wan.
  - DP Headland.
  - MP Gaskill.
  - AJ Nelms.
  - RE Irwin.
- UMIST staff:
  - WS Truscott (Until 10:10).

Approvals

- The minutes from the last meeting were approved.

Testing

- Looking at the fundamental waveguide, the output is a mirror.
- The backshort is also a mirror.

- For the fundamental, each diode is also a mirror.
- Therefore, multiple overlapping cavities are created for > 1 diode.
- Rotating housings will change these section lengths.
- The backshort may just affect the back diode.
- Second harmonics should be affected less by the diodes.

Competition

- Details of a competition were circulated by WS Truscott.
- The "Science, Engineering and Technology Student of the Year".
- £2000 is available for the best student.
- Full details at `http://www.setawards.org/`.
- Team entries are allowed, but one student should represent the team.

Poster

- MP Gaskill has produced an independent poster.
- The design is very similar to RE Irwin's layout.
- The best features of each will be selected for the final design.
- The team moved to a computer to comment on the design.
- The following changes were suggested:
  - The background picture is a good idea.
  - Change the combining oscillator diagram to our design.
  - Include a brief description of the single device oscillator.
  - Get a good graph from oscillator testing.
  - Replace the UMIST logo with a vector image.
  - Include the following references:

    * Barth's paper.
    * The "microwave bible".
    * e2v's web site.
    * Our web site.

- Printing has not currently been arranged for the poster.

Demonstration

- Pictures have been printed for the display.
- Documents will be laminated for public viewing.
- Mechanical drawings will have calculations on the reverse.
- Quantity is being created, quality items will be selected later.
- Name badges have been produced with roles within the team.

Demonstration Meeting

- T York has been emailed regarding the demonstration location.
- He will tell all teams at the same time in the future.
- He has arranged a meeting to discuss this:
    - Thursday 20 May 2004, B29.
    - All managers must attend.
    - All supervisors should attend.
    - Attendance should be confirmed ASAP.

Accenture prize

- This is likely to be won by the tomography team.
- We are acting as consultants to e2v rather than employees.
- We need to differentiate ourselves on this point.
- e2v's role should be made clear in the project demonstration.

Power supply

- Problems were encountered with the PCB automatic routing.
- Extraneous links were created copying PSU components.
- It was suggested that voltage monitoring should be tested.
- Measuring is definitely possible to within $\pm 10\,\mathrm{mV}$.
- The card contains a 12-bit DAC, so greater resolution should be possible, but this must be tested.

Simulation

- Generally progressing well.
- Backshort simulation tests are complete.
- Future work will go into trying to use e2v's diode model.
- WS Truscott will be available to help this afternoon.
- The RLT P Norton made will be simulated.
- Measurements for the RLT will be made ASAP.

Miscellaneous

- A draft epilogue structure was presented.
- Good luck to everyone in the exams.

Proposed actions

RE Irwin	Update the poster according to comments.
JM Higginbotham	Send simulation pictures (preferably vector format) to RE Irwin.
RE Irwin	Contact T York and supervisors about the meeting.

DP Headland	Send current testing graphs to RE Irwin.
RE Irwin	Obtain a photograph of one of the oscillators.
DP Headland	Send new testing graphs to RE Irwin ASAP.

Next meeting

Time	Tuesday 1 June 2004, 09:00.
Place	D2c coffee room.

Meeting adjourned, 11:35.

Fourth Year Project Managers' Meeting Minutes

David Headland

2004-05-20 11:00

Attendance

- Project managers.
- Project supervisors.
- T York.

Meeting progress

- Intention: to discuss the document sent out outlining the demonstration and any other issues teams have about the day.
- The plan is to have the informal part of the demonstration day in the morning; this time is open to anyone who wishes to come. In the afternoon the formal presentations will take place.
- Request was made to change this, to have the formal demonstration in the morning and informal in the afternoon, particularly considering the fragility of some of the teams' works, all four of the student teams voted for this change. Dr York will look into this.
- Location: MB B29 All teams must set up their demonstration area the day before, and be fully ready by 9:30 AM on the day of the demonstration. Penalties will be incurred for not being ready by 9:30 AM. It is recommended that project equipment, computers and any other piece of valuable equipment are not left in B29 overnight.

- All four demonstrations will be in B29, though for the formal afternoon session only the presenting team, their supervisors, industrial collaborators and markers will be present during their hour time slot. There is no restriction on the amount of space each team occupies though consideration for each other is requested.

- On 9 June 2004, B29 will be accessible from 12:00 PM and on the 10 June 2004 the room will be accessible from 8:00 AM, Dr York is going to sort this out.

- There are network ports in the room, so Internet access university server access is possible. May need to take an Internet connection from Eddie Welch's office, since there may only be one point in the room.

- Each team is responsible for organising all of their own equipment, and of particular importance is extension leads! It is recommended that each team carefully calculate how many connections they will need and provide them themselves.

- Each team must organise their own poster/back boards. They can be any size, shape and colour.

- Only one poster may be displayed by each team.

- Each team may use as many tables as they desire, the tables are those already in B29. Dr York will look into moving any additional tables from the room.

- During the formal demonstration the team is responsible for directing the spectators before, during and after their demo, and must be particularly mindful of optimising this throughout the demonstration.

- Before and after the formal demonstration equipment may be moved from B29 if it can be done smoothly and quickly. There will be a few minutes for this before and after the formal. The morning session is 9:30–1:30 and the afternoon session is 1:30–4:30. There is no formal break for lunch, and food is not provided.

- During the informal part of the demonstration there should be at least two members present at all times. It is advised that during the informal session, as markers circulate it is probably best to allow them to look around themselves and not disturb them, just answer any questions they may have.

- The formal session will be marked by six people and viewed by up to 12 people.
- Remember: it is not a power point presentation and the project must be *proved* to work, beyond reasonable doubt.
- Each team has been asked to compile a sheet of suggestions/project feedback, both good and bad to help improve the project for the next fourth year.
- Are the teams interested in organising a social event for that evening, if so, it is recommended that something is organised before the day.
- We are having the space alongside Eddie Welch's office, which has a network socket, mains socket and projector screen. Also, this space is the first space on entering the room, which works well for catching the attention of all the viewers.
- It has been recommended that spectators, for example, students be organised to visit, to increase interest in your display and demonstration to the markers.

Gunn Diode Oscillator Minutes

David Headland

2004-06-01 09:00

Attendance

- Fourth year students:
  - JM Higginbotham.
  - R Wan.
  - DP Headland.
  - MP Gaskill.
  - AJ Nelms.
  - RE Irwin.

Approvals

- The minutes from the last meeting were approved.

Managers' meeting

- The minutes from the managers' meeting were distributed.
- Events and changes were discussed.

Project demonstration

- We may want to take e2v staff for a meal after the demonstration.
- At least two people must be present at all times.
- We *must* be ready for 9:30 to avoid being penalised.
- The room will be open by 8:00 for preparations.
- Films of the testing could be shown in the informal demonstration in the morning to avoid changing settings.
- A list of parts was distributed and discussed.
- It may be useful to split the talking and practical demonstration been people for certain elements, although this will require some planning and choreography.

Self appraisal

- The self appraisal must be completed.
- This week is not a good time because of the epilogue deadline.
- It could be completed after the meal with e2v next Thursday.

Epilogue

- The epilogue structure draft was distributed and discussed.
- Tasks for the epilogue body were assigned as follows

  Acknowledgements: MP Gaskill.

  Executive summary: RE Irwin.

  Introduction: RE Irwin.

  Simulation: JM Higginbotham.

  Power supply: R Wan, AJ Nelms.

  Testing: AJ Nelms, DP Headland.

Conclusions: DP Headland, AJ Nelms.
Future work: All, if required.

- Deadline for submissions is 12:00 noon, Friday 4 July 2004.
- Early submissions are welcomed.

Power supply

- Stripboard layouts have been designed and built.
- They incorporate voltage regulators and current limiters.
- Testing will take place this morning.
- Mounting will take place early this afternoon.
- After mounting the PSU should be usable.
- Inputs can be taken from potentiometers or R Wan's references.
- Voltage monitoring would be very useful.
- Suggest using three panel mounted DVMs for measurements.
- DVMs will not be required for testing.

Simulation

- Simulation is due to be finished today.
- The epilogue section will be written afterwards.
- The Maltese cross can't be used, which is disappointing.
- Help will be sought from WS Truscott.

Poster

- The poster design is almost finished.
- References need to be added.
- Some pictures need to be selected by JM Higginbotham.

Testing

- Testing plans have been discussed.
- Power supply and multiple device oscillator testing will start this afternoon.
- This should be video recorded.
- Next week, if time permits, a video recording of testing the single device oscillator should be taken.

Proposed actions

RE Irwin	Laminate the technical drawings for the display.
DP Headland	Place the managers' meeting minutes into LyX.
RE Irwin	Mail the managers' meeting minutes to DP Headland.
DP Headland	Re-print all minutes and agendas for binding.
RE Irwin	Mail WS Truscott to finalise the mail with e2v.
MP Gaskill	Re-send the documents related to the demonstration.
RE Irwin	Formally invite e2v staff to the demonstration.
JM Higginbotham	Provide simulation pictures to RE Irwin.

Next meeting

Time	Thursday 3 June 2004, 09:00.
Place	D2c coffee room.

Meeting adjourned, 10:08.

Gunn Diode Oscillator Minutes

David Headland

2004-06-03 09:00

Attendance

- Fourth year students:
  - JM Higginbotham.
  - R Wan.
  - DP Headland.
  - MP Gaskill.
  - AJ Nelms.
  - RE Irwin.

Approvals

- The minutes from the last meeting were approved.

Demonstration

- A tasks list was distributed.
- A required props list was distributed.
- People were assigned to sections on each list.
- The presentation will run in chronological order.

- A short video will be available as a last resort backup.
- Boards will be requisitioned from the microwave labs.
- Arrangements for borrowing equipment should be made on Monday.

Epilogue

- Some sections have been started by some people.
- The deadline for all sections is 12:00 Friday 4 June 2004.

Power supply

- The power supply is completed.
- Control is via precision potentiometers.
- The PSU is in use in the testing lab.

Simulation

- All simulations are now complete.
- The following simulations have recently finished:
  - Backshort simulations.
  - Cavity with exact measured components.
- Analysis is starting today.

Poster

- The poster is nearly complete.
- Currently, pictures are required and will be supplied ASAP.
- Organisation has started for printing.

Proposed actions

JM Higginbotham	Create a CD for the appendix containing HFSS data.
All	Think of potential questions and answers for the demo.

Next meeting

Formal meetings have now finished due to the proximity of the close of the project and the number of tasks remaining. The group will meet in the D floor coffee room on Monday 7 June 2004 at 09:00 to do final checking on the epilogue and start detailed preparations from the impending demonstration.