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.