

**TUGAS AKHIR - TF 181801**

**PERANCANGAN *FAULT TOLERANT CONTROL* (FTC) PADA *REGENERATIVE* *ANTI-LOCK BRAKING SYSTEM* DENGAN MOTOR BLDC**

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Dosen Pembimbing

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Departemen Teknik Fisika

Fakultas Teknologi Industri dan Rekayasa Sistem

Institut Teknologi Sepuluh Nopember

Surabaya

20XX



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20XX

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***FINAL PROJECT* - TF 181801**

***FINAL PROJECT* *TITLE***

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2XXX

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# PERNYATAAN ORISINALITAS

Yang bertanda tangan di bawah ini.

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Departemen / Prodi : Teknik Fisika / S1 Teknik Fisika

Dosen Pembimbing / NIP : ….

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Bilamana di kemudian hari ditemukan ketidaksesuaian dengan pernyataan ini, maka saya bersedia menerima sanksi sesuai dengan ketentuan yang berlaku di Institut Teknologi Sepuluh Nopember.

|  |  |
| --- | --- |
| MengetahuiDosen Pembimbing(\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_)NIP. | Surabaya, XX Bulan 2XXXMahasiswa,Materai6000(Nama Saya)NRP. 023XXXXXXXXX |
|  |  |

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**STATEMENT OF ORIGINALITY**

The undersigned below:

Name of student / NRP : \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Department : Engineering Physics

Advisor / NIP : \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

hereby declare that the Final Project with the title of “\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_” is the result of my own work, is original, and is written by following the rules of scientific writing.

If in the future there is a discrepancy with this statement, then I am willing to accept sanctions in accordance with the provisions that apply at Institut Teknologi Sepuluh Nopember.

Surabaya, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Acknowledged

Advisor Student

(\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_) (\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_)

NIP. NRP.

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# LEMBAR PENGESAHAN

JUDUL TUGAS AKHIR DITULIS SINGKAT JELAS DAN MENGGAMBARKAN TEMA POKOK

TUGAS AKHIR

Diajukan untuk memenuhi salah satu syarat

memperoleh gelar Sarjana Teknik pada

Program Studi Sarjana Teknik Fisika

Departemen Teknik Fisika

Fakultas Teknologi Industri dan Rekayasa Sistem

Institut Teknologi Sepuluh Nopember

Oleh: Nama Saya

NRP. 023XXXXXXXXXX

Disetujui oleh Tim Penguji Tugas Akhir:

1. Nama dan gelar pembimbing Pembimbing I
2. Nama dan gelar pembimbing Ko-pembimbing
3. Nama dan gelar penguji Penguji
4. Nama dan gelar penguji Penguji
5. Nama dan gelar penguji Penguji

**SURABAYA**

 Bulan, Tahun

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# APPROVAL SHEET

**THE TITLE OF THE FINAL PROJECT IS WRITTEN BRIEFLY, CLEARLY AND DESCRIBING THE MAIN THEME**

**FINAL PROJECT**

Submitted to fulfill one of the requirements

for obtaining a degree Bachelor of Engineering at

Undergraduate Study Program of Engineering Physics

Department of Engineering Physics

Faculty of Industrial Technology and Systems Engineering

Institut Teknologi Sepuluh Nopember

Oleh:

**NAMA SAYA**

**NRP. 023XXXXXXXXXXX**

Disetujui oleh Tim Penguji Tugas Akhir:

1. Name of Advisor and academic title Advisor
2. Name of Co-Advisor/Examiner and academic title Co-Advisor
3. Name of Examiner and academic title Examiner
4. Name of Examiner and academic title Examiner
5. Name of Examiner and academic title Examiner

**SURABAYA**

**Month, Year**

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**PERANCANGAN *FAULT* *TOLERANT* *CONTROL* (FTC) PADA *REGENERATIVE ANTI-LOCK BRAKING SYSTEM* DENGAN MOTOR BLDC UNTUK APLIKASI MOBIL LISTRIK DENGAN KESALAHAN PADA AKTUATOR**

|  |  |  |
| --- | --- | --- |
| **Nama Mahasiswa / NRP** | **:** | **Nama Saya** |
| **Departemen** | **:** | **Teknik Fisika FTIRS – ITS**  |
| **Dosen Pembimbing** | **:** | **Pembimbing 1** |
|  |  | **Pembimbing 2** |

# Abstrak

 Lorem Ipsum is simply dummy text of the printing and typesetting industry. Lorem Ipsum has been the industry's standard dummy text ever since the 1500s, when an unknown printer took a galley of type and scrambled it to make a type specimen book. It has survived not only five centuries, but also the leap into electronic typesetting, remaining essentially unchanged. It was popularised in the 1960s with the release of Letraset sheets containing Lorem Ipsum passages, and more recently with desktop publishing software like Aldus PageMaker including versions of Lorem Ipsum. Lorem Ipsum is simply dummy text of the printing and typesetting industry. Lorem Ipsum has been the industry's standard dummy text ever since the 1500s, when an unknown printer took a galley of type and scrambled it to make a type specimen book. It has survived not only five centuries, but also the leap into electronic typesetting, remaining essentially unchanged. It was popularised in the 1960s

**Kata Kunci: ABS, *Fault Tolerant Control*, *inverter*, motor BLDC**

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***FAULT TOLERANT CONTROL (FTC) DESIGN ON REGENERATIVE ANTI-LOCK BRAKING SYSTEM WITH BLDC FOR ELECTRIC CAR APPLICATION WITH FAULTS ON ACTUATOR***

|  |  |  |
| --- | --- | --- |
| **Student Name /NRP** | **:** | **My Name / 023xxx** |
| **Department** | **:** | **Engineering Physics FTIRS – ITS**  |
| **Advisor** | **:** | **Name of advisor and academic title** |
|  |  |  |

# Abstract

 Lorem Ipsum is simply dummy text of the printing and typesetting industry. Lorem Ipsum has been the industry's standard dummy text ever since the 1500s, when an unknown printer took a galley of type and scrambled it to make a type specimen book. It has survived not only five centuries, but also the leap into electronic typesetting, remaining essentially unchanged. It was popularised in the 1960s with the release of Letraset sheets containing Lorem Ipsum passages, and more recently with desktop publishing software like Aldus PageMaker including versions of Lorem Ipsum. Lorem Ipsum is simply dummy text of the printing and typesetting industry. Lorem Ipsum has been the industry's standard dummy text ever since the 1500s, when an unknown printer took a galley of type and scrambled it to make a type specimen book. It has survived not only five centuries, but also the leap into electronic typesetting, remaining essentially unchanged. It was popularised in the 1960s

**Keywords: *ABS, Fault Tolerant Control, inverter, motor BLDC***

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# KATA PENGANTAR

Duis autem vel eum iriure dolor in hendrerit in vulputate velit esse molestie consequat, vel illum dolore eu feugiat nulla facilisis at vero eros et accumsan et iusto odio dignissim qui blandit praesent luptatum zzril delenit augue duis dolore te feugait nulla facilisi:

1. Lorem ipsum dolor sit amet, consetetur sadipscing elitr
2. Lorem ipsum dolor sit amet, consetetur sadipscing elitr
3. Lorem ipsum dolor sit amet, consetetur sadipscing elitr
4. Lorem ipsum dolor sit amet, consetetur sadipscing elitr
5. Lorem ipsum dolor sit amet, consetetur sadipscing elitr

Serta pihak-pihak lain yang tidak dapat disebutkan satu-persatu. Semoga laporan tugas akhir ini dapat dipergunakan dengan sebaik-baiknya.

Surabaya, XX Bulan 2XXX

Penulis

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# PENDAHULUAN

## Latar Belakang

Latar belakang berisi alasan mengapa riset yang diambil perlu untuk diselesaikan. Kedua perlu diberikan penjelasan menyeluruh perkembangan riset untuk mengatasi masalah dalam riset yang diambil. Ketiga adalah alasan pemilihan metode dalam riset yang diambil dibandingkan dengan perkembangan pada point kedua. Keempat perlu diberikan penjelasan perkembangan riset kedepan atas diselesaikannya riset yang diambil.

Lorem ipsum dolor sit amet, consetetur sadipscing elitr (Westbrook, 2005). Lorem ipsum dolor sit amet, consetetur sadipscing elitr (Shiosansi, 2008), Lorem ipsum dolor sit amet, consetetur sadipscing elitr (Offer, 2010). Lorem ipsum dolor sit amet, consetetur sadipscing elitr (Tur, 2007).

Lorem ipsum dolor sit amet, consetetur sadipscing elitr (Tur, 2007). Lorem ipsum dolor sit amet, consetetur sadipscing elitr (Gao, 2001). Lorem ipsum dolor sit amet, consetetur sadipscing elitr (Murali, 2017), Lorem ipsum dolor sit amet, consetetur sadipscing elitr (Bai, 2011), Lorem ipsum dolor sit amet, consetetur sadipscing elitr (Gao, 2001).

Lorem ipsum dolor sit amet, consetetur sadipscing elitr (Errabelli, 2012). Lorem ipsum dolor sit amet, consetetur sadipscing elitr (Blanke, 1999). Lorem ipsum dolor sit amet, consetetur sadipscing elitr. Lorem ipsum dolor sit amet, consetetur sadipscing elitr. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod

## Rumusan Masalah

Rumusan masalah berisi runtutan masalah yang akan diselesaikan dalam riset yang diambil:

1. Lorem ipsum dolor sit amet, consetetur sadipscing elitr?
2. Lorem ipsum dolor sit amet, consetetur sadipscing elitr?

## Tujuan

Tujuan dijelaskan untuk, minimal, menjawab rumusan masalah yang dibuat:

1. Lorem ipsum dolor sit amet, consetetur sadipscing elitr
2. Lorem ipsum dolor sit amet, consetetur sadipscing elitr

## Batasan Masalah

Batasan masalah sesuatu yang harus diberikan pada riset yang diambil untuk menghilangkan generalisasi asumsi. Misalkan *brand*, ruang lingkup *plant*, tipe alat, dsb:

1. Lorem ipsum dolor sit amet, consetetur sadipscing elitr
2. Lorem ipsum dolor sit amet, consetetur sadipscing elitr
3. Lorem ipsum dolor sit amet, consetetur sadipscing elitr

## Sistematika Laporan

Sistematika laporan berisi gambaran singkat bagaimana struktur peenulisan laporan tugas akhir untuk memudahkan pembaca dalam mamahami alur laporan. Lorem ipsum dolor sit amet, consetetur sadipscing elitr. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet

# TINJAUAN PUSTAKA DAN DASAR TEORI

## Sub Materi 1

Teori penunjang berisi studi pustaka materi dalam riset yang diambil (Lubbers, 2014). Persamaan ditulis sesuai dengan format berikut, rata kiri dengan **Cambria Math** (Font size: **12**) dan ukuran *numbering* (2.1) adalah **12**. Sitasi harus selalu diberikan jika mengambil referensi dari sumber lain (Tur, 2007):

|  |  |
| --- | --- |
| $$F\_{x}= μ.m.g$$ | (2.1) |
| $$F\_{a}= 0,5.c\_{r}.δ.A\_{f}.v^{2}$$ | (2.2) |



**Gambar 2.1** Quarter car model

## Sub Materi 2



**Gambar 2.2** Kurva hubungan *slip ratio* dengan *friction coefficient mmmmmmmmm*

|  |  |
| --- | --- |
| $$F\_{x}= μ.m.g$$ | (2.3) |

At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet (Gao, 2001).

## Sub Materi 3

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua (Murali, 2017).

Jika Panjang tabel tidak melebihi ukuran A4, maka tabel tidak diperkenankan terpotong dengan halaman lain sehingga harus dalam 1 halaman yang sama (Singh, 2012). Jika panjang tabel melebihi panjang A4, header tabel (baris merah dibawah) harus dimunculkan dalam halaman lanjutan

**Tabel 2.1** Urutan komutasi six-step inverter hmhj mbmbm nmbmmm kkkkkk djduuud ddjj

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Rotor Pos. (deg) | H1 | H2 | H3 | Switch tutup | Phase |
| A | B | C |
| 0-60 | 1 | 0 | 0 | Q1 Q4 | + | - | Off |
| 60-120 | 1 | 1 | 0 | Q1 Q6 | + | Off | - |
| 120-180 | 0 | 1 | 0 | Q3 Q6 | Off | + | - |
| 180-240 | 0 | 1 | 1 | Q3 Q2 | - | + | off |
| 240-300 | 0 | 0 | 1 | Q5 Q2 | - | Off | + |
| 300-360 | 1 | 0 | 1 | Q5 Q4 | off | - | + |

# METODOLOGI PENELITIAN

Metodologi penelitian diawali dengan flowchart detail tentang riset yang diambil. Gambar pada flowchart dapat terkuantifikasi dengan angka. Hal yang bersifat kualitatif dapat dijelaskan dengan detail pada sub materi setelah flowchart untuk lebih menjelaskan alur penelitian.

Catatan, jika data yang digunakan menyerupai materi pada BAB 2, maka sebaiknya melakukan rujukan pada persamaan, gambar, atau tabel yang telah ditulis pada BAB 2 sehingga tidak diperlukan penulisan kembali pada BAB 3.

## Sub Materi 1

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

## Sub Materi 2

### Sub Sub Materi 1

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.:

|  |  |
| --- | --- |
| $$F\_{x}= μ.m.g$$ | (3.1) |
| $$-4\left(F\_{x}+F\_{a}+F\_{w}\right)=m\frac{dv}{dt}$$ | (3.2) |

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat, (2.1), (2.2), (2.3) (Tur, 2007):

**Tabel 3.1** Variabel pada persamaan gaya

|  |  |  |  |
| --- | --- | --- | --- |
| No. | Simbol | Variabel (satuan) | Nilai |
| 1. | $$m$$ | Massa QCM (kg) | 425 |
| 2. | $$g$$ | Percepatan gravitasi (m/s2) | 9,8 |
| 3. | $$c\_{r}$$ | Koefisien aerodinamik | 0,3 |
| 4. | $$δ$$ | Densitas udara (kg/m3) | 1,225 |
| 5. | $$A\_{f}$$ | Luas permukaan frontal (m2) | 3,1 |
| 7. | $$c\_{t}$$ | Koefisien resistansi putaran roda | 0,01 |
| 8. | $$α$$ | Sudut jalan qcm (rad) | 0 |

### Sub Sub Materi 2

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|  |  |
| --- | --- |
| $$μ\left(λ,v\right)=\left(c\_{1}\left(1-e^{-c\_{2}λ}\right)-c\_{3}λ\right).e^{-c\_{4}λv}$$ | (3.3) |

## Sub Materi 3

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum:

## Sub Materi 4

Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum (Tashakori, 2011)



**Gambar 3.1** Rangkaian equivalen BLDC

|  |  |
| --- | --- |
| $$V\_{a}=Ri\_{a}+L\frac{di\_{a}}{dt}+e\_{a}$$ | (3.4) |
| $$V\_{b}=Ri\_{b}+L\frac{di\_{b}}{dt}+e\_{b}$$ | (3.5) |

## Sub Materi 5

Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

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# HASIL DAN PEMBAHASAN

BAB IV membahas secara detail hasil termuan terhadap riset yang diambil untuk menjaawab rumusan masalah.

## Sub Materi 1

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat.

**Gambar 4.1** Respon *slip ratio* saat pengereman

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## Sub Materi 2

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**Tabel 4.1** Performansi kontrol speed

|  |  |
| --- | --- |
| Kriteria Performansi | Nilai |
| Rise time | 0,12 s |
| Settling Time | 0,18 s |
| Max. overshoot | 0% |

## Sub Materi 3

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## Sub Materi 4

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1. 1.
	2.
	3.
	4.

### Kesalahan pada Switch 1

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### Kesalahan pada Switch 2

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### Kesalahan pada Switch 3

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua:

* gkdfhdfhnzd
* khhf.hn.xhhhh
* jhlkxfjhlxjh
* jn,xmfhn.

**Gambar 4.2** Perbandingan *slip ratio* dengan dan tanpa FTC pada kesalahan *switch* 5. Perbandingan *slip ratio* dengan dan tanpa FTC pada kesalahan *Switch* 1 dan 2



**Gambar 4.3** Perbandingan penurunan kecepatan kesalahan *switch* 5 dengan dan tanpa FTC

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# KESIMPULAN DAN SARAN

## Kesimpulan

Kesimpulan menjawab permasalahan dengan penjelasan detail informasi yang telah dibahas pada BAB 4:

* Lorem ipsum dolor sit amet, consetetur sadipscing elitr.
* Lorem ipsum dolor sit amet, consetetur sadipscing elitr.
* Lorem ipsum dolor sit amet, consetetur sadipscing elitr

## Saran

Saran berisi tentang kemungkinan penelitian lanjutan:

* Lorem ipsum dolor sit amet, consetetur sadipscing elitr.
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# LAMPIRAN

1. **Sistem Pengereman Regenerative sebagai ABS**

Zfhzdddh fhxxfh fhddjd hxfgx dngz nfgkdjghskldr gjdkfgsdlkr jgdkfdslk gjdlkfgdl fgsldkglsdg fljgsldj fgjdljs. Jdfgkhdkslgh zgbmbgd zbgglz ngzdkgdklg kjzfglz. jghzdkghz, gkdjhgk dghkdgh dkhfglkdg.

1. **Quarter Car Model**



**Gambar B.1** Diagram blok algoritma hfjsK

1. **Kode Matlab**

clc;

%% parameter

m = 425;

r = 0.325;

Af = 3.1;

Cr = 0.3;

v0 = 27.778;

freq\_max = 20000;

h = 0.01;

nb\_p = 4;

Ts\_vect = 50e-6;

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# BIODATA PENULIS

Pas Foto

Nnnnnnnnnnnnnnnn nnnnnnnnnnn nnnnnnnn hvhhhhhhhh nnnnnnnnn nnnnnnnnnnnn nnnnnnnnn nnnnnnnnnnnn bvm. Mjgdgmdjfghdgh mjfhhhhhhhhhhhhhhhhhhh mfmffffffffm mggggggggggg gggggggggg mgjfhdjhjjjj hfghdgdhgdujd mfmfmfmfmff. Kmmmm mmmmm hdjghghjdghdjh dfshdsgh mmmmm mmmmmvnhbm bmmmmmmmmmm. Mmmm mmmmm mmmmm mmmmm mmmmmmm mmm bbbbbbb bbbbbbbbbb bbbbbbbbbbb nbzcbcxbccc. Msjfkjshflskzkl fsdhrgjseyrs dhfzsdgzsjgs.