LAMPIRAN 1
Dari rangkaian penguatan Darlington dapat dihitung sebagai berikut:

Di sini kita menggunakan panjar kelas A (titik q di tengah garis beban, sehingga:

\[ V_{CE}(q) = \frac{V_{CC}}{2} = 6V \]

Akibatnya \( I_{C2} = \frac{V_{CC} - V_{CE(q)}}{R_C + R_{g2}} = \frac{6V}{1220} = 4,9mA \)

Sehingga \( I_{B2} = \frac{I_{C2}}{h_{fe2}} = \frac{4,9mA}{28} = 0,17mA \)

Arus emitor Q1 terpecah menjadi dua, satu bagian mengalir ke basis Q2 sebagai \( I_{B2} \), yang lain mengalir melalui \( R_{E1} \) sebagai \( I_1 \). Arus \( I_{B2} \) melihat hambatan sebesar \( R_{w2} = h_{fe2} + (1+h_{fe2})R_{E2} \).

Untuk \( h_{fe2} = r_{a2} + (1+h_{fe2})r_{e2} \) dengan \( r_{e2} = \frac{25}{I_{E2}(mA)} = \frac{25}{4,9} = 5,1\Omega \)

Sehingga \( (1+h_{fe2})r_{e2} = (29)(5,1) = 148 \Omega \)

Misalkan \( r_{a2} = 12 \Omega \), maka \( h_{fe2} = 150 \Omega \) dan \( R_{w2} \) adalah \( 150 + (29)(220) = 6k\Omega \).
Misalkan kita pilih $RE_1 = 1 \Omega$. Karena $IC2 = 4,9 \ mA$, maka emitter $Q2$ berada pada tegangan 30 V di atas tegangan tanah.

Basis $Q2$ berada pada satu $VE = 0,6 \ V$ di atas emitter, sehingga berada pada tegangan 30,6 V di atas tegangan tanah.

Ini berarti: $I_i = \frac{V_{ES2}}{R_{E1}} = \frac{30,6V}{1 \ \Omega} = 30,6 mA$ maka $I_{E1} = I_i + I_{B2} = 30,6 \ mA + 0,17 mA = 30,77 \ mA = 30 \ mA$

Sekarang kita hitung $h_{ie1} = r_b + (1 + h_{fe})r_e$ dengan $r_e = \frac{25}{I_{E1}(mA)} = \frac{25}{30} \equiv 0,833$,

kita dapat mengabaikan $r_{b2}$ sehingga $h_{ie1} = (1 + h_{fe})r_e = (1 + 350)0,833 \equiv 300\Omega$

Hambatan masukan menghadap pada basis transistor $Q1$ adalah:

$R_{ui} = h_{ie1} + (1 + h_{fe}1)R_{E1} / R_{R2}$

$R_{ui} = 300\Omega + (350\Omega)(1 \ \Omega / 6k\Omega) \equiv 300k\Omega$

$K_{n} = \frac{V_o}{V_i} = \frac{i_o R_o}{i_b R_u} = K_i \frac{R_o}{R_u}$ dengan $K_i = \frac{i_o}{i_b}$

$i_o = h_{fe2}i_{2} = h_{fe2}(0,5)(1 + h_{fe}1)i_{b1}$

$K_i = \frac{i_o}{i_b} = h_{fe2}(0,5)(1 + h_{fe}1) = (28)(0,5)(350) \equiv 5.10^3$

$R_o = R_C = 1k\Omega \ \ R_u = 300k\Omega$

Akibatnya $K_n = K_i \frac{R_o}{R_u} = \frac{(5.10^3)(1k\Omega)}{300k\Omega} = 16,67 \equiv 15$
LAMPIRAN 2
LAMPIRAN 3
LAMPIRAN 3

Data hubungan antara arus masukan dan arus keluaran

<table>
<thead>
<tr>
<th>No</th>
<th>$I_r$ (µA)</th>
<th>$I$ (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>10.54</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>10.83</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>10.83</td>
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<td>4</td>
<td>30</td>
<td>10.83</td>
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<td>5</td>
<td>40</td>
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<td>6</td>
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<td>90</td>
<td>10.69</td>
</tr>
<tr>
<td>11</td>
<td>100</td>
<td>10.69</td>
</tr>
<tr>
<td>12</td>
<td>110</td>
<td>10.71</td>
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<tr>
<td>13</td>
<td>120</td>
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<tr>
<td>14</td>
<td>130</td>
<td>10.73</td>
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<td>15</td>
<td>140</td>
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<td>150</td>
<td>10.74</td>
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<td>17</td>
<td>160</td>
<td>10.75</td>
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<tr>
<td>18</td>
<td>170</td>
<td>10.8</td>
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<td>180</td>
<td>10.8</td>
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<tr>
<td>20</td>
<td>190</td>
<td>10.78</td>
</tr>
<tr>
<td>21</td>
<td>200</td>
<td>10.83</td>
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<td>22</td>
<td>210</td>
<td>10.87</td>
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<td>23</td>
<td>220</td>
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<td>24</td>
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<td>30</td>
<td>290</td>
<td>10.96</td>
</tr>
<tr>
<td>31</td>
<td>300</td>
<td>10.96</td>
</tr>
</tbody>
</table>
LAMPIRAN 4
Gambar 1. Ruang kerja Lab. Elektronika dan Instrumentasi BATAN Yogyakarta

Gambar 2. Alat Sistem pengendali dan penggerak motor stepper yang akan digunakan untuk memutar variak catu daya
LAMPIRAN 5
Stepper Motors

Unipolar permanent magnet type

A range of 12V bi-directional stepper motors with a 1° step angle, for many applications. Applying the correct electrical pulse sequence (dual phase energization) to the winding of the stepper motor results in the specified step angle of rotation of the shaft. This gives 8 steps per revolution for the 7.5° motor and 24 for the 15° motor. The step angle can be halved if the motor is driven by a modified pulse sequence. The speed and direction of rotation are determined respectively by the input frequency and step sequence. This provides an ideal solution for both speed and non-feedback position control.

Applications include:
- Photoc breeders, X-Y plotters, computer peripherals, computer printers, ink jet printers, microscopes, paper feeders, vending machines, gaming machines etc.
- These motors are commercially available with RS stepper motor drives as stock nos. 332-258 and 342-051 (see later in this section) giving excellent torque performance. These motors also allow half stepping if required, resulting in higher resolution; good performance stability and fast step rates. Alternatively the RS range of stepper motor IC's in the Semiconductors - Analogue Section can be utilized to control the motors.

If complex movement profiles are required then the RS stepper motor control board can be used in conjunction with the drive cards to vary step rate, acceleration/deceleration, velocity etc. (stock nos. 440-099).

7.5° and 15° Unipolar

In addition to direct drive applications, RS stock nos. 440-292 and 440-278 can be fitted to the RS range of synchronous gearboxes; RS stock nos. 322-990 etc. to provide reduced step angles and higher torque capability. The output step angle for each gearbox withstands when used with stock nos. 440-292 and 440-278 is given below. These angles are halved if the motor step angle is halved.

<table>
<thead>
<tr>
<th>Gearbox</th>
<th>440-292</th>
<th>440-278</th>
</tr>
</thead>
<tbody>
<tr>
<td>322-658</td>
<td>10°</td>
<td>5°</td>
</tr>
<tr>
<td>326-156</td>
<td>9°</td>
<td>5°</td>
</tr>
<tr>
<td>336-444</td>
<td>9°</td>
<td>5°</td>
</tr>
<tr>
<td>336-459</td>
<td>9°</td>
<td>5°</td>
</tr>
<tr>
<td>440-627</td>
<td>9°</td>
<td>5°</td>
</tr>
</tbody>
</table>

Note: Typical gearbox backlash is 2° and should be allowed for when positional accuracy is critical.

Motor Data Sheet No. B10560, March 91 is available on request. See complete set of RS Motor Data Sheets in the Technical Data Section.

Size 1 and 2

<table>
<thead>
<tr>
<th>Gearbox</th>
<th>440-292</th>
<th>440-278</th>
</tr>
</thead>
<tbody>
<tr>
<td>332-647</td>
<td>5°</td>
<td>3°</td>
</tr>
<tr>
<td>332-953</td>
<td>5°</td>
<td>3°</td>
</tr>
</tbody>
</table>

Note: Maximum output torque per gearhead varies as follows:
- Output torque: 1.5N* (5°)
- Holes: 1.5N* (5°)
- Gearbox: 1.5N* (5°)
- Power consumption: 2W

* Maximum load torque per gearhead varies as follows:
- Stepping angle: 1.5N* (5°)
- Holes: 1.5N* (5°)
- Gearbox: 1.5N* (5°)
- Power consumption: 2W

RS Data Sheet No. A14597, November 92 is available on request. See complete set of RS Data Sheets in the Technical Data Section.

In addition to direct drive applications, RS stock nos. 440-292 and 440-278 can be fitted to the RS range of synchronous gearboxes; RS stock nos. 322-990 etc. to provide reduced step angles and higher torque capability. The output step angle for each gearbox withstands when used with stock nos. 440-292 and 440-278 is given below. These angles are halved if the motor step angle is halved.
1-8° Step Angle

A range of hybrid stepper motors with 4-phase construction resulting in much higher working torque and stepping rates than available from the permanent magnet types, while at the same time maintaining very high resolution due to the small step angle. Applying the correct electrical pulse sequence to the windings of the stepper motor results in a 18° step angle rotation of the spindle (i.e., 200 steps per revolution). When correctly loaded and driven these motors will produce discrete output steps. The number of steps and speed of rotation are adjusted by the number of pulses and frequency of the input signal. This provides an ideal method of both speed and position control.

Applications include:
- High resolution requirements.
- Robotics.
- Paper feed mechanism.
- Telescope printers.
- Small machine tools.
- Computer peripherals.
- X-Y plotters.

The motors are directly compatible with the RS stepper motor drive boards stock no. 332-098, 342-051 and 440-240 (which can provide microstepping facilities) which can also drive either motor (if required) in the half step mode i.e. 0.9° per step resulting in higher resolution, greater performance stability and faster stepping rates.

The direction, velocity, acceleration/deceleration can be controlled by the stepper motor controller, see later in this section.

Type 17, 23 & 34 with and without Rear Shaft Extensions

<table>
<thead>
<tr>
<th>Gearbox stock no.</th>
<th>Ratio</th>
<th>Step angle</th>
<th>Steps/Rev full step</th>
</tr>
</thead>
<tbody>
<tr>
<td>718-852</td>
<td>5:1</td>
<td>0.98°</td>
<td>1000</td>
</tr>
<tr>
<td>718-866</td>
<td>25:2</td>
<td>0.144°</td>
<td>2500</td>
</tr>
<tr>
<td>718-874</td>
<td>25:1</td>
<td>0.18°</td>
<td>5000</td>
</tr>
<tr>
<td>718-883</td>
<td>50:1</td>
<td>0.39°</td>
<td>10000</td>
</tr>
<tr>
<td>718-895</td>
<td>100:1</td>
<td>0.18°</td>
<td>25000</td>
</tr>
<tr>
<td>718-903</td>
<td>15:1</td>
<td>0.18°</td>
<td>25000</td>
</tr>
<tr>
<td>718-919</td>
<td>200:1</td>
<td>0.20°</td>
<td>50000</td>
</tr>
<tr>
<td>718-925</td>
<td>500:1</td>
<td>0.12°</td>
<td>250000</td>
</tr>
</tbody>
</table>

S.S.M. = 1

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*Note: if motor and board are sharing the same power supply, the current capability of the board should be at least X (motor current per phase) + board current.*
**Polar Choppers**

- A single eurocard complete with a 32-way plug connector to suit eurocard wiring systems. The board employs the single bipolar chopped constant current to provide a substantial increase in the efficiency of the stepup motor. This increases the efficiency of the system by removing the power dissipating dropper resistors from the unipolar drive mode.

**6A with Micro Stepping Option Card**

- Drive board
  - Drives motors up to 70V d.c. and 6A/phase
  - On board output drive current setting (0 to 5A)
  - Output overload protection
  - Synchronisation output for multi-axis systems
  - Full and half step drive modes
  - Provision for assembly on board oscillator (if external clock not available) having clock pulse output, base speed, top speed and stop/run control inputs
  - TTL and CMOS compatible control interface
  - Output disabled to allow manual motor rotation
  - 5V and 12V d.c. auxiliary outputs for external device energisation
  - Up to two of these boards plus the microstepping add on cards can be connected to the programmable 2 axis control board and the stepper power supply by using the stepper system backplane. All connections are made except motor and 240V a.c., reducing start up time to a few minutes

- User instructions supplied

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**Stepper Motor Drive Accessories**

- Back Plane and Power Supply

- The RS stepper drive system back plane allows the RS stepper drive power supply to be readily connected to two of the bipolar stepper drive cards. Connection is without the need to use a soldering iron enabling a complete system to be constructed in a minimum of time.

- The nature of construction of the back planes and power supply enable a very flexible single or 2 axis system to be produced. Both the 3A & 6A drives can be utilised, the latter with or without add-on microstep card, or a combination of both as the power supply produces all the necessary output voltages. The drives can be fed with external control signals or, by the addition of the programmable 2 axis control card a stand alone system can be produced catering for many applications.

- The whole system can be built into a standard 19 in. wide by 3U high Euro Rack. All connections are made via screw terminals to the rear of the back plane.

---

**Technical specification**

- Steady voltage
  - Motor: 20-70V d.c.
  - Logic: 15-24V d.c.
- Motor and logic may share the same supply.
- Control inputs
  - Logic: TTL compatible

**Auxiliary outputs**

- Motor drive
  - 2A-6A output on board via DIL switches
- Control outputs
  - 5V, 5mA max.
- Logic 0
  - 0V d.c.
- Logic 1
  - 5.3V
- Monitor outputs
  - Open collector transistors
- Clock inputs
  - Full step 200Hz max.
- Operating temp
  - 0°C to 40°C

---

**S.S.M. = 1**

- Stock no.

**6A drive board**

- Stepper motor drive system

---

**S.S.M. = 10**

- Stock no.

**S.S.M. = 1**

- Screw pack

---

**S.S.M. = 1 bag**

- Stock no.

---

**S.S.M. = 1 bag**

- Stock no.

---

**RS Data Sheet No. 812199, November 87 is available on request. See complete set of RS Data Sheets in the Technical Books Section.**

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**RS Data Sheet No. 81214, November 87 is available on request. See complete set of RS Data Sheets in the Technical Books Section.**