Disediakan oleh	:	No keluaran:	:
Disemak oleh	:	No. pindaan	:
Diluluskan oleh	:	Tarikh kuatkuasa	:

SEE/SEI/SET/SEM/SEL/SEC 4712
FAKULTI KEJURUTERAAN ELEKTRIK
UNIVERSITI TEKNOLOGI MALAYSIA
KAMPUS SKUDAI
JOHOR

MAKMAL ELEKTRONIK KUASA

Applications of Power Electronic Converters: Open-loop DC Drives

Applications of Power Electronic Converters: Open-loop DC Drives

Objectives:

To understanding the basic principle and operation of power electronic converters:

a) Single phase controlled rectifier
b) Two-quadrant dc-dc converter

To see how they are applied to simple open-loop dc drive systems.

Introduction and Background:

Power electronic converters are used to convert and control electrical energy. They consist of power semiconductor devices operated as *switches* and passive elements such as inductors and/or capacitors. Ideally, there will be no losses in power electronic converters since there are no losses in ideal switches, inductors or capacitors. In this experiment we will study on two types of power electronic converters and their applications in DC drive systems:

AC to DC – using controlled rectifier
DC to DC – using dc-dc converter or chopper

Why do we need to covert electrical energy? Most of the time electrical load does not match electrical source that is available to us. For example, we cannot connect DC motors to AC sources, and vice versa. Even if we have a DC source and a DC load, most likely we still need a DC–DC converter for an efficient utilization of electrical energy. Today, the applications of power electronic converters can be found in almost all aspects of our daily lives.

One of the many applications of power electronic converters is electrical drive. In this experiment we will look on how power electronic converters are used to control the speed of small permanent magnet DC motors. By assuming negligible voltage drop across armature resistance (for unloaded motor), the speed will be directly proportional to applied voltage, thus can be controlled using power electronic converters. This experiment will only deal with a simple *open–loop* control. A closed-loop control – which is required in many applications such as robotics, electric vehicle or industrial drives – normally is more complicated and hence requires advanced modeling technique and advanced control systems theory.

In this experiment you will need to calculate the average values (or DC values) of the voltage waveforms. In general, any periodic waveform f(t), with period T has a an average value F_{av} given by:

$$F_{av} = \frac{1}{T}\int_{t_o}^{t_o+T} f(t)dt$$

In a controlled rectifier circuit, the output DC voltage depends on the firing or delay angle and, in the case of a *discontinuous current* mode, also on the extinction angle. In order to calculate the average voltage from the waveforms, these angles need to be measured. For a two-quadrant dc-dc converter operating in quadrants 1 and 2, the average output voltage only depends on the duty cycle.

Pre-Lab assignment:

1. Students are strongly encouraged to read the following before attending a lab session:

   Introduction to Power Electronics, by D. Hart , Prentice Hall
   Chapter 4, Section 4.3.
   Chapter 6, Section 6.3 and 6.5
   Power Electronics: Converters, applications and design, by Ned Mohan, John Wiley and Sons Inc.
   Chapter 13, Section 13.7

2. Understanding power electronic systems can be accomplished via simulations. Before simulating any power electronic system, it need to be modeled - read Chapter 13 of *Power Electronics: Converters, applications and design* (by Ned

Mohan) to understand how DC motors are modeled. You can download the simulink files of the drive systems for this lab session from http://encon.fke.utm.my/courses/lab/ . They are implemented using the MATLAB ver 6.5 with SymPowerSystem toolbox. Study, in particular, how the converters and DC motor are modeled. Also, study how the control signals are generated.

List of equipment:

Modules from Leybold, GmBH : 725-12, 734-02, 735-12, 735-346, 735-741, 735-095, 735-261
Small permanent magnet motor (rated voltage : 20V or 24V)
HP oscilloscope 100 MHz

Procedure:

This experiment consists of TWO parts. You are required to attempt both parts. Since the duration of a lab session is 180 minutes, you are advised not to spend more than 70 minutes on each part.

***Part 1**. Single phase controlled rectifier*
Using the modules on your bench, construct the circuit of Fig. 1. The firing signals for the SCRs are obtained from module #735 12. Use module #734 02 to obtain a variable voltage level, which is fed to 735 12 to control the delay angle of the SCRs. The output of the rectifier is connected to a 20V permanent magnet DC motor (or a 24V permanent magnet DC motor, depending on which bench you are assigned).

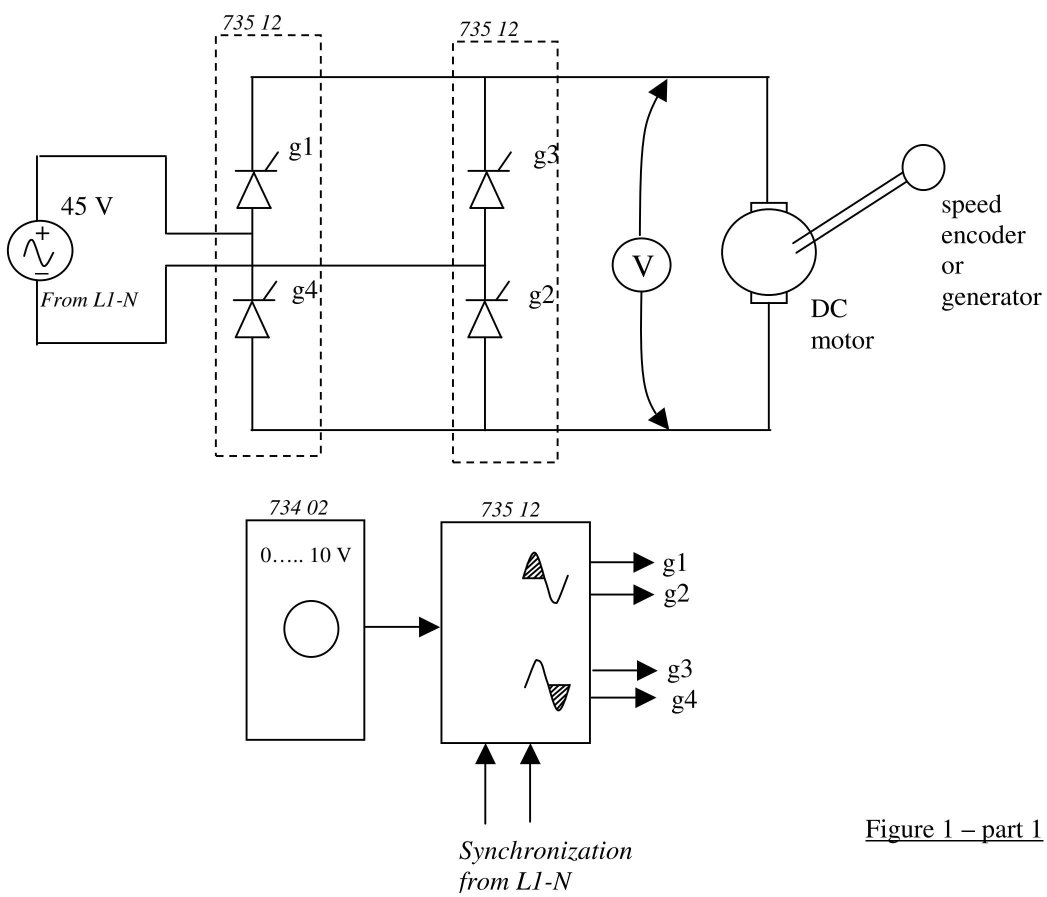

Figure 1 – part 1

The armature voltage can be varied by varying the firing angle of the SRC's – make sure that it DOES NOT exceed the rated voltage (which is 20V or 24V depending on which bench you are assigned) by observing the DC voltmeter. Use module # 735 261 to display the armature voltage and armature current on the oscilloscope.

Adjust the delay angle such that the average armature voltage from the voltmeter gives:

a) 50% of rated voltage
b) 75% of rated voltage
b) 100% of rated voltage

Sketch the armature voltage and current waveforms at these settings. From the waveform, measure the delay, the extinction angles and the back emf voltage.

Part 2 *2-Quadrant dc-dc converter*

Using the modules on your bench, construct the circuit of Fig. 2. The two IGBTs are triggered using module # 735 341 with the function set to give constant frequency with adjustable duty ratio. Set the frequency to 5 kHz. The average voltage can be varied by varying the duty cycle using the knob on 734 02. Again, make sure that the armature voltage DOES NOT exceed its rated. Use module # 735 261 to display the armature voltage and armature current on the oscilloscope.

Adjust the duty ratio such that the armature motor is at:

a) 50% of rated voltage
b) 75% of rated voltage
b) 100% of rated voltage

Sketch the armature voltage and current waveforms at these settings. Obtain the duty ratios from the waveforms.

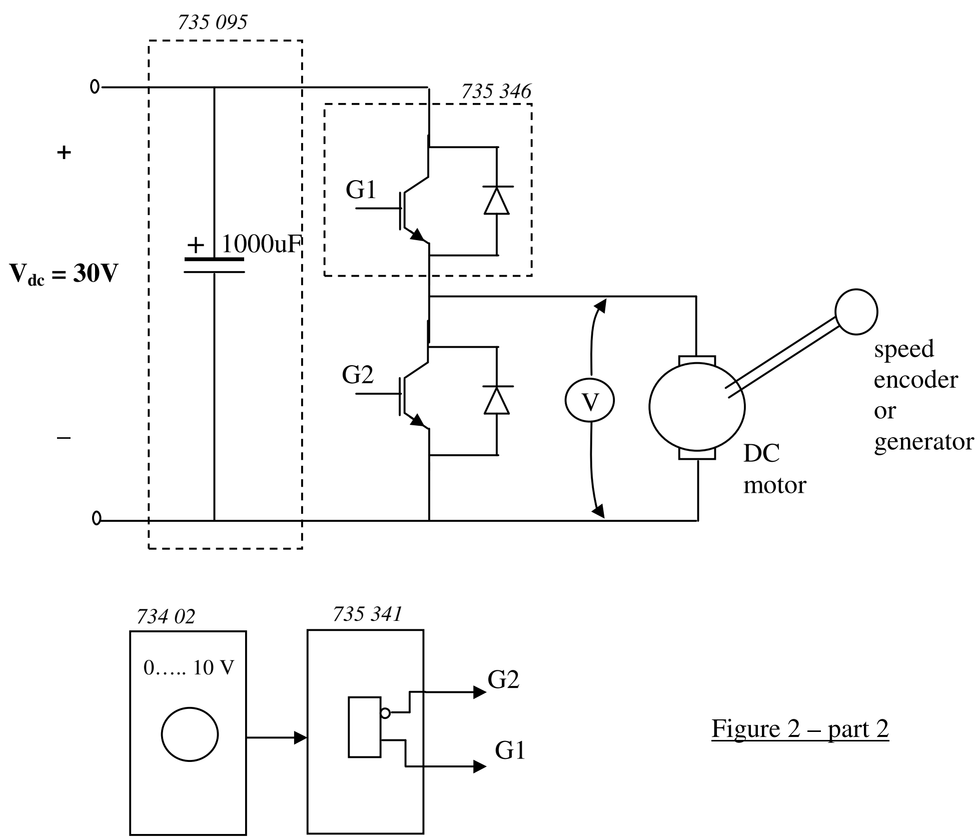

Figure 2 – part 2

Discussions:

1. Your discussion should contain at least the following (but not limited to):

   For each part of the experiment,

   a) Calculate the average voltage from the waveform for each value of the armature voltage. Compare the calculated values with the measured voltage. Discuss on the possible causes for the differences
   b) Is this drive capable of regenerative braking? Why?

YOU MAY SKIP THE FOLLOWING SECTION. HOWEVER, STUDENTS WHO WISH TO ATTEMPT THIS SECTION WILL RECEIVE BONUS MARKS.

2. Briefly discuss and compare on the waveforms of the voltage and current obtained from the experiments with the simulation results

References

Introduction to Power Electronics, by D. Hart , Prentice Hall
Power Electronics: Converters, applications and design, by Ned Mohan, John Wiley and Sons Inc.