

# Chapter 6

## Practical Part of the Training Course

In this part of the workshop an attempt will be made to test and modify one or more existing local designs of fluorescent lamp inverters, charge regulators and DC-AC converters. Most countries have several manufacturers so it should not be difficult to find samples for testing. It is recommended that three samples be obtained from every type of a certain device in order to ensure that there are always spare devices in case one fails.

For all three subjects, the following order will be maintained:

- First a checklist will be made, based on the local requirements and test procedures. These test procedures will be discussed so the execution of the tests is clear before starting. A sample checklist is given in appendix 12.
- In this workshop the samples will first have to be fully tested. When a device has some characteristics that do not meet the requirements, these will have to be improved after all the tests are complete. Never assume that a certain requirement will be met. *Always execute all tests, even when a test seems unnecessary.*
- An attempt will then be made to improve the weak spots. It can be very worthwhile just to experiment with some component values to see what happens when small changes are made. This increases the understanding of the set-up and the behavior of the device.
- The aim is to have a short report on all three subjects at the end of the workshop. These will describe the identified modifications and their effects on performance and safety of the device.  
Training in each subject area will take about one week.

### 6.1 Fluorescent Lamp Inverters

#### 6.1.1 Measuring Fluorescent Lamp Inverters

In this stage all functional tests can be carried out. When a calibrated digital oscilloscope is used, the electrical efficiency and the crest factor can be measured. A good electrical efficiency measurement can raise some problems. Input power can easily be measured, but the output power measurement is more difficult. Because true RMS meters are quite expensive, they are not always available in developing countries. A good solution is to store the file from the oscilloscope as an Excel file, and multiply output voltage and current from every measuring point. Excel can then calculate the output power to the lamp. Measuring with an external shunt resis-



For an introduction to light and lighting, turn to appendix 9.

For a list of equipment needed to complete the practical part of the training course, turn to appendix 10.

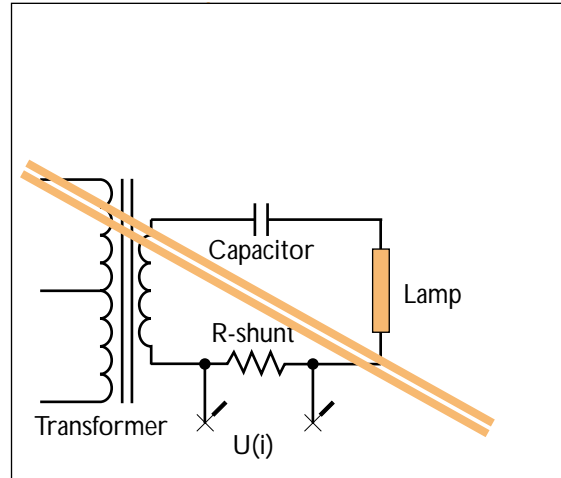
For a course evaluation, turn to appendix 11.

*Training Course:  
First Week*

tor and adding this voltage to the scope is not a good solution, as shown in **figure 6.1**. This shunt resistor can add parasitic capacity or inductance to the secondary circuit, particularly if the resistor is metal wound. Furthermore, this resistor cannot be calibrated, and its signal has to be amplified so much that the signal and the noise ratio from the signal is too large. The result is not reliable. When measuring with the scope, a **calibrated current-probe** has to be used.

An important measurement, defined in most standards, is the luminous efficacy ( $\text{lumen/watt}_{\text{dc}}$ ). Details and description of this measurement can be found in Section 2.1.5, Measurements of Luminous Flux. When some changes have been made in the design, a relative lumen/watt measurement will give the percentage increase in the luminous efficacy.

Within the time of this workshop it is not possible to make a long-term lifetime and switching durability test. It might be possible to test the ability of the inverter to function without the lamp. This test normally takes one or two hours.



## 6.1.2 Modifications

Modifications are made with the knowledge already acquired and common sense. When the modifications are being tested, it often appears that the new design does not respond as expected. Inverters are balanced and sensitive devices. When one factor is changed, others will also be affected. In most cases some experimenting is required to find the right balance and the right result.

In some cases the design is so poor that optimization of the circuit is not possible. For example, we can take a look at inverter set-up 1 in Section 2.2.5, Different Transistor Set-Ups. The basic set-up is clearly not ideal. The wave shape can never be made symmetrical, because of the use of only one transistor. The crest factor might be reduced a little but so many components will have to be added to make the design reliable under different circumstances that a whole new set-up could be better.

## 6.2 Charge Regulators

### 6.2.1 General

Within the past decade, numerous types of charge regulators have been developed, from very basic charge regulators—sometimes combined with a DC-AC inverter or a solar lantern—to sophisticated digital devices with complex state-of-charge algorithms. This latter family of charge regulators will be manufactured by companies that have their own R&D department. When improvements are needed, they will prefer to improve it themselves rather than go to another institute and reveal all the details about their product. The companies that do need help are those making the cheaper and simpler type of charge regulators. This type of device is mostly used in inexpensive solar home systems for large-scale implementation in rural areas. Those manufacturers do not always have the knowledge themselves, so technical support can be very useful.

*Training Course:  
Second Week*

The keywords for the charge regulator are as follows:

- Safety.
- Reliability.
- Energy-saving.

Solar home systems are often used under extreme conditions, in remote areas, or in fragile houses. Hence safety and reliability will be very important factors. New customers are not always used to living with electrical energy. Under these circumstances it is not surprising that problems can arise in the field. And when something *can* go wrong, it *will* go wrong at some time. Because spare parts are hard to get in remote areas, BOS components have to be as reliable as possible.

Solar energy is relatively expensive, so unnecessary energy loss should be reduced to a minimum. Once again, it can be stressed that over the lifetime of the system, a quiescent current reduction of 1 mA gives the customer 1.6 kWh of energy extra over the lifetime of the charge regulator. This has to be taken into account when modifications are made.

## 6.2.2 Measurements

Normally the features of the charge regulator are defined at the outset. Mostly the manufacturer does not send the complete documentation with test samples. Before the testing starts it is best to know how the device will respond.

Normally in a laboratory, power supplies are used to simulate the battery and PV. Special attention has to be paid to the current limiters. They should not exceed 125 percent of the rated power of the charge regulator.

A few items are of particular importance:

- Charge regulators can respond differently to power supplies than they would do to a real battery and a real PV module. PWM regulators, in particular, could show a different behavior. When abnormal behavior does occur, this has to be kept in mind.
- The overcurrent protection test should be done *on one sample*. If the device fails, you still have the other samples to work with.
- *The most destructive tests have to be saved for last*. For this test the current limiter of the power supply can be increased to 150 percent of the rated power of the charge regulator. Normally it should take action at 125 percent, so when the protection malfunctions there is a good chance that the regulator will not survive the test.

## 6.2.3 Modifications

When a charge regulator is functioning correctly according to the standards, but the quiescent current alone is too high, modifications must be made for that aspect without influencing other functions.

However, a modification can sometimes be made for a whole part of the diagram. For example, a certain charge regulator has an “electronic fuse” that makes use of many components. When another set-up of this “fuse” can be created with far fewer components, it is worthwhile to try it out. Then you are making changes in the diagram with the objective of component reduction. The other features should, of course, not be influenced. These modifications might not always be necessary for passing the official



tests. The manufacturer can be advised and then decide whether the modification will be implemented or not.



*Training Course:  
Third Week*

## 6.3 DC–AC Converters

### 6.3.1 General

As described in Chapter 4, there are many ways in which a DC–AC converter can be arranged, not only in the way the power bridge is designed, but especially the steering principle. If it is an analog design, improvements can be made easily. If the steering is based on a processor, using PWM techniques, it will not be possible to investigate the design within this one week of the workshop. The two reasons for this are as follows:

- The processor technique itself is too complicated to be able to gain sufficient insight into its program within the period of this training course.
- These devices are made by manufacturing companies that employ good technicians. As indicated earlier, they are not likely to provide information, especially processor programs, to third parties.

This workshop focuses on the small, inexpensive inverters, most commonly used in the power range below 500 watts.

### 6.3.2 Measurements at DC–AC Converters

When measuring at DC–AC inverters, some important points must be kept in mind. First of all, note the following:

- **HIGH VOLTAGE ALERT.** Whatever the measurement may be, use cables that are safe to touch. There must be no open endings or stripped wire endings. A mistake can easily be made.
- **NEVER BEGIN WITH THE MOST DESTRUCTIVE TEST.** Just as for charge regulators, the short-circuit test and overload test at the output should be executed last.
- **USE SHORT WIRES BETWEEN THE POWER SOURCE AND THE INVERTER THAT IS BEING MEASURED.** Energy losses should be brought to a minimum. The connection wires have to be thick enough to handle 1.5 times the maximum rated current. It is preferable to use wires that are too thick rather than too thin, not only because of the heat production but also to ensure that a proper measurement is made. When the input voltage is being measured and the cables are not suitable, voltage-drop may occur between the voltage meter and the inverter. When the efficiency is calculated, the input power ( $VA = \text{watt}$ ) will not be correctly measured.

### 6.3.3 Modifications

Testing a DC–AC inverter can take place with a closed box. When modifications are being made, the box will have to be open. Before starting on any modifications, think very carefully to be sure that you have assessed all the implications. Think again very carefully before switching on the power. The same is true for FLIs and charge regulators, but the consequences with DC–AC inverters can be more severe.

The modifications to the electronics should be based on the same principle as set down for fluorescent lamps and charge regulators.