- The voltage drop measured between the PV input terminal and the battery terminal should be less than 4% at full charging current, for example, approximately 0.5 V in a 12-V system.
- The voltage drop measured between the battery terminal and the load terminal should be less than 4% at full load current, for example, approximately 0.5 V in a 12-V system.
- The above-mentioned figures lead to an efficiency of >96% under rated charging as well as discharging conditions.

4. Safety aspects and compliance to codes.

- The charge controller must be protected against the reverse polarity of the input voltage and the battery voltage, for example, by a combination of fuses and diodes. Also, interchange of the inputs and outputs must not lead to damage.
- The charge controller must permanently withstand the maximum possible open-circuit voltage of the PV generator. This occurs at maximum insolation and minimum module temperature.
- Inputs and outputs must be protected against transient over-voltages by appropriate voltage arresters, for example, varistors.
- The charge controller must be designed according to the ambient temperatures at the usage site.
- The housing for the charge controller must withstand the environmental stress at the usage site, for example, protection level IP 00 inside a control cabinet, or IP 65 for outdoor applications.
- The electronic components should be protected by lacquer or encapsulation.
- The terminals should be generously dimensioned and robust. Cage clamps are a preferred solution.
- The charge controller must comply with relevant codes concerning electric safety and electromagnetic compatibility (EMC). It must have a Communautés Européennes (CE) label.

19.1.2 Charge Equaliser for Long Battery Strings

19.1.2.1 Introduction

All electrochemical storage systems react sensitively to operating states that do not conform to their specifications, such as overcharging, deep discharge or reversed polarity. The general observations are that the lifetime is shortened, the storage capacity and the efficiency are diminished and more maintenance is required. Further, detrimental conditions can arise with some batteries, for example, lithium-ion batteries, which lead to destruction or even explosion.

Thus, the manufacturers specify the allowable charging and discharging voltages, currents and also temperatures very precisely for individual cells – for the voltages, tolerances on the order of 1% are no exception.

However, on proceeding from the individual cell to series connection of several cells or groups of cells, which are usually needed, a well-known phenomenon is observed: in all applications, from laptops through PV systems and electric vehicles to