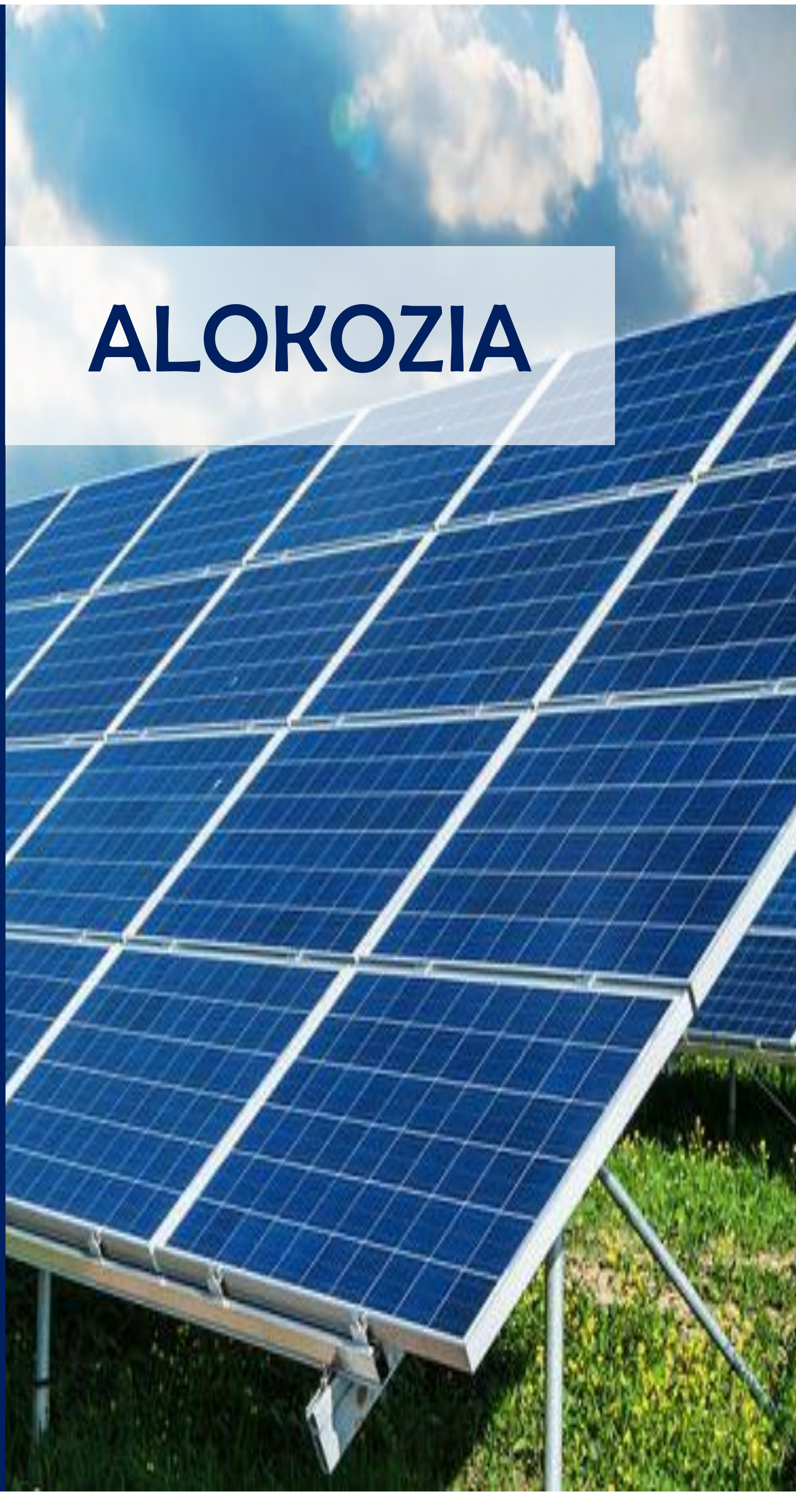
Alokozia Limited

Alokozia

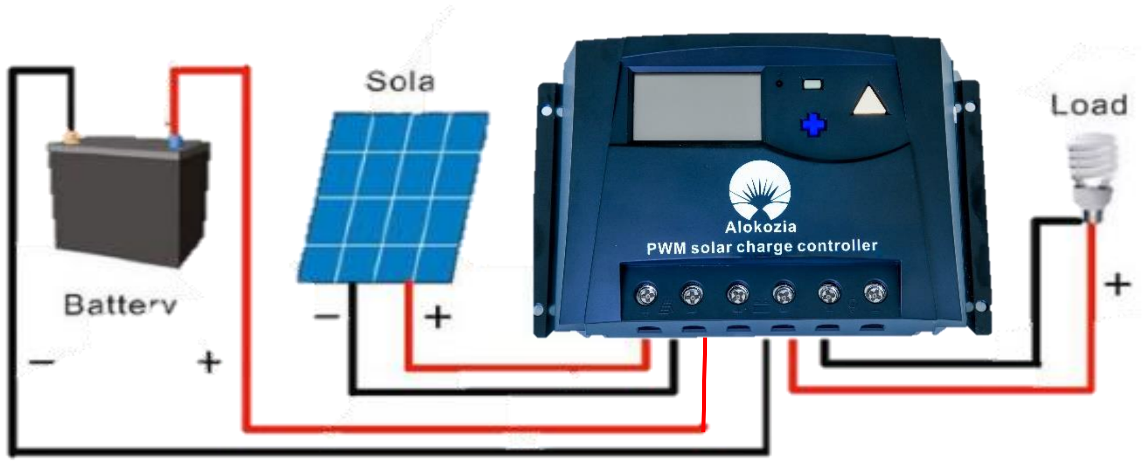


THE INNOVATIVE
AND QUICK SYSTEM

www.Alokozia.com

Charge Controller

Basics Solar modules produce electricity when the sun shines. The charge controller regulates the flow of electricity from the solar modules to the battery bank. When the battery bank is low, the charge controller feeds all of the electricity from the array to the batteries. When the batteries reach a state of full charge, the charge controller stops or redirects the supply of electricity to prevent overcharging. Modern charge controllers have the ability to hold the battery bank in a "float" state of charge if the bank is not being used. At night, the charge controller prevents a reverse flow of current from the batteries to the modules.

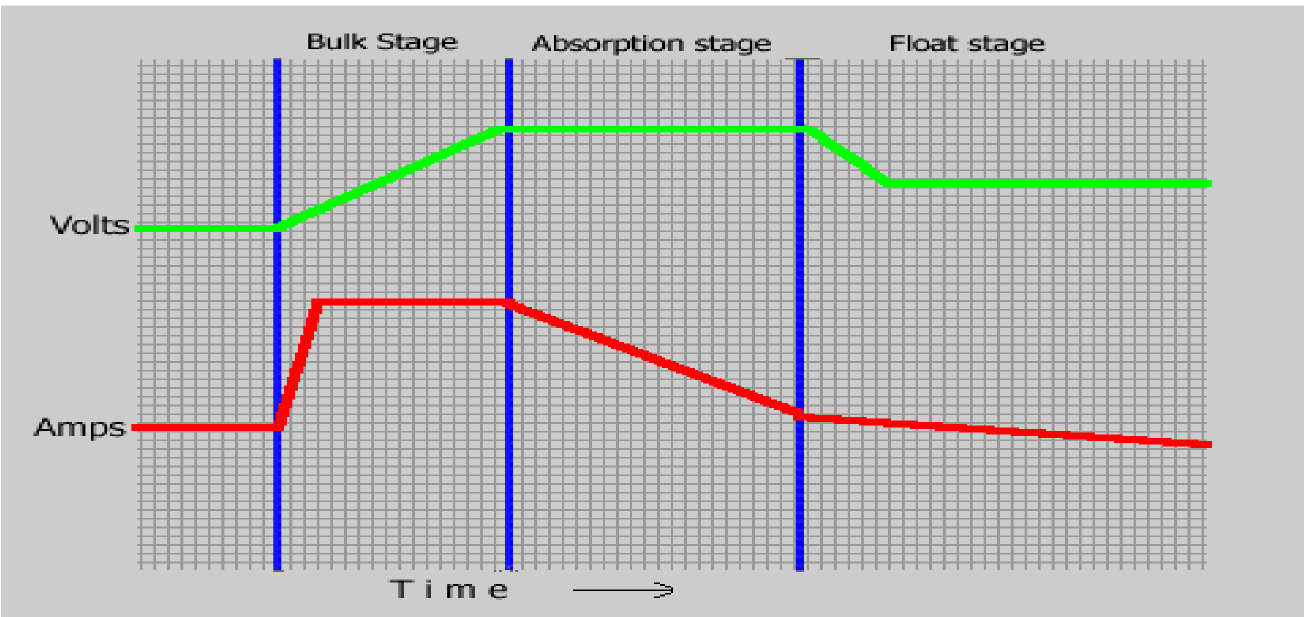


Why a Charge Controller is necessary

Since the brighter the sunlight, the more voltage the solar cells produce, the excessive voltage could damage the batteries. A charge controller is used to maintain the proper charging voltage on the batteries. As the input voltage from the solar array rises, the charge controller regulates the charge to the batteries preventing any overcharging. Modern multi-stage charge controllers

Most quality charge controller units have what is known as a 3 stage charge cycle that goes like this:

1) ***BULK:*** *During the Bulk phase of the charge cycle, the voltage gradually rises to the Bulk level (usually 14.4 to 14.6 volts) while the batteries draw maximum current. When Bulk level voltage is reached the absorption stage begins.*



2) ***ABSORPTION:*** *During this phase the voltage is maintained at Bulk voltage level for a specified time (usually an hour) while the current gradually tapers off as the batteries charge up*

3) ***FLOAT:*** *After the absorption time passes the voltage is lowered to float level (usually 13.4 to 13.7 volts) and the batteries draw a small maintenance current until the next cycle.*

Most charge controllers are a variation of one these four basic types

1. **Shunt Regulator**
2. **Series Regulator**
3. **PWM Regulator**
4. **MPPT Charge Controller**

SHUNT REGULATORS

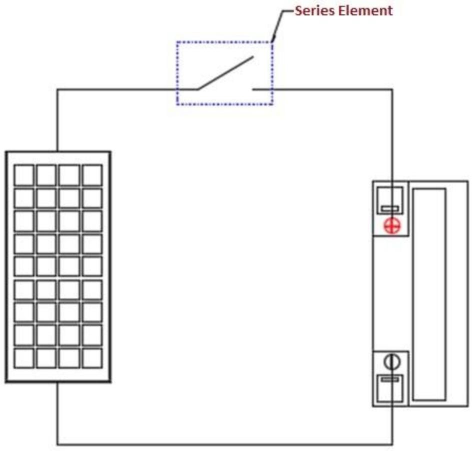
Shunt regulators function by short circuiting the solar array when the battery reaches a set voltage. When the battery voltage drops, the array is un-shorted and current is allowed to flow to the battery again.
This is also sometimes referred to as a pulse regulator, since the current can be "pulsed" to the battery as the array current is regulated. As the charge regulation is either on or off, it's simply a single stage charge controller. As the regulator sees the full current from the solar array during regulation, the shunt regulators get hot and are generally only used for small solar arrays.

Shunt regulators are generally solid-state and contain a blocking diode and a transistor. The solar array is shorted by a transistor (or relay) and the blocking diode prevents the battery from being shorted at the same time. Shunt regulators are generally for negatively grounded systems only as the block diode is usually in the positive line. Shunt regulators are on/off type controllers. This means the solar array is either on or off; the battery sees the full charge current available or none. The regulator allows current from the array to flow to the battery until the disconnect voltage is reached, at which time the solar array is shorted, preventing any further current to flow to the battery. Without any charge current, the battery voltage will drop until the reconnect voltage is reached at which time the regulator will allow current to flow to the battery again. The battery voltage will rise and the cycle will repeat. When the shunt regulator shorts the array during regulation, measuring the array voltage during this time will yield an array voltage that should be less than 1V. During normal charging, the array voltage should be slightly higher than the battery voltage (battery voltage + the voltage drop from diodes or transistors). If array open circuit voltage was ever measured during normal operation, this would indicate a problem.

SERIES REGULATOR

Series regulators function by open circuiting the solar array when the battery reaches a set voltage. When the battery voltage drops, the array is reconnected and current is allowed to flow to the battery again.

Series regulators generally use a relay or transistor to connect and disconnect the solar array. As the relay (or transistor) can be placed in either the positive or negative line, Series regulators can be used in positive and negative ground systems. Series regulators (similarly to shunt regulators) are on/off type controllers. The solar array is either on/off, so the battery sees the full charge current or none. The regulator allows the current from the array to flow to the battery until the disconnect voltage is reached, at which time the solar array is disconnected (open circuited) and prevents any further current to flow to the battery. Without any charge current, battery voltage will drop until the reconnect voltage is reached, at which time the regulator will allow current to flow to the battery again. The battery voltage will rise, and the cycle will repeat. It is sometimes referred to as a pulse regulator, since the current can be "pulsed" to the battery as the array current is regulated. The duration of the pulses can be from hours to seconds depending on: battery SOC & health, load current, temp., etc. Unlike shunt regulators, some series regulators can control multiple relays (or transistors), allowing for multiple disconnect/reconnect set points and stepped charge current. If the series regulator has a single relay, it is simply a single stage charge controller. Additional relays with different set points can make the regulator a multi-stage controller. As the regulator opens the solar array to regulate the battery voltage, series regulators run much cooler than shunt regulators (especially if a relay is used instead of a transistor). For this reason, series regulators are well suited for large solar arrays.

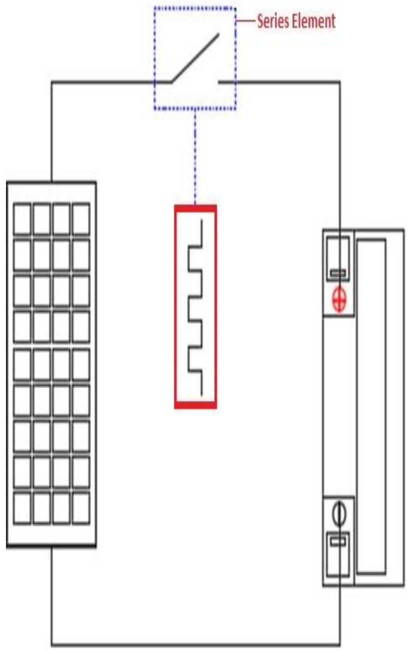


When the series regulator opens the array during regulation, measuring the array voltage during this time will yield an array voltage that should be close to the open circuit value. During normal charging, the array voltage should be slightly higher than the battery voltage (battery voltage + the voltage drop from diodes or transistors). If an array voltage value is less than the battery voltage was ever measured during normal operation, this would indicate a problem.

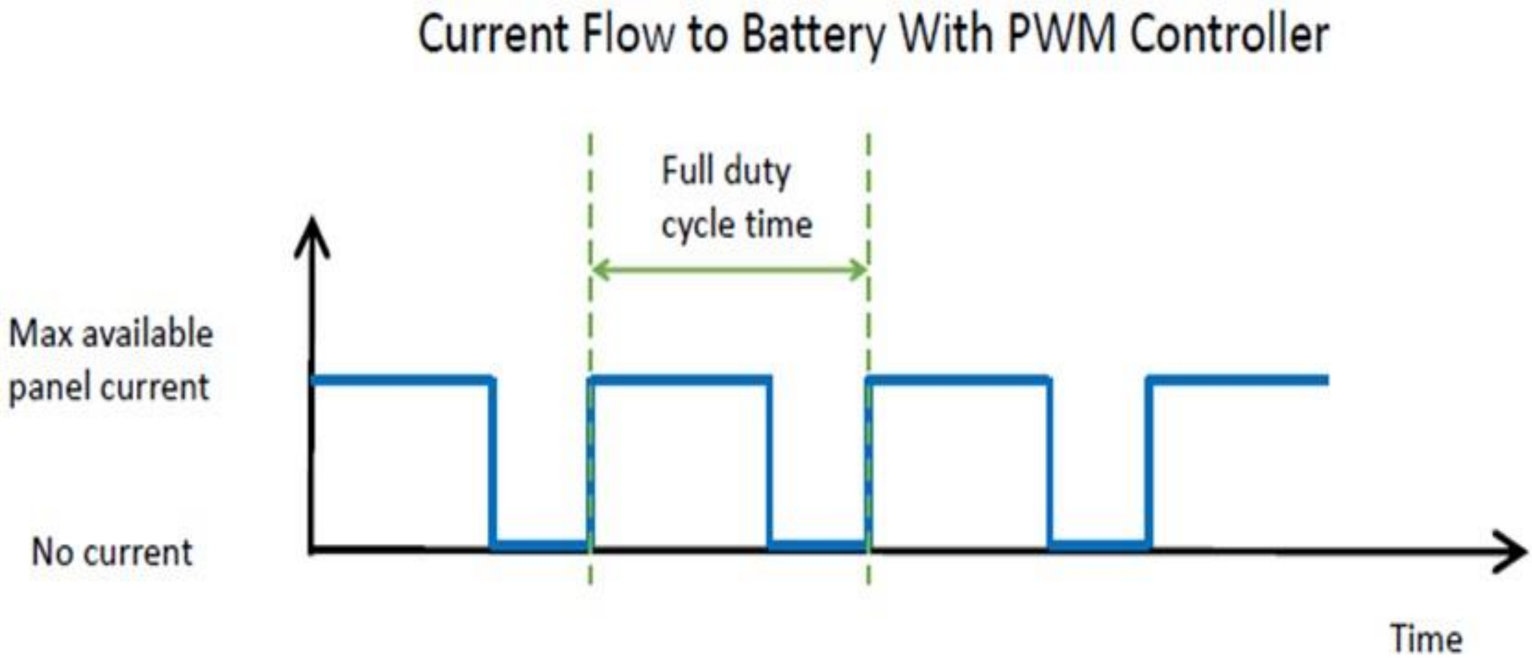
PULSE WIDTH MODULATION (PWM) REGULATOR

PWM regulators are similar to series regulators, but they use a transistor instead of a relay to open the array. By switching the transistor at high frequency with various modulated widths, a constant voltage can be maintained. The PWM regulator self-adjusts by varying the widths (lengths) and speed of the pulses sent to the battery. Unlike the on/off charge controllers which instantaneously cut off the power transfer to minimize battery overcharging, PWM regulators act like a rapid on/off controller constantly.

When the width is at 100%, the transistor is at full ON, allowing the solar array to bulk charge the battery. When the width is at 0% the transistor is OFF, open circuiting the array preventing any current from flowing to the battery when the battery is fully charged.
Like the series regulator, the transistor can be placed in either the positive or negative line, allowing the regulator to be used in positive and negative ground systems. The difference between the series regulator and the PWM regulator is the PWM of the transistor. When the modulation width is at 100% or 0%, the regulator is essentially a series regulator, it is that modulation width variation that allows the PWM regulator to create a constant voltage to the battery as opposed to the on/off of the series regulator.
The below figure shows an example of a PWM regulator regulating with a 70% on 30% off duty cycle. Some PWM regulators have provisions for converting to a series (on/off) regulator. This could be needed for sensitive loads that have an issue with the noise created by the frequency of the PWM. Some PWM regulators have provisions for converting to a series (on/off) regulator. This could be needed for sensitive loads that have an issue with the noise created by the frequency of the PWM. Because PWM charge controllers require transistors, they are always solid-state; this means heat dissipation can become a problem, especially in larger solar arrays.

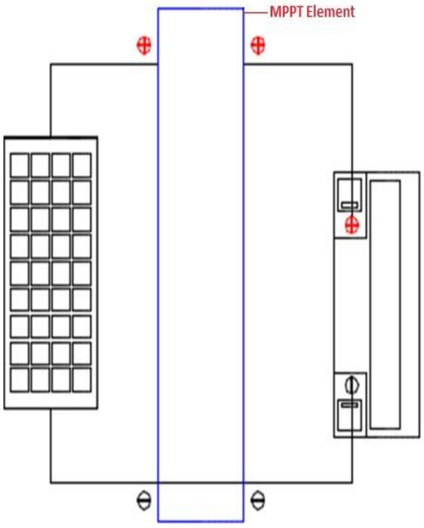


As with series regulators, because the PWM regulator regulates by opening the array during regulation (at high frequency), if you were to measure the array voltage during this time, the array voltage can be anywhere between battery voltage and open circuit voltage depending on the regulator's charging stage. If an array voltage value less than the battery voltage was ever measured during normal operation, this would indicate a problem.



MPPT CHARGE CONTROLLER

The Maximum Power Point Tracking (MPPT) charge controller takes the PWM to the next level, by allowing the array voltage to vary from the battery voltage. By varying the array input, the charge controller can find the point at which the solar array produces the maximum power. The MPPT process works like this. Imagine having a battery that is low, at 12 V. A MPPT takes a voltage of 17.6 volts at 7.4 amps and converts it down, so that what the battery gets is now 10.8 amps at 12 volts. MPPT controllers takes the DC input from the solar panels, convert it to high frequency AC, and then change it once again to a different DC voltage and current. The point is the voltage will exactly adhere to the requirements of the battery. As the MPPT charge controller uses the negative line as a reference and then switches the positive line, they can be used in negative ground systems only. It is crucial to understand that voltage is a potential difference; the 'difference' refers to the difference between ground potential and some potential. This means that the starting point is below zero, but this is only used as a reference point.



Since MPPT charge controllers can vary the charge current to the battery, the regulator can be a multi-stage charger with bulk, absorption, and float settings. They are always solid state; this means heat dissipation can become a problem, especially in larger solar arrays. MPPT controllers are typically step-down converters, so the array voltage always needs to be higher than the battery voltage. Therefore, an array voltage value less than the battery voltage during normal operation would indicate a problem. Charge controllers are arguably the most important components of off-grid solar systems. Without them, batteries would be overwhelmed and unable to keep up with the dynamic changes in energy that come from solar panels. When choosing the correct charge controller, it is important to keep in mind the specifics of the project at hand; each controller is applicable for various scenarios and like most things in life requires trade-offs.

What is difference between PWM and MPPT Solar Charge Controllers?

A simple comparison between the two most used types of solar charge controllers.

*The two main types of solar charge controllers are the **PWM** and the **MPPT.** While PWM is essentially a switch that connects a solar array to the battery, the MPPT is more sophisticated, since it will adjust its input voltage to harvest the maximum power from the solar array and then transform this power to supply the varying voltage requirement of the battery plus load.*

To compare them on the technical level, below you find a comparison table, that takes into account six different aspects: the array voltage, the battery voltage, the system size, the off-grid or grid-tie and the array sizing method.

SUMMARY OF COMPARISON

	PWM Charge Controller	***MPPT Charge Controller***
Array Voltage	*PV array & battery voltages should match*	*PV array voltage can be higher than battery voltage*
Battery Voltage	*Operates at battery voltage so it performs well in warm temperatures and when the battery is almost full*	*Operates above battery voltage so it is can provide "boost" in cold temperatures and when the battery is low.*
System Size	*Typically recommended for use in smaller systems where MPPT benefits are minimal*	*≈ 150W – 200W or higher to take advantage of MPPT benefits*
Off-Grid or Grid-Tie	*Must use off-grid PV modules typically with Vmp ≈ 17 to 18 Volts for every 12V nominal battery voltage*	*Enables the use of lower cost/grid-tie PV Modules helping bring down the overall PV system cost*
Array Sizing Method	*PV array sized in Amps (based on current produced when PV array is operating at battery voltage)*	*PV array sized in Watts (based on the Controller Max. Charging Current x Battery Voltage)*

Charge Controller Sizing and Selection

Each time you charge deep cycle batteries with solar panels, it's necessary to use a charge controller in the circuit in order to protect the battery from overcharging or from over discharging. The exception to this rule is when using solar panels smaller than 5 Watts.

SOLAR CHARGE CONTROLLER

Choosing the most suitable charge controller is simple and only requires two steps:

Step 1 – Voltage selection

Select a charge controller that is compatible with the system voltage. The standard configurations are 12, 24, and 48 volts. If you are wiring your batteries for 24 volts you need a charge controller that is rated at 24 volts.
Some controllers are voltage specific, meaning that the voltage cannot be changed or substituted. Other more sophisticated controllers include a voltage auto-detect feature, which allows it to be used with different voltage settings.

Step 2 – Current capacity

Select a charge controller that can handle the maximum output current of the solar panel (or solar array). The maximum possible current that a PV panel can generate is the "short circuit current," indicated as I_{sc} in the panel's label or specs sheet. It's recommended to include a safety factor for isolated events as well. For example, a solar panel with a LSC of 7.89 amp could potentially produce an extra 25% on a sunny day with very clear snow pack. (additional light reflected off the snow). This results in a possible maximum of 9.86 amp (7.89 x 1.25 = 9.86 amp). In this case, a 10 amp charge controller would be recommended.

Alokozia Limited

Contact

Address	Contact	
Mirwais Market Madad Chowki Office	0093 + 704475600	Info@Alokozia.com
No: 10,11,12 Kandahar, Afghanistan	0093 + 785922004	www.Alokozia.com

THE INNOVATIVE
AND QUICK SYSTEM