Automated Irrigation with Sun Tracking Solar Cell and Moisture Sensor

Er. Faruk Poyen, Balaka Dutta, Swarup Manna, Arkeya Pal, Dr. Apurba K Ghosh, and Prof. Rajib Bandhopadhyay

***Abstract*----**Choice of proper methods is always important in the field of irrigation. By indulging the optimum methods, we can ensure maximized yield from the field. In this era of sensors and technological development, it is the ripest time to involve these advancements in this domain as well. Water being one of the most precious resources, it is never to be wasted. Again sunlight which is such an abundant resource must be utilized. The method we put in this paper correlates two different techniques viz. measuring water content in a field and employing solar power to drive motors for running submersible pumps as and when required. Adding on to these we have developed an arrangement so that the solar panels can track the orientation of the sunlight and adjust themselves accordingly. The unique feature of the proposed system is that instead of taking the earth as its reference, it takes the sun as a guiding source. Active sensors constantly monitor the sunlight and rotate the panel towards the direction where the intensity is most. The light dependent resistors do the job of sensing the change in the position of the sun. An electro mechanical arrangement aligns the panels accordingly. The entire set up is controlled by an Arduino Atmel AVR microcontroller which will trigger the relays as and when required. The expectations agree to great extent to the desired efficiency.

***Keywords*----**Inverters, Soil moisture sensor, Solar Tracking System, Submersible pump.

I. INTRODUCTION

IMPROVING irrigation efficiency can contribute greatly to reducing production cost of crops, making the demand supply response more effecient. Through proper irrigation technologies, average vegetable yields can be maintained (or increased) while minimizing environmental impacts caused due to wastage of resources. Recent technological advances have made soil water sensors available for efficient and automatic operation of irrigation systems. The amount of water required for any particular crop will be accounted for by a soil moisture sensor made from very easily and cheaply available Gypsum. The proposal frees one from manually operating the pump and also the sensor network brings down the wastage of water [1], [2].To meet the demand for energy, harnessing of non-conventional/renewable energy becomes a necessity. Solar energy is the most abundant and uniformly distributed among all the available non-conventional sources. Even though technology for trapping solar energy is already in existence, the process can be further improved to increase its efficiency. Moreover solar power is renewable. The sun will keep on shining anyway, so it makes sense to utilize it.

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II. OVERVIEW

The paper here takes note on two techniques merged together to bring out the best possible results. One part deals with automatic sensing of the moisture content of the farming land employing gypsum. Based on the reading obtained from sensor network, care will be taken about how we can employ solar energy for driving hi-power water pumping motor with the use of solar tracking technology integrated with the system. The motor used by our automatic plant irrigation to water the soil is driven by pure solar energy which makes it highly efficient [4], [5]. Since renewable energy consumption is employed, our work does not rely on any external power source.

III. SOIL MOISTURE SENSOR

There are quite a few very commonly used and easily available chemical compounds which show changes in their physical as well as electrical properties under the presence of different amount of water present in their amorphous as well as crystalline structure.

Fig. 1 shows the different levels of soil moisture tension for different soil and plant growth conditions.

Gypsum ($CaSO_4.2H_2O$) is one such basic compound which has been used as a sensor in this very current context [10], [11], [12]. One corporeal property of gypsum is that it offers marked impedance and therefore acts as a resistive material when dry, letting no current to flow through it. On being hydrated, the block allows electrons to pass between the probes efficiently plummeting the impedance between the probes. On being inundated the block offers practically zero resistance. Carrying out heuristic analysis and putting those

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data in table, we can land down with a mathematical relationship that exists between water content and gypsum. The key success of the sensor viz. Gypsum is the number of hydrated molecules [8], [9], [10]. Fig. 2 shows a very set-up for initial testing done on wet, dry and intermediate sand to check for the sensor functionality.

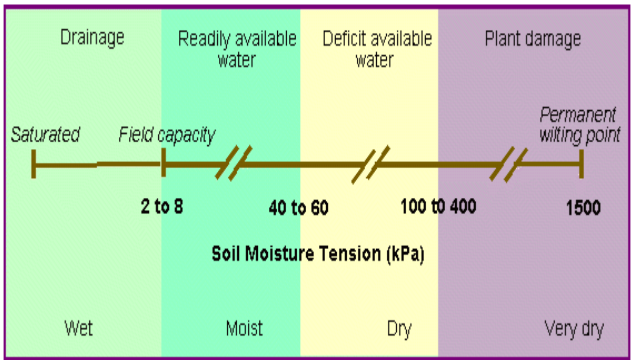

Fig. 1 Relationship of available soil moisture to soil water tension

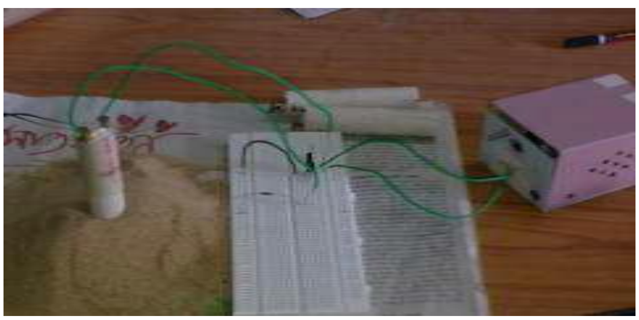

Fig. 2 Diagram of the soil moisture sensor

IV. Result Obtained With Sensor ($CaSO_4.2H_2O$)

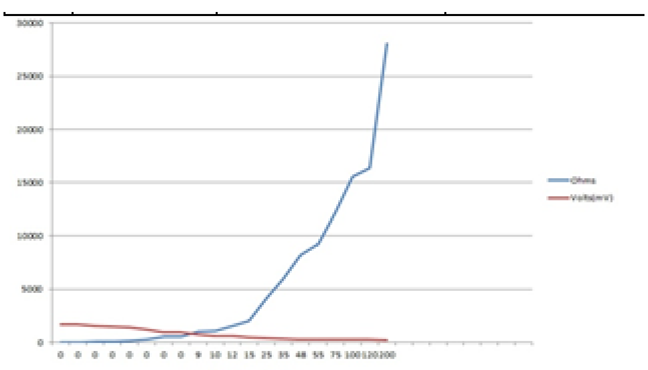

Fig 3 Response curve Soil Water Tension versus Impedance

Table 1 reflects the values of impedance offered by sand under different temperature conditions for different amount of water content in it.

TABLE 1
Impedance Response Under Different Temperature Conditions For Sand

SL. No	Temp.	Type of material/ sample	Resistance across probe(Ω)
1.	10 ° C	a) No sample	>10MΩ
	10 ° C	b) Sand (DRY)	10000Ω
	10 ° C	c) Sand (semi WET)	7100Ω
	10 ° C	d) Sand (dipped in water)	790Ω
2.	25 ° C	e) No sample	>10MΩ
	25 ° C	f) Sand (DRY)	12800Ω
	25 ° C	g) Sand (semi WET)	8300Ω
	25 ° C	h) Sand (dipped in water)	810Ω
3.	40 ° C	i) No sample	>10MΩ
	40 ° C	j) Sand (DRY)	13900Ω
	40 ° C	k) Sand (semi WET)	9000Ω
	40 ° C	l) Sand (dipped in water)	920Ω
4.	50 ° C	m) No sample	>10MΩ
	50 ° C	n) Sand (DRY)	13000Ω
	50 ° C	o) Sand (semi WET)	9100Ω
	50 ° C	p) Sand (dipped in water)	1200Ω
5.	60 ° C	q) No sample	>10MΩ
	60 ° C	r) San (DRY)	16500Ω
	60 ° C	s) Sand (semi WET)	10500Ω
	60 ° C	t) Sand (dipped in water)	1800Ω

V. System Set-Up

The accessories we need for the set-up are

a) Gypsum based soil moisture sensor.
b) Solar panels with tracking system
b) Electro mechanical arrangement for panel movement
c) Submersible pumps
c) Inverters
d) Batteries

The system starts from the sensor network and ends at the watering system and Arduino 386 acts as brain of the set-up. The solar panels store energy from sunlight. The electro mechanical set up provides movement to the panels according to the sun's position. The moisture sensor network tracks the requirement of water by the field and a submersible motor is run based on the water requirement, all happening without any human intervention. The circuit comprises sensor parts built using op-amp IC LM324. Op-amps are configured here as a comparator. A sensor network has been netted to monitor and record the content of moisture in the field. The Micro controller is used to control the whole system. It monitors the sensors and when sensors sense the dry condition then the micro controller will switch on the relay and vice versa. The micro controller does the above job after it receives the signals from the sensors, and these signals operate under the control of software which is stored in ROM. Fig. 4 provides a schematic diagram of the set-up.

On the other hand solar engine works as follows:
1. The solar cell starts charging the capacitor and the voltage rises.
2. As soon as the capacitor reaches around 2.7 V the 1381 turns pin 1 high and turns the 3904 ON.
3. When the 3904 turns on, it brings the base of the 3906 low which turns the 3906 ON.
4. With the 3906 ON current is supplied to the base of the 3904 which keeps it ON.
5. Now current can flow through the motor and it starts running.
6. When the voltage gets down to 0.7V the transistors turn OFF and the process is repeated, as explained in Fig 4.

Fig. 5 (a), (b), (c) and (d) show the circuit diagrams of the sensor network and controller.

VI. Block And Circuit Diagram Representation

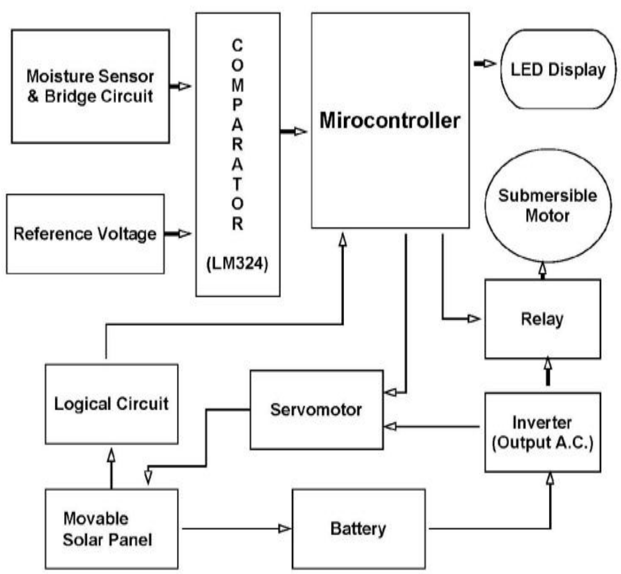

Fig 4 Block Diagram Representation of entire Set Up

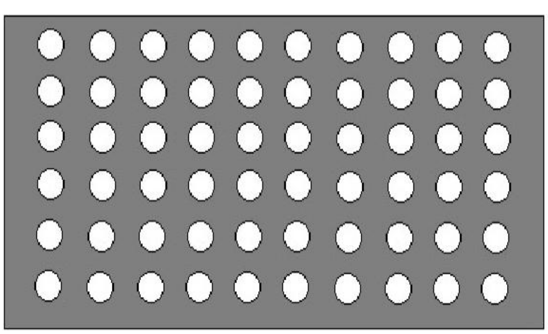

Fig 5(a) Sensor Network placed in the field

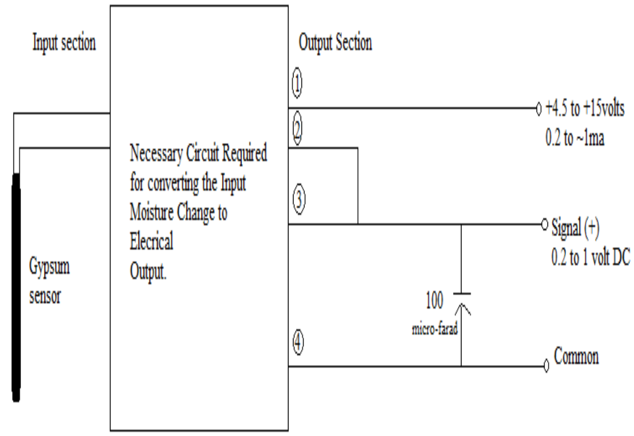

Fig. 5(b) Moisture content to Volt output

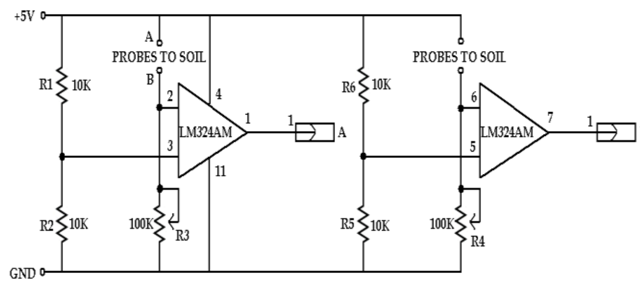

Fig.5(c) Circuit Diagram Representation of Sensor Network

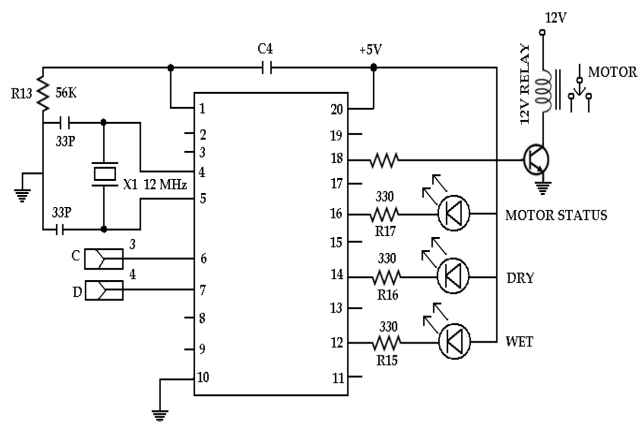

Fig. 5(d) Circuit Diagram Representation of Controller

VII. Algorithm for Moisture Sensor Module

Step 1: Design a moisture sensor network in such a way that the O/P voltage in case of dry soil (75kPa, 270 mV) is more than wet condition (8kPa, 720 mV).
Step 2: Set the ref. voltage, which must be equal or less than the output voltage obtained from the moisture network sensor at fully wet (< 8kPa) state of soil.
Step 3: Compare the sensor O/P with the ref. I/P using a comparator. If the sensor O/P is more than ref. then comparator O/P will be high (logic 1), and if the sensor o/p is equal or less than the ref voltage then comparator O/P will be low (logic 0).

Step 4: Check whether the battery connected with solar system is fully charged or not from the control panel, installed with the solar arrangement.

Step 5: Now check these condition through microcontroller:

a.) If comparator O/P is 1 & battery charge level is not enough to drive motor;

Glow the status LED of dry soil, send a low signal (logic 0) to the relay.

b.) If comparator O/P is 1 & battery charge level is enough to drive motor;

Glow the status LED of dry soil and motor is running, send a high signal (logic 1) to the relay.

c.) If the comparator O/P is 0;

Irrespective of the battery charge condition glow the status LED of wet soil, send a low signal (logic 0) to the relay.

Step 6: When microcontroller sends a high signal (logic 1) at the I/P of relay it make contact between the inverter and the induction type submersible motor and the motor will start.

Step 7: Go to step 3.

Fig 6 provides the flow chart of the sensor module and the motor arrangement.

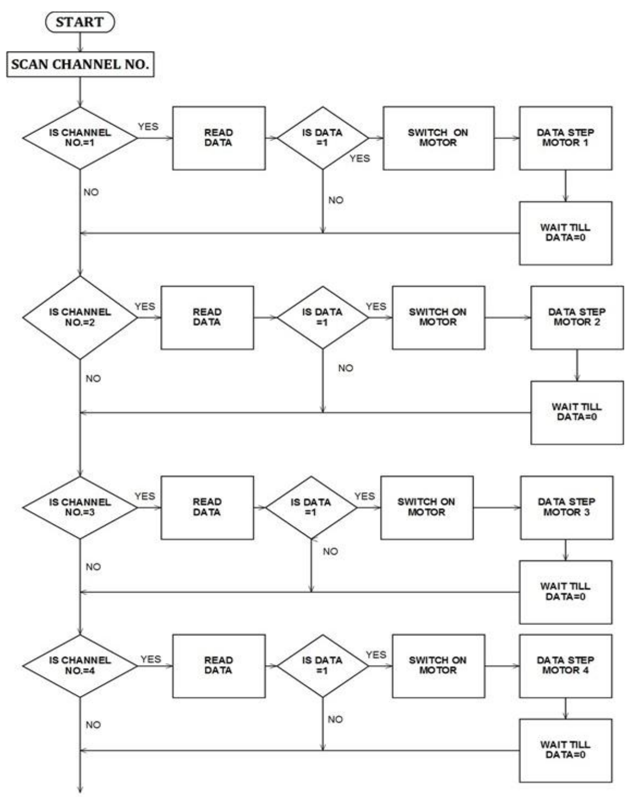

Fig 6 Flow Chart of Moisture Sensor Module and Motor Unit

VIII. SOLAR TRACKING SYSTEM

Solar tracker directs solar panels or modules toward the sun throughout the day. These help to minimize the angle of incidence (the angle that a ray of light makes with a line perpendicular to the surface) between the incoming light and the panel, which increases the amount of energy. Thus, it increases the overall efficiency by 20-30% [3], [4], [5].

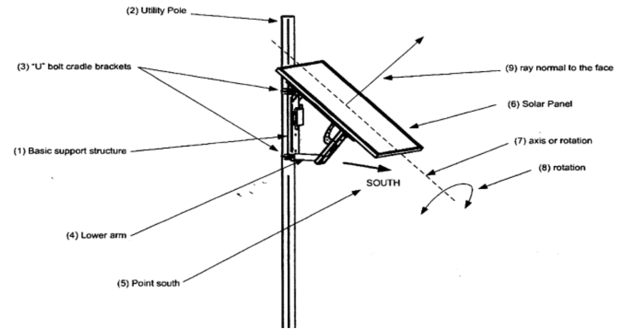

Fig. 7 Basic arrangement of Single axis Solar Panel

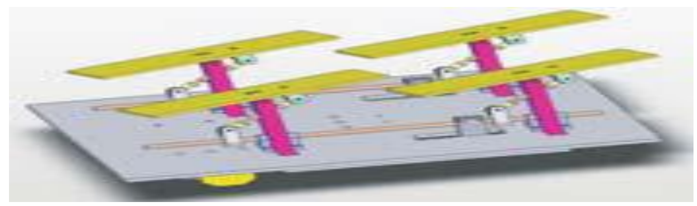

Fig 8 Schematic Model of Panel Network

Here, the proposed solar tracking system is a single axis solar tracking system. The single-axis solar trackers (fig. 7 and fig 8) rotate on one axis moving back and forth in a single direction (between east & west). It is generally recommended to use the dual axis solar tracking system but, due to high cost of electrical appliances used in the system and as the elevation angle of the sun remains almost invariant during a month and varies little in a year [6], the single axis solar tracker system can be usable with some proper measures. The different angle of sun with the horizontal/vertical (shown in the fig 10) in the major seasons such as Summer, Winter and Spring are measured first and they are set in the solar panel according to the seasons. Then, the solar panel is to be set to move only from east to west according to the sensor output throughout a season.

Construction:

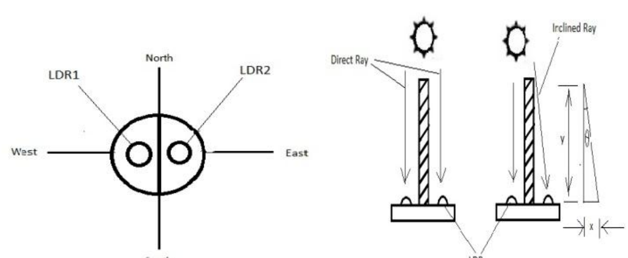

Fig 9(a) (b) LDR arrangement on board

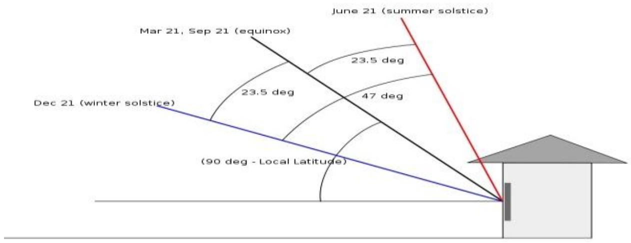

Fig 10 Elevation angle of Sun during Different Season

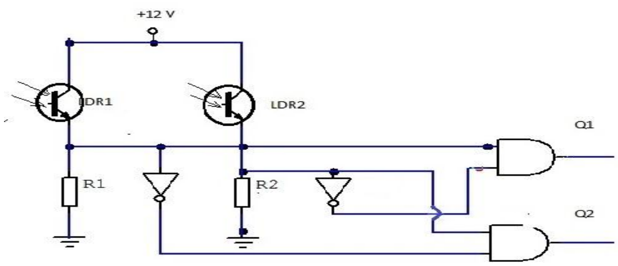

Fig 11 Digital Logic for LDR responses

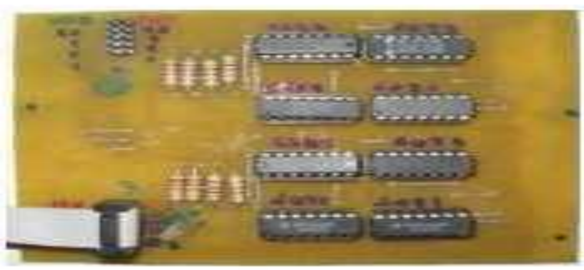

Fig 12 On board Logic Circuit design of LDR response

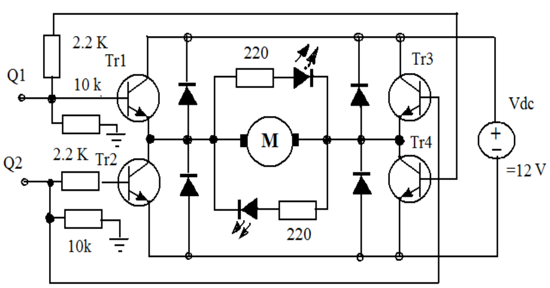

Fig 13 Motor gear arrangement for Panel Movement

It consists of two LDRs mounted on a plate and a barrier is placed between the LDRs perpendicular to the plate. Thus, it results in the absence of sunlight on an LDR while the sun is bent towards the other LDR as shown in the fig 9 (a) and (b). The LDR output is fed to a logical circuit to give a suitable output which is again fed into the Microcontroller input Ports, fig 11 and fig 12.The microcontroller issues control signals to the servomotors according to the received signal in the input ports. It results a specific angular rotation of the servomotor as well as the solar panel from the east to west .The sensor arrangement being mounted on the solar panel tracks the sun throughout the whole day and makes automatic rotation of the panel with the sun.

Algorithm for Solar Tracking Module:

1. According to the output of LDR1 & LDR2 ,the logic circuit produces output Q1 & Q2 as per the Truth Table Boolean Expression:
   $Q1 = L1.L2'$
   $Q2 = L2.L1'$
2. Q1 and Q2 are fed to the two Input Ports of Microcontroller.
3. The Microcontroller is programmed to check the input ports at a specific interval of time.
4. If Q1 ='1' and Q2 ='0' ,the sun is towards the west, microcontroller issues clock signal to servomotor for a particular time interval which will rotate the solar panel toward the west.
5. If Q2='1' and Q1='0' , the sun is towards the east, microcontroller issues clock signal to servomotor for a particular time interval which will rotate the solar panel toward the east.
6. If Q1=Q2='0' or if Q1=Q2='1' there is no signal issued from the microcontroller to the servomotor.

INPUTS		OUTPUTS	
L1	L2	Q1	Q2
0	0	0	0
0	1	0	1
1	0	1	0
1	1	0	0

The panels attain their end position at dusk. Sensing no further light, the panels reset themselves to their initial position so that they can start functioning in the same manner the next day and hence. Between the extreme position and reset position, a 1 hour delay is provided to the system. The entire coding for this controller is done in Pyhton.

IX. Conclusion

The scope of success of this particular project is multi faced. The most important feature of this paper is, it looks forward to the future and can lead to a revolutionary aspect towards farming and irrigation. There are limitations as well to the proposed work as we need to make the cultivators aware of the far fledged advantages to this technique and have to make them acquainted to how the system works and in case of any problem what actions need to be taken.

The solar tracking system is a renewable and non-consumable technique. It leads to a pollution free system. The designed system requires minimum maintenance with a practically good level of improvement of system efficiency for the comparative cost of acquisition of systems of similar output capacity. It frees itself from human interference and thereby saving human resource. The bottom line of the entire talk is if we can resort to this new and revolutionary technique, we can bring about another "Green Revolution", which is highly desirable and need of the hour.

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