PLC Based Multi Starter Control using Single Control System for Induction Motor

S.Usha, C.Subramani, M.Venkatesan, S.Dhanush ragav, B.Aasif Imraan

Abstract— Most customarily used motor in the industries are induction motor due to its low cost, robustness and less maintenance. The change in the existing framework is necessary in order to make the motor more efficient one. This paper cast enlightenment about the PLC based 3 phase multi-starter control induction motor with energy efficient single control system. In order to start the engine's operation by its own power, starters are used. Various starters are available to initiate the 3-phase induction motor namely Direct On-line, Star-delta, autotransformer and rotor impedance. The employment of this PLC based techniques helps to increase the energy efficiency of the motor .The employability of PLC in this system is to help in the growth of automation. The hardware and software results of the multi starter control using single control systems are analysed.

I. INTRODUCTION

Effectiveness of the motor varies according to the starter used .In order to the satisfies the requirement for the customers, and Increase in the energy and cost efficiency of the motor one has to provide the proper type of starter for the existing type of motor. To overcome this, PLC based multi starter control using single control system for induction motor has been implemented. The employment of this PLC based techniques helps to increase the cost and energy efficiency of the motor and the starters are switched in order for their requirements for a better efficiency. These PLC based multi starter control using single control system, helps to switch the starter easily when it is in operating condition.

Automation is usually done in order for a better efficiency of cost and energy, and to operate in a safely working condition [1].PLC is used here as it provide greater flexibility. The error diagnosis is easy and can be corrected in the working condition itself.[4] .PLC came into existence with the name of MODICAN084 and the main man in the invention of PLC was Dick Morley and later he was considered as the Father of the PLC[5][6]. PLC is programmed using ladder diagram for intelligent switching between the two starters.[7]

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This project deals with energy efficient and helps in the reduction of the cost by using a single control system for various type of motors, that is the multi starter control, that can be used for the operation of star delta and DOL type sttarters.So that, cost gets reduced even though the working operation is considered same. In order to make user friendly and ease of using the introduction of mobile controller that makes this more useful for the switching operation. Usage of PLC over soft starter, because this produces the harmonics in a large amount compared to PLC

II HARDWARE COMPONENT AND ITS DESCRIPTION

A) PLC:

The Relay is used in industries mainly in the manufacturing process .As it consume a large amount of power and required to be replaced frequently ,they have been replaced by PLC. They are form of digital computer which is used in electromechanical process to enable automation. PLC are reliable under harsh environmental conditions and are programed using the given programming language on a computer and are transferred to the PLC using a cable .The program is referred by a ladder logical diagram and SELECT PLC brand is used to keep the cost low.

b) HC 06 BLUETOOTH MODULE:

This is a pair of slave Bluetooth module, which is used universally for wireless serial communication. This is paired along with a master Bluetooth module in a laptop or phone and the communication of data can take place. All the data received and transmitted are in real time.

c) ARDUINO ATMEGA328P:

It consist of 8 bit AVR Risc based microcontroller. They can used in places where there is a need of simple, low cost microcontroller.

d) RELAY:

These are usually made up of electromagnets, which in general purpose used as a switch. The working of relay is simple, the signals that are obtained from the one end of the device controls the switching operation of the other end of the device. Their main operation is to break the contact of the signal without the human involvement of switching operation .The working is done with the control of high powered circuit using a low powered circuit.

2.1) Direct On-Line (DOL) starter :

DOL is a simple and economical starter and is widely used in squirrel cage induction motor. It directly interfaces the contacts of the engine to the full supply voltage. The starting current is exceptionally extensive, usually as 6 times the evaluated current. The initial torque is probably going to be 0.75 times the full load torque.
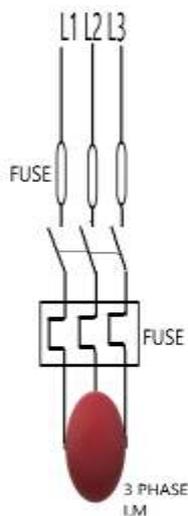

Fig 1 DOL starter

2.2)Star-Delta Starter:

The star delta starter is a most commonly used type of starter in starting of the induction motor. Working of star delta starter is simple when the switch is in start position the stator winding connected in star.While the motor attains the speed which is about 80% of the rated speed .They are switched into delta connections,while in this condition the starting line current is one third compared to the starting current accompanied winding connected in the delta.In case of the star delta starter ,the developed torque is directrly propotional to the square of the voltage.
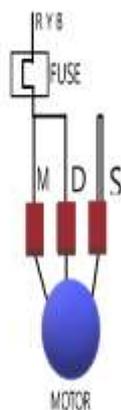

Fig:2 (Model to Star delta)

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2.3) Synthesi of Star delta and DOL using PLC:

The SELECT brand in PLC has been used,since it is cheap when compared to other type of brand in PLC. Usage of a self pro software for programming regarding PLC has been executed.This software slightly differ from RS LOGIC 500. This software helps in programming the ladder diagram .The circuit has been designed which helps in switching between the star delta and DOL starter using selector switch .In the

selector switch ,↑ arrow indicates Star delta function whereas ↓ arrow indicates DOL starter. When the selector switch is in star delta mode, M coil and S coil closes, it indicates the star current has been passed.It has been designed in such a way, after 5 seconds M coil and S coil opens and D coil gets closed and delta current is passed. If it is tried to be managed in parallel aspect the starter will get damaged. So the seconds are maintained in order to avoid damage. This damage will not be carried away to the DOL because of the usage of the selector positioning switch. When the ↓ arrow is pulled down The DOL is started so there will be no damage to the Star delta .In DOL starter M and S coil opens and D coil closes and starts the motor. The functions of both star delta and DOL circuit has been programmed in a single ladder diagram .When both circuit is operating together there is a chance of receiving a high current. In order to avoid that programming is made in the OVER LOAD CURRENT RELAY in the M coil.
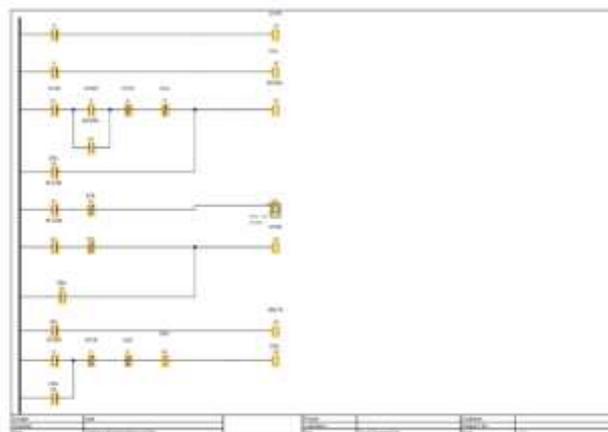
2.4) LADDER DIAGRAM:
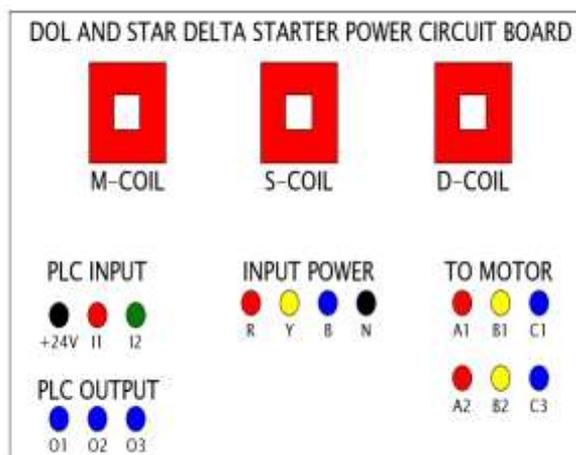

Fig:3 simulation of proposed model

Fig:4 control panel design of proposed model

Fig 3 simulation of proposed model represents the combination of star delta and DOL using PLC ladder simulation diagram. Fig 4 control panel design of proposed model represents the vision of panel board diagram which includes the combination of DOL and Star delta starter with the advantages of having input and output of the motor and starter , with the usage of less wires compared to other .

2.5) DOL:

NO LOAD CONDITION:

V	A	W1	W2	S1	S2	RPM	T	O/P	PF	η%	%Slip
210	2.1	-400	640	2	2	1495	0	0	0.804	63.14	2

Table1: No load test

This test is usually done in order to determine the efficiency and to note the value of the circuit parameters of the three phase induction motor .And with help of the device, two wattmeter power is note down and is represented as W1,W2.When the motor is in running condition the input power should be equal to the constant iron, friction and windage loss of the three phase induction motor

LOADED CONDITION:

V	A	W1	W2	S1	S2	RPM	T	O/P	PF	η%	%Slip
210	1.8	180	40	2	0.1	1522	16.75	265	0.336	61.6	3
210	2.5	180	30	7	0.2	1448	60.37	909	0.1273	68.4	3.46
210	4.5	180	60	10	.4	1440	84.78	1277	0.8088	62.2	4

Table 2:Performance of induction motor under load test
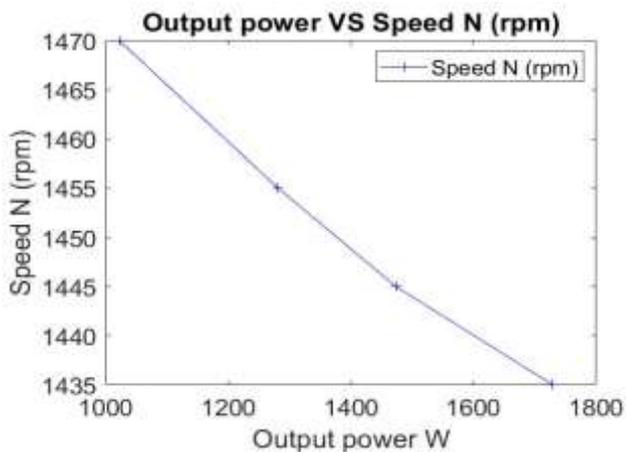

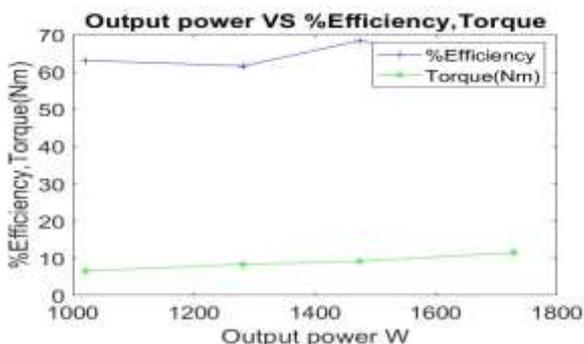**Fig:5 Speed performance**

Fig.no:6 Efficiency and torque performance of induction motor
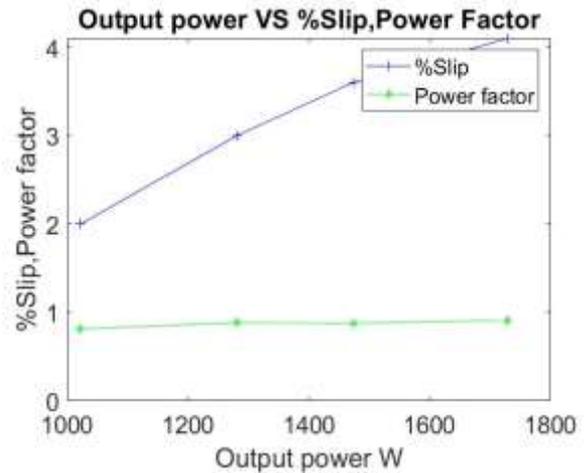

Fig:7 Power factor of induction motor

Fig no 5 represents the output power in the x axis and the speed in the y axis .output power is inversely proportional to the speed in the induction motor .This relation is reflected in the plotted graph .Fig 6 represents the output power in the x axis and efficiency and % torque in the y axis of the induction motor the efficiency is about 65% and the torque increases with increase in output power. This relation is reflected in the plotted graph. Fig 7 represents output power in the x axis and %slip and power factor in y axis. The ouput power is found to be directly proportional to the power factor. and slip . This relation is reflected in the plotted graph.

Calculation:

Output power $=2*3.14*N*T/60$
1. $2*3.14*1522*1.6775/60=265$
2. $2*3.14*1448*6.0037/60=909$
3. $2*3.14*1440*8.4758/60=1277$
4. $2*3.14*1436*11.47/60=1772$
Efficiency $=$output/input$*100$,3hp=750 =   3*750 = 2250
1. $2250/220*100=63.4\%$
2. $2250/210*100=61.6\%$
3. $2250/240*100=68.4\%$
4. $2250/300*100=62.2\%$
Slip $= [Ns-N/Ns]*100$, Ns=3hp =3*750=1500
1. $1500-1522/1500*100 = 1.4\%$
2. $1500-1448/1500*100 =3.46\%$
3. $1500-1440/1500*100 =4\%$
4. $1500-1436/1500*100=4.2\%$
Power factor $=$input power$/1.732*V*I$
1. $220/1.732*210*1.8=0.336$
2. $210/1.732*210*2.5=0.1273$
3. $210/1.732*210*4.5=0.808$
4. $210/1.732*210*6.5=0.1203$
Torque $=9.81*(s1-s2)*R$ R=0.9
1. $9.81*(2-0.1)*0.9 =16.7751$
2. $9.81*6.8*0.9=60.0372$
3. $9.81*(10-0.4)*0.9=84.78$
4. $9.81*(14-1)*0.9=114.72$

2.6) STAR DELTA:

Loaded Test:

Vl(V)	IL(A)	Input(W)	Load(S1)	Load(S2)	T(Nm)	Speed N (rpm)	Output power (W)	%slip	%η	Pf
210	1.9	170	5	0.2	42.37	1470	6519	2	38.3	0.1356
210	2.3	210	10	0.3	85.6	1453	13010	3.1	61.9	0.1384
210	2.7	290	12	0.4	102.41	1451	15553	3.2	53.5	0.1688
210	3.0	360	16	0.7	135	1447	20456	3.5	50.7	0.1819

Table 3:Inductiono motor load test using Star delta starter

CALCULATION:

Slip= [Ns-N/Ns]*100   : Ns=120f/p

f=50Hz   p=4

    1) [1500-1470/1500]*100 =2%

    2) [1500-1453/1500]*100 =3.1%

    3) [1500-1451/1500]*100 =3.2%

    4) [1500-1447/1500]*100 =3.5%

Torque = 9.81*(s1-s2)*R   : R=0.9

1) 9.81*4.8*0.9 =42.379

2) 9.81*9.7*0.9 =85.6

3) 9.81*11.6*0.9=102.41

4) 9.81*15.3*0.9=135.0

Output power= 2*3.14*N*T/60

1) 2*3.14*1470*42.34/60   =6519

2) 2*3.14*1453*85.6/60   =13018

3) 2*3.14*1451*102.41/60 =6519

4) 2*3.14*1447*135/60   =20446

%Efficiency =output/input*100   output is 3hp

3*750=2250

1) 2250/170*100=13.2

2) 2250/210*100=10.7

3) 2250/290*100=7.75

4) 2250/360*100=6.25

Power factor =input power/3.14*V*I

1) 170/3.14*1.9*210 =0.1356

2) 210/3.14*2.3*210=0.13842```

3) 290/3.14*2.7*210=0.1628

4) 360/3.14*3*210=0.1819

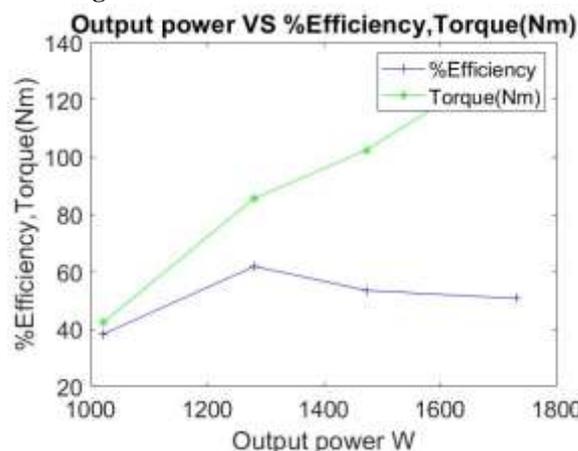**Fig no.9 Efficiency performance of induction motor using star delta starter**

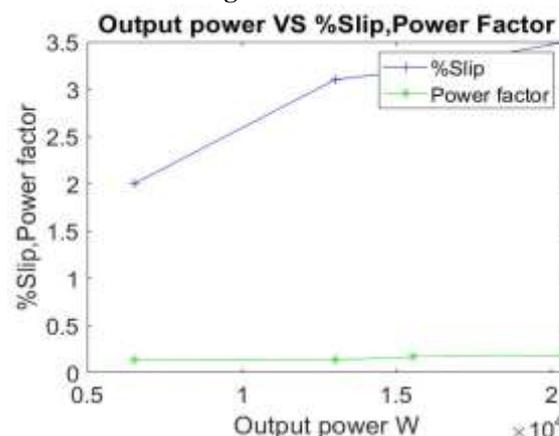**Fig No.10 Power factor of induction motor using star delta starter**

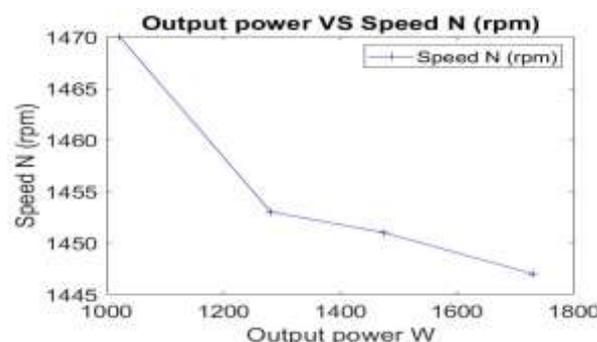**Fig No.8 Torque performance of induction motor using star delta starter**

Fig No.11 Speed performance of induction motor

Fig 8 represents the relationship between the slip in x axis and torque of the three phase induction motor in the y-axis .The torque is directly proportional to slip. this relation is reflected in the plotted graph. Fig 9. represents the relationship between the output power in x axis and efficiency and torque in y axis of the induction motor .the output power is directly proportional to torque but the efficiency remains the same. Fig. 10 represents the relationship between the output power in x axis and slip and power factor in the y axis. The output power is directly proportional to slip and power factor that is increases in output power causes increases the slip and power factor. Fig 11 represents the relationship between the output power in x axis and speed in y axis of the three phase induction motor . The output power is indirectly proportional to speed.

III.PROPOSED MODEL & RESULTS

Fig12.Proposed system model

Fig 12 represents the manual implementation of fig 4.In order to make advance in this implementation ,mobile starter controller has been implemented. This helps to switch ON and OFF through Wi-Fi, Bluetooth. This also indicates fault, overload current ,and incase any other fault, it indicates by displaying PRE in the color of red. The program used in SELFPRO is also used in Arduino programming from that it is connected to the mobile application through Bluetooth module.


```
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56        void set RemoteXY_Init ();
57        pinMode (PIN_STOP, OUTPUT);
58        pinMode (PIN_START, OUTPUT);
59        pinMode (R, INPUT);
60        pinMode (Y, INPUT);
61        pinMode (B, INPUT);
62        pinMode (DOL, OUTPUT);
63        pinMode (STAR, OUTPUT);
64        pinMode (ROTOR, OUTPUT);
65        }
66        void loop(.)
67 *      {
68        RemoteXY_Handler ();
69        digitalWrite(PIN_STOP, (RemoteXY.STOP==0)?LOW:HIGH);
70        digitalWrite(PIN_START, (RemoteXY.START==0)?LOW:HIGH);
71        if (digitalRead(R) == HIGH)
72          RemoteXY.led_1_r = 255;
73        else
74          RemoteXY.led_1_r = 0;
75        if (digitalRead(Y) == HIGH)
76          RemoteXY.led_2_g = 255;
77        else
78          RemoteXY.led_2_g = 0;
79        if (digitalRead(B) == HIGH)
80          RemoteXY.led_3_b = 255;
```

Fig:13 represents the sample of Arduino program for mobile application.

3.1)MOBILE CONTROLLER:

In paper and pulp industries ,the operation is fully enclosed in a closed surface ,in order for the human to take measure the reading is difficult, so once the manual switch is on, in this case mobile application is useful.It is controlled through Remote XY application software.

Mobile starter controller is used to control electric motors agricultural pump sets with the help of GSM technology. It allows for switching on and off of a electric devices. Applications are air break contractor, old button starter oil cooled starter.It can be used on any pump set like mono block open well submersible and bore well submersible pump sets.It should be used with the power range of 0.5 to 100 HP pump sets.

Fig no.14 represents the normal working condition of REMOTE XY APPLICATION

Fig 15 Fault analysis of proposed model

In Fig:15 ,Three phases R,Y,B indicated by red, green, and blue but in case of fault occurred in any of the phases it indicates through black color. In case of any fault occurs, PRE is indicated by RED color.This Mobile application can be used in every android smartphones.The Start and Stop button in this App indicates the start of the induction motor and stop of the induction motor.

IV.CONCLUSION

A project has been done with all the required functions.As said earlier,the mobile controller also has been made on this invention with almost swithching on and off is possible and the Remote XY App works on every android smartphones. Almost all the features of the App have been designed and Implemented. It can be accessed from that mobile phones and password can be assigned for the security purposes, alert interruption , number of phases functioning currently ,alerts switching on and off of pump set and protects it from dry run

phase failure low voltage and phase imbalance this allows for saving time and energy for the farmers.This cost efficient control system is useful for many applications .Thus project has been done for reducing the cost purposes and user friendly purposes.

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APPENDICES


```
/////////////////////////////////////////
//        RemoteXY include library
// RemoteXY select connection mode and include library
#define REMOTEXY_MODE__SOFTSERIAL
#include <SoftwareSerial.h>
#include <RemoteXY.h>
// RemoteXY connection settings
#define REMOTEXY_SERIAL_RX 2
#define REMOTEXY_SERIAL_TX 3
#define REMOTEXY_SERIAL_SPEED 9600
// RemoteXY configurate
#pragma pack(push, 1)
uint8_t RemoteXY_CONF[] =
{ 255, 3, 0, 3, 0, 163, 0, 8, 13, 0,
  1, 0, 40, 44, 18, 18, 1, 31, 0, 1,
  0, 74, 43, 19, 19, 12, 24, 0, 3, 3,
  -7, 15, 18, 48, 2, 26, 65, 4, 40, 15,
  12, 12, 65, 2, 60, 15, 12, 12, 65, 1,
  80, 15, 12, 12, 129, 0, 74, 37, 19, 6,
  24, 83, 84, 65, 82, 84, 0, 129, 0, 41,
  38, 16, 6, 24, 83, 84, 79, 80, 0, 129,
  0, 11, 21, 19, 6, 24, 68, 79, 76, 0,
  129, 0, 11, 36, 19, 6, 24, 83, 84, 65,
  82, 0, 129, 0, 11, 52, 19, 6, 24, 82,
  79, 84, 79, 82, 0, 129, 0, 44, 18, 4,
  6, 24, 82, 0, 129, 0, 64, 18, 4, 6,
  /* 24,89,0,129,0,84,18,4,6,24,
```

```
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28   66,0,129,0,26,2,58,6,24,83,
29   77,65,82,84,32,83,84,65,82,84,
30   69,82,0,130,1,-98,10,208,3,16 };
31   // this structure defines all the variables of your control interface
32   struct {
33     // input variable
34     uint8_t STOP; // =1 if button pressed, else =0
35     uint8_t START; // =1 if button pressed, else =0
36     uint8_t select_1; // =0 if select position A, =1 if position B, =2 if position C, ...
37     // output variable
38     uint8_t led_1_r; // =0..255 LED Red brightness
39     uint8_t led_2_g; // =0..255 LED Green brightness
40     uint8_t led_3_b; // =0..255 LED Blue brightness
41     // other variable
42     uint8_t connect_flag;  // =1 if wire connected, else =0
43   } RemoteXY;
44   #pragma pack(pop)
45   /////////////////////////////////////////////
46   //         END RemoteXY include       //
47   /////////////////////////////////////////////
48   #define PIN_STOP 12
49   #define PIN_START 11
50   #define R 7
51   #define Y 6
52   #define B 5
53   #define DOL A0
54   #define STAR A1
55   #define ROTOR A2
```

```
sketch_mar12a.ino   ReadMe.adoc   ▼

63     pinMode (STAR, OUTPUT);
64     pinMode (ROTOR, OUTPUT);
65   }
66   void loop(.)
67   {
68     RemoteXY_Handler ();
69     digitalWrite(PIN_STOP, (RemoteXY.STOP==0)?LOW:HIGH);
70     digitalWrite(PIN_START, (RemoteXY.START==0)?LOW:HIGH);
71     if (digitalRead(R) == HIGH)
72       RemoteXY.led_1_r = 255;
73     else
74       RemoteXY.led_1_r = 0;
75     if (digitalRead(Y) == HIGH)
76       RemoteXY.led_2_g = 255;
77     else
78       RemoteXY.led_2_g = 0;
79     if (digitalRead(B) == HIGH)
80       RemoteXY.led_3_b = 255;
81     else
82       RemoteXY.led_3_b = 0;
83     if (RemoteXY.select_1==0) digitalWrite(DOL, HIGH);
84     else digitalWrite(DOL, LOW);
85     if (RemoteXY.select_1==1) digitalWrite(STAR, HIGH);
86     else digitalWrite(STAR, LOW);
87     if (RemoteXY.select_1==2) digitalWrite(ROTOR, HIGH);
88     else digitalWrite(ROTOR, LOW);
```

```
sketch_mar12a.ino   ReadMe.adoc   ▼

56     void set RemoteXY_Init ();
57     pinMode (PIN_STOP, OUTPUT);
58     pinMode (PIN_START, OUTPUT);
59     pinMode (R, INPUT);
60     pinMode (Y, INPUT);
61     pinMode (B, INPUT);
62     pinMode (DOL, OUTPUT);
63     pinMode (STAR, OUTPUT);
64     pinMode (ROTOR, OUTPUT);
65   }
66   void loop(.)
67   {
68     RemoteXY_Handler ();
69     digitalWrite(PIN_STOP, (RemoteXY.STOP==0)?LOW:HIGH);
70     digitalWrite(PIN_START, (RemoteXY.START==0)?LOW:HIGH);
71     if (digitalRead(R) == HIGH)
72       RemoteXY.led_1_r = 255;
73     else
74       RemoteXY.led_1_r = 0;
75     if (digitalRead(Y) == HIGH)
76       RemoteXY.led_2_g = 255;
77     else
78       RemoteXY.led_2_g = 0;
79     if (digitalRead(B) == HIGH)
80       RemoteXY.led_3_b = 255;
```