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SOLAR POWERED DOME SHUTTER CONTROL

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ABSTRACT

Conventional Telescope Dome Shutter Control has bi-parting shutter driven by a AC three phase induction motor to which AC power is fed through circumferential busbars. These busbars frequently requires maintenance and some times hazardous to human being in case of open type busbars.

A different approach is implemented to eliminate the use of busbars. The Power source required for Dome Shutter is made available on the Dome itself which will avoid the use of busbars. To have a simple and loss less Shutter Drive, a DC Source, by means of battery, is used to drive a DC motor through a Gear Box. The DC source recharged by a suitable Solar Panel fixed at outside of the Dome.

Local control on the Dome Shutter Control Unit and remote control through Radio controls are available for Shutter Operations.

KEY WORDS : Shutter Control, DC Drive, Solar Panel and Radio Controls.

INTRODUCTION

The medium or large sized bi-parting Shutter on the Dome is normally driven by a motor coupled to it through a reduction gear box and a small sized Shutter can be of hand driven type. The motor driven type shutters were fed AC power through the circumferential busbars which are fixed on the Building Wall. Current Collectors and Drive Controllers are fixed on the moving part. i.e on the Dome.

A different technique is adapted in 2m telescope in IAO, Hanle. The circumferential busbar was totally eliminated by a Power Coupler whose stationary part is fixed on the Telescope building wall and the mating part is fixed in the dome. Power Coupler's moving and fixed parts are first locked at particular position of dome before operating the Dome shutter.

In our approach the busbar and the power coupler arrangement is totally avoided. The Source for the shutter drive is fixed on the dome itself. A lead acid battery forms the power source for the drive. The drive motor can be of AC or DC. To minimize the conversion losses a DC motor is preferred.

The DC motor is coupled to the shutter drive with a suitable reduction gear box to match the shutter speed. A charging circuit for the battery is built using a Solar panel fixed on the outside of the Dome. A Radio

uplink is used for issuing commands to shutter drive control unit and a downlink is used for getting Shutter limits and Battery status to the Control room.

On an experimental basis this system is installed in 30 inch telescope Dome and is working fine.

30 INCH TELESCOPE DOME SHUTTER.

The 30 inch telescope Dome shutter was hand cranked in the initial days. Now the 30 inch telescope drive is modernized using PMAC control system. The dome also is to be synchronized with the telescope movement. Since the whole Control system is operated from the ground floor Control Room, it requires that the dome shutter drive also needs to be transformed from hand cranking to motor driven.

The existing 30 inch building and dome do not have busbar arrangement and hence it is decided to implement the solar powered busbar less Dome shutter control in 30 inch telescope.

The Shutter slit is 2m wide and the two parts of shutter are clamped to a chain which is connected to a sprocket . The sprocket is mounted on the output side of a gear box which 70:1 ratio.

The input of the Gear box is coupled to a 0.25HP, 24V, 1800RPM DC motor. .

A 12V – 26Ah Sealed Maintenance free lead acid is used as a DC power Source for the DC Motor.

A 40W, 17V, 2.28A Solar panel is used for charging the battery.

A set of 433MHz and 866MHz Tx/Rx modules are used for giving remote commands.

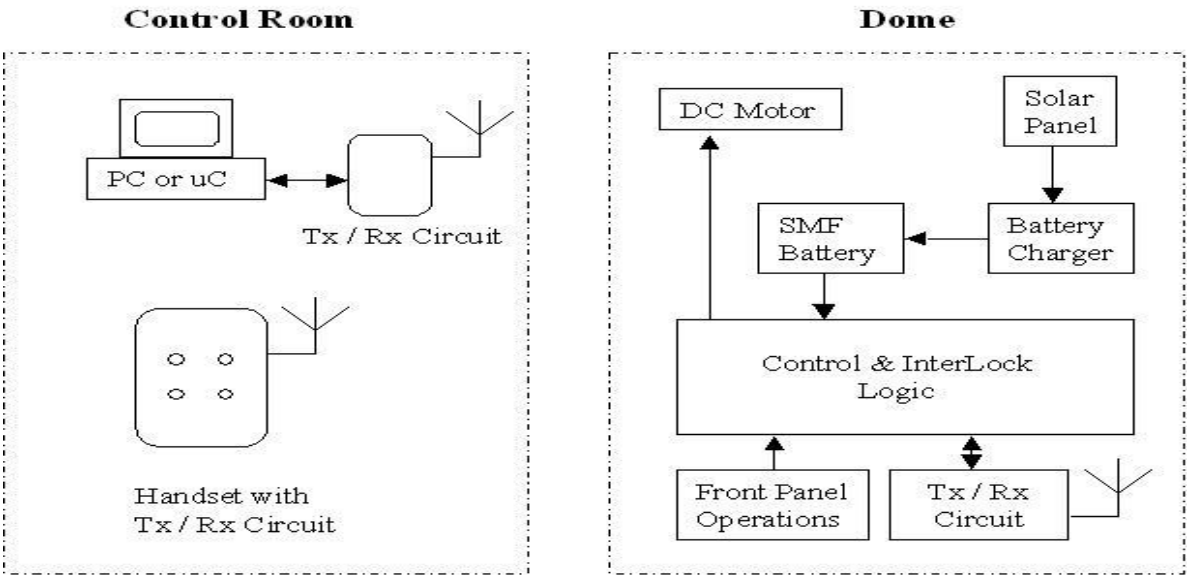


Fig 1 : Control Schematic

The above fig shows the circuit on Handset unit or the PC Digital I/O Port or a Micro controller based port or from all the three.

PERMANENT MAGNET DC MOTOR

To minimise conversion losses a Permanent Magnet, Totally Enclosed No Ventilation [TENV] type DC MOTOR is used.

The Specifications are
TYPE NO.: CDP3410 – V24,
0.25HP / 1800 RPM / NEMA FRAME 56C,
24 VDC / 10.6 FLA.

A detailed Spec sheet is given in Annexure.

This DC Motor is armature controlled and the field is provided by a Permanent Magnet. The rated speed is 1800 RPM at 24V DC.

Fig 2 : CDP3410 – V24 BALDOR DC MOTOR.

The above figure shows the image of the DC Motor used.

Two 12V 26Ah batteries connected in series were initially used for operating this Motor at rated speed. With the given gear box, the shutter opening speed was very high and was producing unwanted noise while operating. So the speed is now reduced to half by operating the motor at 12V DC. Now it was taking ~23s to open or close.

The motor is taking 2.5A at 12V DC under normal load conditions. The Shutter operation is possible for an hour even without charging, for the given AH value of the battery. To minimize the fumes in the observing floor a Sealed Maintenance Free Battery is used.

SOLAR PANEL & BATTERY CHARGING CIRCUIT.

To keep the SMF battery under charged condition, a Solar Panel with battery charging circuit is inserted into the system.

A battery must be charged at $1/10^{th}$ of its AH value. A source of 17V, 2.5A would be sufficient to keep the 12V, 26AH battery in charged condition.

To supply the power to the Battery Charger Circuit, a 17.6V, 2.28A, 40W Solar panel is fitted on the outside of Dome is used.

A simple and effective charger circuit given in fig 3 is used to charge the Battery. The charging current can be adjusted by R5 to the required level depending upon the Battery is used.

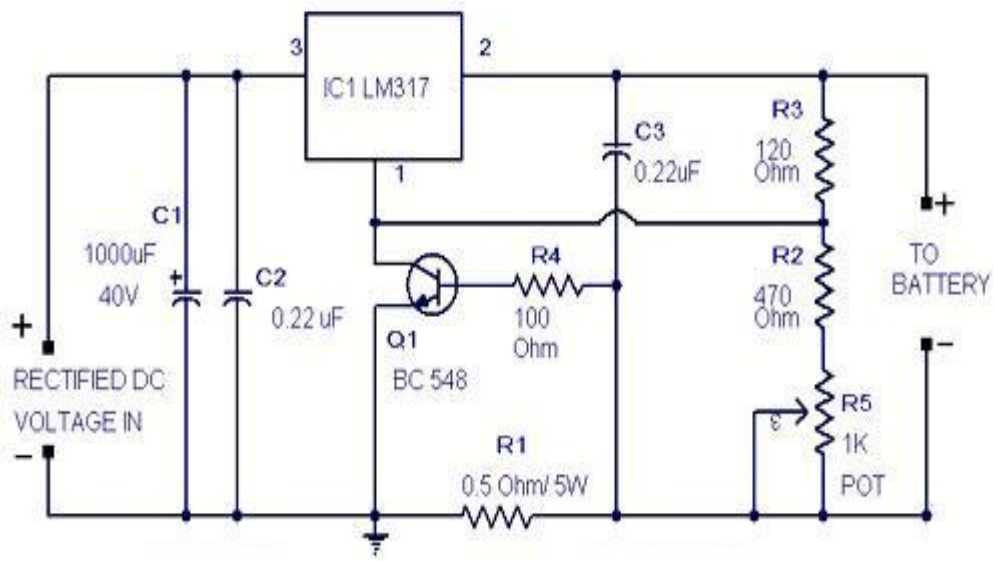


Fig 3 : Simple Lead Acid Battery Charger using LM317.

The Charging current is adjusted to 2A for a fully drained condition, the charging current is inversely proportional to the Battery Terminal Voltage and the Charger floats when the Battery is fully charged. Fact Sheet for MS6X10 Solar Panel is placed in annexure.

The Solar Panel used in this circuit provides excellent performance even in dull light conditions. The cost of the Solar Panel for the given power is ~ Rs 6000.00 only. 10 years of power warranty for performance of not

less than 90% of the nominal power and 25 years of power warranty for performance of not less than 80% of the nominal power is guaranteed for the given Solar Panel.

DOME SHUTTER CONTROL UNIT

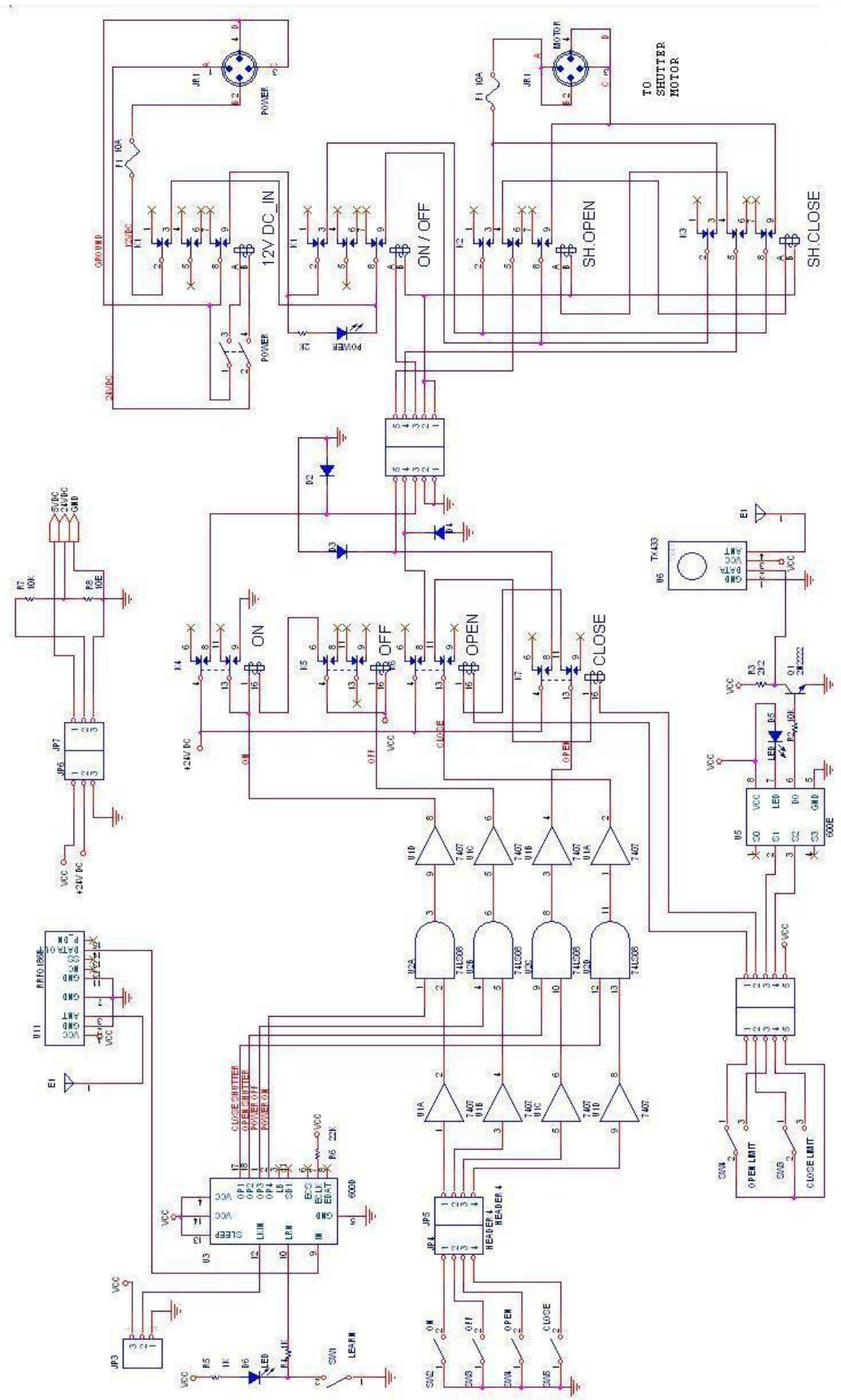


Fig 4 : Control Schematic for Shutter Control

Fig 5 : Basic Control Unit.

The circuit diagram in fig 4 shows interlock circuitry for Dome Shutter Operations from front panel and wireless Handset.

The front panel has Shutter Drive Unit ON, OFF, Shutter OPEN and CLOSE operating switches which operate on Hall Effect principle and can be directly interfaced to Digital Circuits. The output of these switches are active low.

The Wireless Receiver circuit consists of a RRFQ868 Receiver module and a 600D RF Decoder IC. The RF Receiver receives the data from the matched Transmitter RTFQ866 module and Serial Data is fed to the Decoder 600D. The 600D decodes into 4 bit data as it was transmitted from RTFQ866. These 4 bit data represents Shutter Drive Unit ON, OFF, Shutter OPEN and CLOSE operating commands through RF Transmitter from a Handset or a PC Digital Port.

This Transmitter and Receiver operates at 866MHz and the pair enables the simple implementation of a data link at distances upto 75m in-building and 250m open ground. The Tx and Rx modules operates over a wide range of power supply of 3 – 12V.

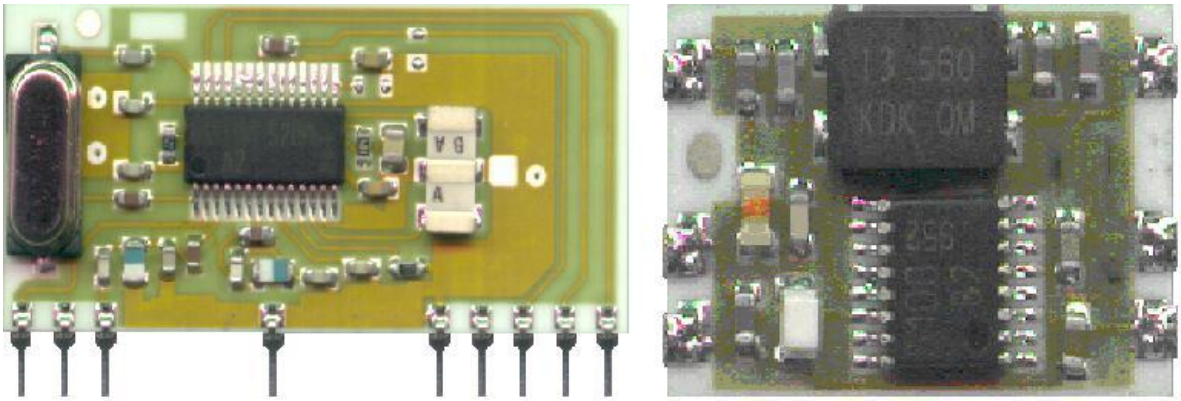


Fig 6 : RRFQ1 and RTFQ1 [866 MHz } Rx ,Tx modules.

The Encoder [600E] and Decoder [600] ICs are used for encoding and decoding the Serial data to and from the Tx and Rx modules respectively.

The RF600E/D chipset use a fully balanced Manchester encoded data protocol designed for optimum use of the radio transmission path. Manchester encoding the data enables the superhetrodyne receiver 'data slicer' to maintain efficiency for the duration of the data packet, (unlike many other encoder/decoder systems) which results in reduced bit errors and therefore ensures maximum range.

The Operational commands from Front Panel switches and Wireless Receiver Circuit are combined in the logic circuits and the DIP relays are operated accordingly. A set of High Power Capacity DC 12V Relays are used to switch DC Power to the Shutter Motor. These High Power DC relays are Interlocked through Open/Close limit switches and Polarity reversal contacts.

The following circuit presented in Fig 7 is for Wireless Handset Operation implemented through Transmitter Circuit and ON/OFF, OPEN/ CLOSE annunciations were through Receiver Circuit.

The RF600D has an easy learn feature enabling it to learn up to 7 unique RF600E encoder devices in standalone mode. With this feature , the receiver can accept unique commands from 7 transmitters from different locations. To avoid cross link between commands and limits, a 866MHz Transmitter at Console end and Receiver at Dome Shutter end are used for sending and receiving commands. Similarly a 433MHz Transmitter at Dome Shutter end and receiver at Console end for sending and receiving Limits and ON/OFF signals.

The fig 7 shows the circuit on Handset unit or the PC Digital I/O Port or a Micro controller based port or from all the three.

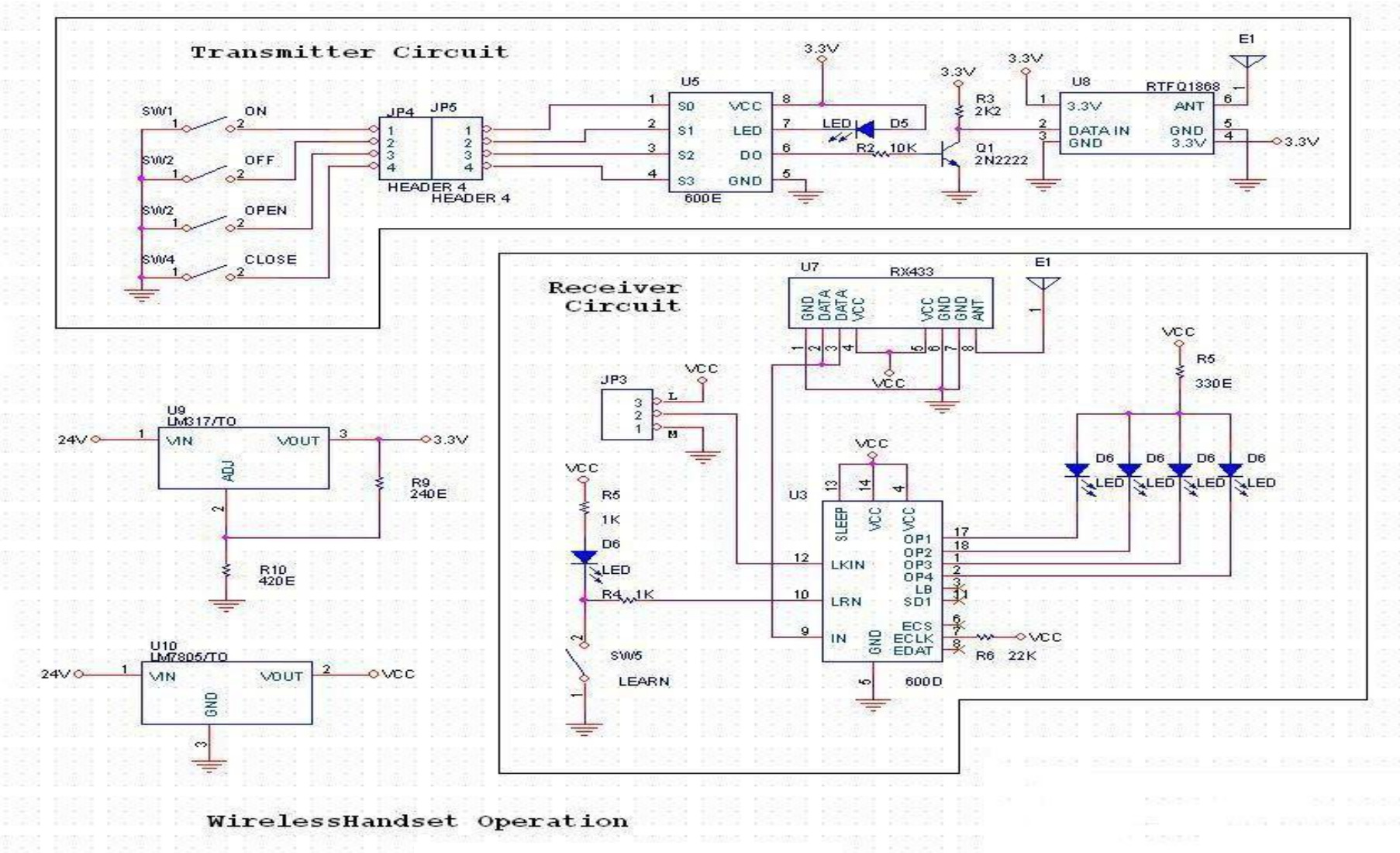


Fig 7 : Handset Operation Schematic

Shri K. Ravi involved in the design concept, preparing data about the Components available in the market, Component selection, designing the Internal Control and Interlock Circuitry and in Radio Control Unit development.

Shri P. Anbazhagan involved in preliminary discussions in designing the Solar Powered Busbar less Shutter Control, in choosing the appropriate components for the shutter control and in procuring the selected components in right time.

Shri A. Ramachandiran and Shri S. Venkateswara Rao were involved in fixing the Open, Close limit positions, Shutter Control Unit Internal wiring and testing the setup in Laboratory.

Acknowledgements :

We are thankful to Shir F. Gabriel, Shri A. Mani, Shri V. Loganathan, Shri R. Annamalai, Shri D. Karthikeyan and the entire Mechanical division of VBO for their efforts in converting the hand cranking arrangement into a Motor Driven mechanism for Dome Shutter and fixing up the Dome Shutter Control Unit, Solar Panel. We are also thankful to Shri A.V. Ananth for his valuable discussions and permitting us to implement in 75cm Telescope.

References :

Electronic Newsletters :

1. Simple but effective *battery charger circuit using* IC *LM 317*.The *circuit* can be used to charge 12V lead acid batteries. ***...****www.****circuits****today.com/****battery-charger-circuit-using-lm317.***

Instrumentation Documentation :

1. RF / IR Encoder / Decoder Chipset data sheets from RF Solutions Ltd.

2. FM Transmitter & Receiver Hybrid Modules data sheets from RF Solutions Ltd.

3. M-Series 6x10 Solar Panel Data sheets from IndSolEnergy pvt ltd.

ANNEXURE

FM TRANSMITTER & RECEIVER HYBRID MODULES.

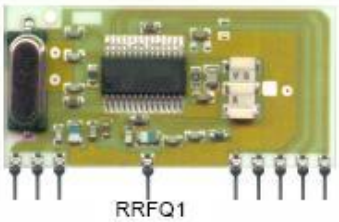
FM-RTFQ SERIES FM-RRFQ SERIES

- FM Radio Transmitter & Receivers
- Available As 315 or 433 or 868MHz
- Transmit Range Up To 250m
- Miniature Packages
- Data Rate upto 9.6Kbps
- No Adjustable Components
- Very Stable Operating Frequency
- Operates from –20 to +85°C

RTFQ1

Transmitter

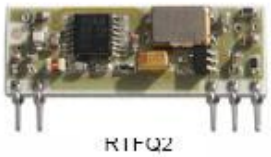
- 3-12 Supply Voltage
- SIL or DIL Package



RRFQ1

Receiver

- PLL XTAL Design
- CMOS/TTL Output
- RSSI Output
- **Standby Mode (max 100nA)**
- 5V Supply Voltage



RTFQ2

Applications

- Wireless Security Systems
- Car Alarms
- Remote Gate Controls
- Remote Sensing
- Data Capture
- Sensor Reporting

RRFQ2

Description

These miniature RF modules provide a cost effective high performance FM Radio data link, at either 315, 433.92 or 868MHz. Manufactured using laser trimmed Thick Film ceramic Hybrid the modules exhibits extremely stable electronic characteristics over an Industrial Temperature range. The hybrid technology uses no adjustable components and ensures very reliable operation.
This transmitter and receiver pair enables the simple implementation of a data link at distances upto 75 metres in-building and 250 metres open ground.

These modules will suit one-to-one and multi-node wireless links in applications including car and building security, EPOS and inventory tracking, remote industrial process monitoring and computer networking. Because of their small size and low power requirements, both modules are ideal for use in portable, battery-powered applications such as hand-held terminals.

BALDOR · DODGE · RELIANCE

DC Motor Performance Data

Record # 504
Typical performance - not guaranteed values

Winding: 34WGZ610	**Type:** 3416P	**Enclosure:** TENV

Nameplate Data	
Rated Output (HP)	0.25 HP
RPM	1800
Armature Volts	24
Armature Amps	10.6
Field Volts	
Field Amps	
Rating - Duty	40C AMB-CONT
Power Supply Code	A

General Characteristics	
Armature Resistance	0.129 ohms
Commutating Winding Resistance	
Series Winding Resistance	
Shunt Winding Resistance	
Armature Inductance	0.936 mH
Armature Inertia	
Maximun rated RPM with field weakening	
Maximum allowable inrush amps	
Full Load Temperature Rise	

Load Characteristics at 24 Armature Volts

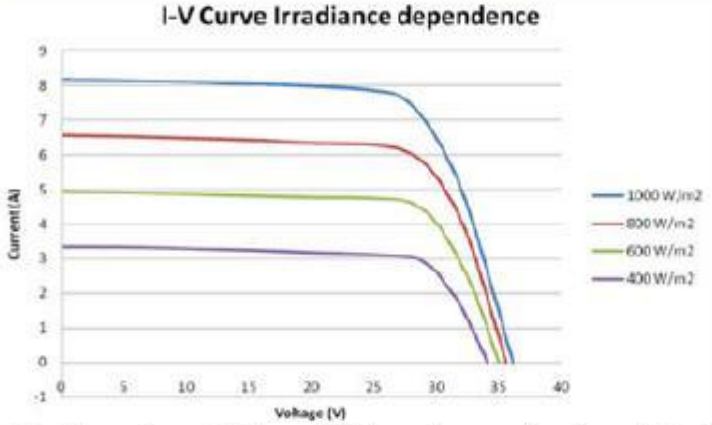
Load Point	1	2	3	4	5	6	7
Armature Amps	2.4	5.05	7.74	10.65	13.4	16.01	18.82
RPM	1825	1795	1753	1707	1666	1635	1596
Torque (LB-FT)	0	0.25	0.5	0.75	1	1.25	1.5

M-Series 6x10

- High quality TUV and UL certified raw materials
- Standard power tolerance + - 3%
- 5 years of product workmanship warranty
- 10 years of power warranty for performance of not less than 90% of the nominal power
- 25 years of power warranty for performance of not less than 80% of the nominal power
- ISO 9001:2008 certified manufacturing process
- IEC 61215, IEC 61730 certified

Irradiance Dependence Chart				
Irradiance	**1000 W/m^2**	**800 W/m^2**	**600 W/m^2**	**400 W/m^2**
Isc	100%	-19,60%	-39,50%	-59,20%
Voc	100%	-1,38%	-3,05%	-5,50%

IV Curves Under Different Irradiance Levels



Current/voltage characteristics with dependence on irradiance tested at AM 1,5 and 25°C

Warranty and Certifications	
Warranty	5 years limited product workmaniship warranty 10 years limited power warranty (for 90% of NP) 25 years limited power warranty (for 80% of NP)
Certificates*	IEC 61215, Safety tested IEC 61730, CE Marking UL 1703*, Class C Fire Rating*

Power Series (37 Wp – 40 Wp) Design and Mechanical Data			
Nominal Power (Pnom)	**12V, 37 W**	**12V, 38 W**	**12V, 40 W**
Nominal Maximum Output Voltage (Vmp)	17.5V	17.4V	17.6V
Nominal Maximum Output Current (Imp)	2.11A	2.19A	2.28A
Open-Circuit Voltage (Voc)	21.5V	21.8V	21.8V
Short-Circuit Current (Isc)	2.40A	2.52A	2.67A
Dimensions (Tolerance +4/-1mm)	645X545	645X545	645X545
Thickness (Tolerances ±1mm)		23mm	
Weight		19 kgs	
Packing		5pcs/ctn	
Size	69.1*23*62.6cm	69.1*23*62.6cm	69.1*23*62.6cm
Characteristic Data			
Type of Solar Cells		Monocrystalline 125mmx125mm	
Connection		Connection box with bypass diodes, 90cm leading cable, length of poles (-) 1.1m, (+1.4m)	
Temperature			
Power - Tk (Pn)		-0.47%/°C	
Open Circuit Voltage Tk (Upc)		-0.38%/°C	
Short Circuit Current Tk (I)		+0.10%/°C	
Limits			
Max System Voltage		1000Voc	
Opening Module Temperature		-40 ~ +90oC	
Max Load		5400N/M2	
Tolerance		±5%	

RF / IR Encoder / Decoder Chipset
RF Evaluation Boards,

RF600E
RF600D

- Highly Secure KeeLoq Protocol
- RF Encoder & Decoder IC's
- Simple to Use
- Stand Alone Operation
- Achieves Maximum Range from RF Modules
- 1 – 4 Switch Options (15 states)
- Decoder Serial Output
- Led Indication of Transmission
- Directly Compatible with Keeloq Decoder
- Easy Learn Feature of Transmitters
- Sleep Mode
- Up to 48 Transmitters can be Learned
- Optimum Range:
  - ⇒ AM up to 100m
  - ⇒ FM up to 200m
  - ⇒ IR up to 20m
- Compatible with RF Solutions Systems

Typical Applications

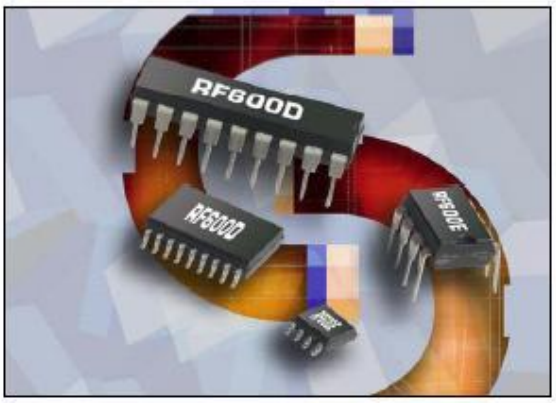
- General Purpose Remote Control
- Automotive alarm systems
- Gate and garage openers
- Electronic door locks
- Identity tokens
- Burglar alarm systems

Encoder

- 2.0-6.6V operation
- Automatic Battery Level Monitor
- 'Manchester' modulation
- 8 pin DIP/SOIC package

Decoder

- 18 pin DIP/SOIC package
- 4 Digital Outputs (15 States)
- Asynchronous serial interface
- 4.5V – 5.5V operation



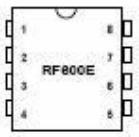
Description

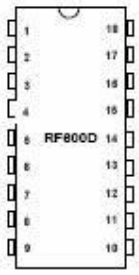
The RF Solutions RF600E, & RF600D are easy to use encoder and decoder I/C's. They have been designed to achieve the maximum possible range from any radio / Infra Red transmitter receiver set.

Unlike other encoder /decoder devices the RF600E/600D provide an unprecedented level of security which prevents copying or grabbing whist also obtaining optimum range from the transmitter and receiver.

The devices are very easy to use and can be inserted directly into a circuit. The RF600D has an easy learn feature enabling it to learn up to 7 unique RF600E encoder devices in standalone mode or up to 48 encoder devices when used in conjunction with an external EEPROM.

These devices enable a simple but secure remote telemetry application whilst obtaining the maximum range from the radio set.





Pin Descriptions

Name	Pin Number	Description
S0	1	Switch input 0
S1	2	Switch input 1
S2	3	Switch input 2
S3	4	Switch input 3
Vss	5	Ground reference connection
OP	6	Data output
LED	7	Cathode connection for directly driving LED during transmission
Vcc	8	Positive supply voltage connection

S0-3

These are the switch inputs which when operated wake up the RF600E and cause transmission. They may be switched directly to Vcc. Transmission occurs for the duration of the switch operation.

Vcc / Vss

The power supply needs to be a stable regulated voltage with <10mV ripple. Note that in idle mode the transmitter current drain is typically only 100nA.

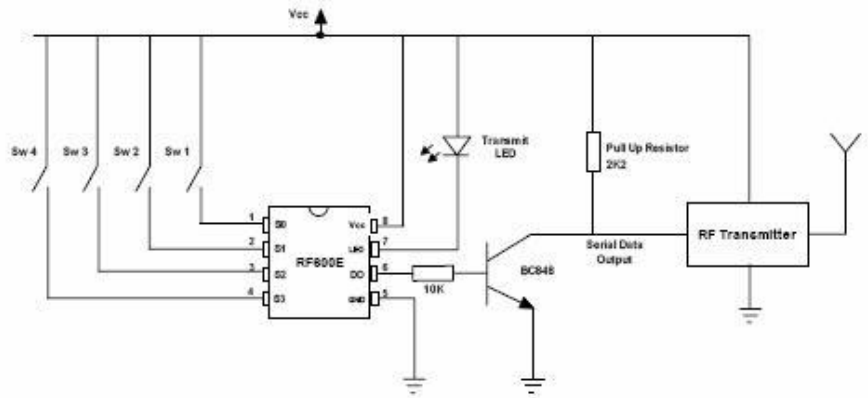
OP

Data Output, this is a standard CMOS / TTL output that may be connected directly to the data input pin of the RF Module. In the event that this represents a load to Vcc then a buffer stage between the data output and the RF module will be required.

LED

A direct LED drive with internal current limit of typically 1 mA operates when the RF600E is transmitting.

Typical Application Circuit Diagram for FM radio modules



Not that a circuit constructed using AM radio modules does not need to have transistor BC848, resistor 10K or 2k2 Pull up resistor fitted.

Pin Descriptions

Pin Number	Name	Input / Output?	Description
1	OP3	Out	Data Output 3 (S2)
2	OP4	Out	Data Output 4 (S3)
3	LB	Out	Low Battery, goes Low when Low Battery Valid
4	Vcc	In	Positive supply voltage connection
5	Vss	In	Connect to GND
6	ECS	Out	Connects to EEPROM 'CS' pin
7	ECLK	Out	Connects to EEPROM 'CLK' pin. Also sets data mark.
8	EDAT	In / Out	Connects to EEPROM 'Data' pin
9	IN	In	RF / IR Data input
10	LRN	In	Learn / Erase Switch Input & Status LED Drive
11	SD1	Out	Serial Data output
12	LKIN	In	Option Link Input for Momentary or Latched outputs
13	SLEEP	In	High = Run, Low = Sleep Mode
14	Vcc	In	Positive supply voltage connection
15	Unused	N/A	No Connection
16	Unused	N/A	No Connection
17	OP1	Out	Data Output 1 (S0)
18	OP2	Out	Data Output 2 (S1)

Vcc / Vss

The power supply needs to be a stable regulated voltage with <10mV ripple

OP1-4

Digital Data outputs 1-4. These outputs are asserted LOW when the relevant inputs (S0 – S3) on the RF600E are asserted. (see latch/unlatch information under 'LKIN').

LB

The RF600E automatically measures the battery voltage each time it is operated (see RF600E data). This information is transmitted to the RF600D and if a low battery condition exists then the low battery output is taken low. This indication is latched until data from a decoder with a good battery is received at which time the output indication is cleared. (output goes high).

ECS / ECLK / EDAT

These connections are for interface to the EEPROM, which is used to store the identity of the encoders taught to the system.

ECLK AM / FM Selection

Note that the ECLK output to the EEPROM is also used for data mark selection. The data mark input sets the input of the RF600D to be compatible with AM or FM radio modulation.

When the ECS control line is low (i.e. when the EEPROM is not selected) the ECLK line is made an input and a check is made for the presence of a pull-down or pull-up resistor.

If the data mark selection is pull-down then the RF600D will be set to receive Sync Low AM data.

If the data mark selection is pull-up then the RF600D will be set to receive Sync High FM and IR data.

IN

This is the data input to the decoder, it may be connected directly to the RF receiver module or IR receiver module.

LRN

This input is used to set the decoder module to 'Learn Mode' and for the 'Erase Function' and is also used to drive the Status LED.

Learn Mode: is achieved by pulling this input to GND briefly

Erase Mode: is achieved by pulling this input to GND for >8 seconds. This causes the EEPROM to be erased of all pre-learnt RF600E encoders.

Learn Operation using momentary push switch (As application circuit)

1. Press briefly and release the learn switch
2. The status LED will illuminate while the switch is pressed and remain on when released.
3. Operate the transmitter encoder once, status LED on the decoder will extinguish
4. Operate the transmitter encoder a second time, status LED on the decoder will flash
5. After the status LED has stopped flashing the transmitter has been successfully taught to the decoder
6. This transmitter will now operate the system

Up to 7 unique encoders may be learnt to each RF600D. This can be extended to 48 encoders with the use of the 93C76 EEPROM.

Erase Operation using momentary push switch (As application circuit)

To completely erase all transmitter data, press and hold the learn switch on the decoder for 8 seconds. The status LED will illuminate continuously whilst the switch is held down and then flash while the decoder erases all memory. It may take several seconds until the erase function is complete. After the status LED is extinguished all the encoder identities are erased from the decoders eeprom memory.

SD1

Outputs serial ASCII data after each valid transmitter signal. (See previous section for more information)

LKIN

This high impedance input is used to set the digital outputs to momentary or latched actions

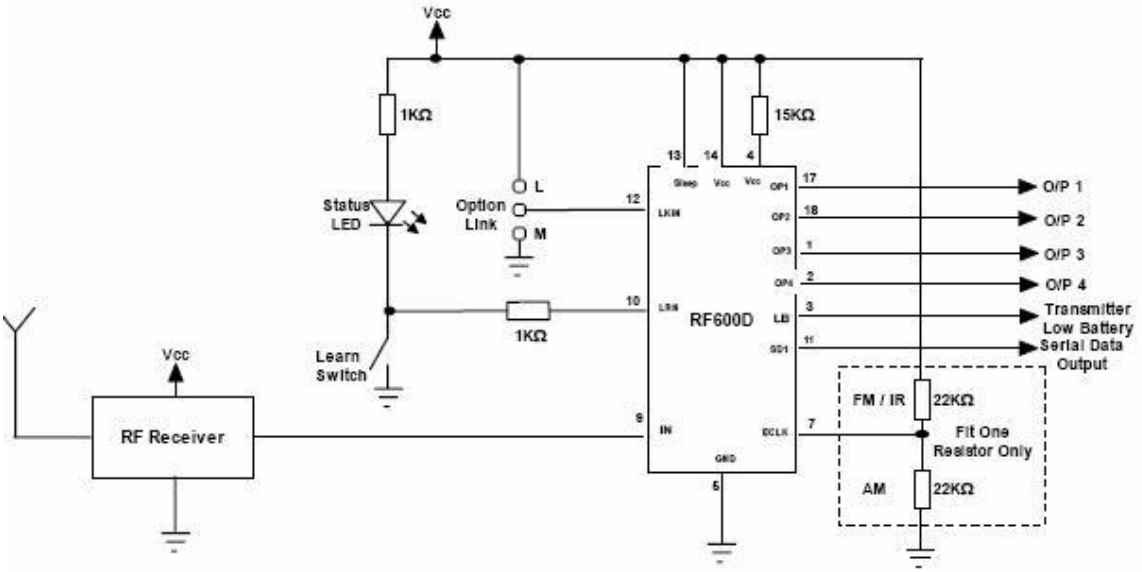
LKIN Status	Digital Outputs Function
High	Latching
Low	Momentary

Momentary : Output is only asserted for the duration of the valid transmit signal.

Latching: Output state is changed on each valid transmitted signal.

NB The outputs S0 – S3 can only be operated after a RF600E encoder has been learnt to the RF600D decoder.

RF600D Application Circuit – Stand Alone operation



This circuit provides a complete decoding solution capable of learning up to 7 unique encoders