Building The SMT Keyall Discrete kit
and from Jackson Harbor Press
Using: a high voltage keying interface

The SMT Keyall Discrete is an accessory for a keyer, hand key or bug which will allow operation with nearly any transmitter. The circuit is a solid state relay which will key solid state (nominal 12 V / 13.8V), cathode keyed tube rigs (high positive keying voltage) or grid block tube rigs (high negative keying voltage). The SMT Keyall Discrete will even key transmitters like the original Tuna Tin 2 which requires a keying output which is isolated from ground. The SMT Keyall Discrete output can be made fully optically isolated from the keyer input. The SMT Keyall Discrete can even be used as a conventional solid state relay for DC or AC loads - appropriate protection devices such as an MOV and a series fuse should be added by the builder for these non-ham applications.

The Keyall and Keyall HV kits have been popular. But I realized that the way they work is apparently mysterious to some hams. The SMT Keyall Discrete is an attempt to make the inner workings of the design literally visible while adding a bit of fun. The Discrete in the name refers to the use of basic components such as resistor, capacitor, LEDs and MOSFETs rather than the "integrated" components of the original designs.

But why a surface mount version ? The main reason is that the surface mount LEDs can be mounted very close together resulting in excellent light transmission. The short circuit current (a figure of merit) is comparable to commercially available integrated Photo Voltaic Isolators. This means that the SMT Discrete Keyall can drive almost any high voltage MOSFET transistor regardless of the gate capacitance.

Circuit Explanation: The kit uses fourteen (12 red and 2 blue) LEDs to take the place of the PVI (Photo-Voltaic Isolator) IC used in the Keyall and Keyall HV kits. Half of the LEDs are used as conventional LEDs that light up when the key (or keyer) is pressed. The other half of the LEDs are used as photo-diodes (aka solar cells) to generate a DC voltage when the key is pressed. These generated voltages are used to turn on (or off) the MOSFET transistors. The light source + solar cell combination provides isolation between the key and the potential high voltage of the transmitter. The pair of MOSFET output transistors allow the kit to switch DC (either polarity) or AC loads, doesn't matter which output is connected to which load polarity. This is just like a mechanical relay so this configuration is known as a solid state relay or SSR. The third MOSFET is a depletion mode transistor which for the purposes of the kit means that if the gate voltage is zero (with respect to the source) the transistor is ON. If the gate voltage is made negative then the transistor turns OFF. This allows the pair of blue LEDs to control the third MOSFET by allowing it to short out the gate capacitance of the output transistors when the LEDs are off and allow the gate capacitors of the output transistors to charge up when the LEDs are on.

General notes about building: While the surface mount parts used are relatively large (1206 passives) the builder should have some kind of magnification to see the markings and be able to inspect the soldering.

The components should be soldered in place one at a time. Good quality solder wick is suggested to clean up any excess solder. A good quality tweezers can help to orient and hold the part while soldering. The pads and traces are small and delicate - a small tipped, low power (25 watts or less) soldering iron should be used.

The three transistors used in this kit are all MOS devices. This means that they should be handled as little as possible to prevent static damage. The builder should use a grounding strap and anti-static mat if available or at the very least, work on a grounded metal surface and be sure to touch ground prior to touching the transistors.

Building the kit - Step 1) Get the parts together: All of the necessary board mounted components have been supplied. You will still have to provide off-board items from the stocklist to fully implement the kit including the enclosure, input and output jacks, battery holder (or power jack) and mounting hardware.

Step 2) Identify and orient the components: The components should be easy to identify and place. The LEDs must be oriented correctly to function - the anode (positive) side has a chamfer on one corner. Keep the LEDs on the paper until ready to solder, it's impossible to tell the red and blue LEDs apart visually. The LED anodes are all oriented towards the left edge of the circuit board as shown on the parts placement diagram.

Step 3) Mount and solder the components on the board: Use the parts placement diagram along with the parts list (back of this manual) for the placement and orientation of the parts.

The LEDs are soldered in pairs, face to face with the anodes (positive end) to the left – the best way to do this is by clamping the LEDs together using a clamping tweezers or a plain tweezers with something like a binder clip to keep the LEDs together:

Here is a suggested building sequence:

1) D7/D14, the only two blue LEDs, clamp the LEDs together with the anodes (chamfered sides) oriented to the left. Place at the right side near the "blue" silk screenings.

Then,while still clamped, solder the LEDs. Note that since there is a gap between the LED contacts and the board, it will be necessary to deposit a "fillet" of solder for each of the four contacts.

2) Note for steps 3 to 8, some may find it easier to work from left to right with the red LEDs but I preferred this right to left sequence, it's up to the builder.
3) D6/D13, the first two red LEDs, clamp together, anodes to the left and then place to the left of D7/D14 and solder in place.
4) D5/D12, the second pair of red LEDs, clamp together, anodes to the left and then place to the left of D6/D13 and solder in place.
5) D4/D11, the third pair of red LEDs, clamp together, anodes to the left and then place to the left of D5/D12 and solder in place.
6) D3/D10, the fourth pair of red LEDs, clamp together, anodes to the left and then place to the left of D4/D11 and solder in place.
7) D2/D9, the fifth pair of red LEDs, clamp together, anodes to the left and then place to the left of D3/D10 and solder in place.
8) D1/D8, the sixth and last pair of red LEDs, clamp together, anodes to the left and then place to the left of D2/D9 and solder in place.
9) Inspect the LEDs, make sure that the chamfer (notch) on D1-D7 is towards the left (D8-D14 should also have the chamfer to the left but it's hard to see).
10) R2, the 120 ohm resistor (marked 121), place as indicated on the silk screen at the bottom left of the board and solder in place.
11) R1, the 3k ohm resistor (marked 302), place as indicated on the silk screen at the bottom right of the board and solder in place.
12) R3, the 10 megohm resistor (marked 1005), place as indicated on the silk screen at the middle right of the board and solder in place.
13) C1, the .01 uF ceramic capacitor, place as indicated on the silk screen at the top center of the board and solder in place. Note that I didn't have a C1 while building the prototype, that's why it doesn't show on the parts placement top view.
14) Q3, the LND150 TO-92 MOSFET transistor, place as indicated on the silk screen and solder in place.
15) Q1 and Q2, place them as indicated on the silk screen and solder both in place. Normally the surface mount parts would be installed alone at the top of the board and the other two positions left open as shown on the top view. **However, there are silk screened positions with holes for either TO-220 or the larger TO-247 transistors if the builder would like to use "better" parts. But only 1 pair of Q1 and Q1 should be soldered in place – don't try to operate them in parallel.**

Finally, make sure that all the connections are soldered and clip the leads.

Step 4) Check your work: Before proceeding, take the time to check the bottom of the board for solder bridges. Use the Bottom view diagram as a guide to visually check for these shorts. It may help to clean the flux from the board and then use a strong light in conjunction with a magnifying glass to see these problems. After you are convinced that the board is OK, solder up the connections to the power/key and output jacks as shown on the hookup diagram.

Operation: With the power to the SMT Keyall Discrete connected, a VOM can be connected (in current measuring mode) in series with the positive lead to measure the active current - this current should be in the range of 20 mA, a little lower or higher is OK, the prototype measured 17 mA at 13.8 volts with a 120 ohm resistor. Connect the input (keyer, key, bug) device to the SMT Keyall Discrete input and the output to the transmitter. The polarity of the output isn't important, either one can be grounded and the other will switch positive, negative or AC voltages.

Construction Notes: There are many modifications that could be made to this kit, here are a few ideas:

If the builder wants to completely isolate the keyer from the transmitter, do NOT ground either of the SMT Keyall Discrete outputs to the case. (Also, use a battery to power the SMT Keyall Discrete rather than a station supply which may be grounded.) Instead, use either a stereo 1/4 inch (connecting the SMT Keyall Discrete outputs to tip and ring) OR use another output connector such as two insulated binding posts and connect the two SMT Keyall Discrete outputs to the binding posts. An appropriate cable will then need to be made for this isolated output configuration. This type of isolated output is useful for transmitters like the original Tuna Tin 2 which has the key connection between the positive supply voltage and the transmitter power supply input. If the voltages being switched are for a tube rig, be sure to use a jack and plug that can operate safely at the high (greater than the common 13.8 volts) voltage.

A pair of 9 volt batteries in series could be used in place of the 13.8 volt supply but R2 should be increased to 300 ohms or so. R1 can probably be left at 10k ohms. OR, a 9 volt battery could be connected in series to three 1.5 volt cells to get roughly 13.5 volts which is close enough. I have also used ten Nimh cells in series to power the kit.

The 6 red LEDs will "drop" over 11.6 volts at 20 mA so any other power source than the 13.8 volts common in a ham shack should be at least 11.6 volts. A different resistor value can be calculated using this formula: $R2 = (V - 11.6) / .02$ Then the next higher standard value resistor can be used.

While I usually like to enclose my kits in a metal box, a translucent or transparent lidded box may be more fun since the LED light will be visible as keying occurs.

It is possible to key two separate positive loads with the kit such as a cathode keyed VFO along with the cathode keyed rig. OUT1 is connected to one load, OUT2 is connected to the other, the common ground connection for both is made to the unlabeled hole below C1. This is the common source connection for the three MOSFET transistors.

Different keying transistors may be used for either higher keying voltages than the stock 500 or 1000 volt MOSFET transistors OR for lower ON-resistance MOSFETs – note that these "better" transistors can be pricey. The through hole transistors can be in either the TO-220 or the largerTO-247 packages (see the silk screen in the middle of the board for size comparison).

Notes:

The circuit of the SMT Keyall Discrete optically isolates the load from the input and LED power. No tests have been conducted to rate the isolation potential but it certainly will prevent the "bite" encountered when a forearm accidentally is brushed across the terminals of a straight key.

Please feel free to email with any questions, comments, suggestions or problems with the kit - email to: wb9kzy at wb9kzy dot com

Best Regards and thanks for choosing the SMT Keyall Discrete kit,
Chuck Olson, WB9KZY

SMT Keyall Discrete Parts List

Qty	Ref	Part Name	Description
2	Q1,Q2	IRFRC20	600 V n-channel enhancement MOSFET, DPAK
1	Q3	LND150	High voltage n-channel depletion MOSFET, SOT23-3
1			circuit board
1	C1		.01 uF 1000 V ceramic disc capacitor
1	R1		3K ohm resistor – marked 302
1	R2		120 ohm resistor – marked 120
1	R3		10 megohm resistor – marked 1005

The following items are ***NOT*** included with the kit:

1	mono input jack from key or keyer
1	battery holder or 9V snaps or external power connector
1	Mono output jack to rig
	enclosure