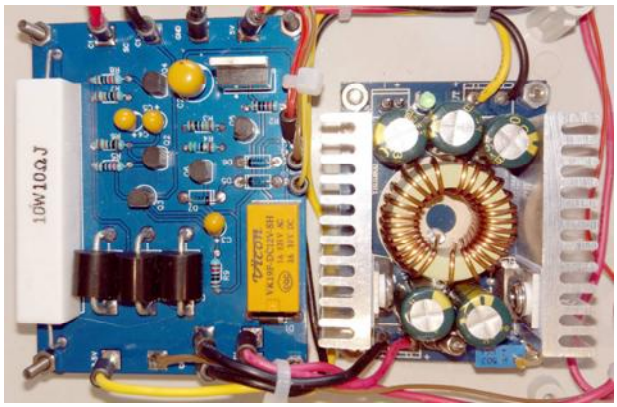
Raspberry Pi Power Supply

An issue confronting Raspberry Pi users, is SD card corruption due do improper system shutdown. Ordinarily before removing power from the Raspberry Pi, one should execute the "**sudo shutdown -h**"



Simple routine can be incorporated into the system, sensing either an operator shutdown or a power failure.

In the case of a power failure, we need some reserve of energy, keeping the Raspberry Pi alive long enough to perform the shutdown procedure.

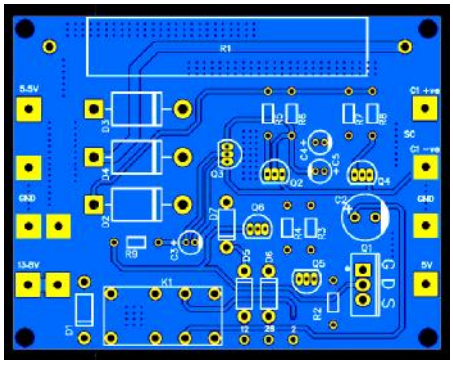
In designing the power supply, consideration was given to what kind of energy source would be most suitable, if using a battery the charging adds complexity to the circuit.

One device that provides a very simple charging method is a super capacitor only requiring a current limiting resistor.

The size of the capacitor in my application was largely driven by economics, it had to have sufficient capacity and include a charge balancing board, the cheapest I could find was the 250 Farad 5.4 Volts, providing an energy store of 1350 Coulombs, enough energy to power the Raspberry Pi during the shutdown.

Using a buck inverter is a good solution for a power source; this exhibits good regulation with high current capability. Many modules are on offer; however the selection had to meet the following criteria:
a/ Have sufficient current ability to charge the Super Capacitor.
b/ Have the lowest possible ripple noise.

Having tested several of them, I chose this module from eBay costing less than $10.00, it provides a regulated adjustable output of 5.0 Volts from a source of 13.8 volts or less, with a maximum current ability of 12 Amps. (WARNING before using this device, set the output voltage to 5 Volts)



Code to be installed into the Raspberry Pi for Power supply control:
1/ Power Fail Routine (Signal to Power Down)
2/ Heart Tick Routine (Maintain Power to the Raspberry Pi)
3/ Modification to boot/config.txt (Provide SD card activity signal)

Mod to config.txt
# Use external LED as SD ACT LED
dtoverlay=pi3-act-led,gpio=12

Signals required for the Power Supply Operation are:
a/ Power On/Off/Fail (B4)
b/ Heart Tick indicating Normal Running (B3)
c/ SD card Activity Normal running (B2)
The 500 mS Heart Tick signal of 3.3 Volts is applied to B3, this keeps the power supply turned on, delivering 5 Volts to the Raspberry Pi.
Power On/Off timing is achieved by the action of C2 and C3.

Shutdown Process
When a logic zero is applied to B4 (Power Off/Fail) The Raspberry Pi commences the shutdown process. During this process the SD card activity signal is used to extend the ON time of the Power Supply, When the Heart Tick and SD card activity ceases, the timing capacitor C2 fully discharges, then the power to the Raspberry Pi is turned off.

Circuit Actions
The Power switching (On/Off) is performed by Q1, a P Channel FET
D1 Absorbs back EMF from the relay to protect any devices sharing the 13.8 Volt rail.
D3 and R1 form the Super Capacitor charging circuit.
D2 Power source from the Inverter.
D4 Power source from the super capacitor.
Q5 and Q6 are used for the control of Q1, if Q5 is off, Q1 is pinched off. (Power Off)
Q2 and Q4 form an astable switch, controlled by Q3, if Q3 is on (saturated), the astable is turned off.
Q6 is the charge controller to power-up and keep the power on if Heart Tick or SD activity is present.
The Relay serves as a power fail detector, choosing an electromechanical device solves problems with slow decay of input voltages, providing a solid signal indicating power failure.
Note that the Buck Inverter has a wide range of input voltage to maintain a regulated 5.5 Volt output, thus only when the voltage at the relay armature falls below the holding voltage, a power fail signal is sent to the Raspberry Pi.
Voltage variations taking place on the input of the regulator above the holding voltage of the relay will have no consequence to the regulated output or the functionality of the Raspberry Pi.

The circuit has to meet 3 conditions,
a/ Operator Power on/off
b/ Power fail
c/ Auto reboot if power is available but the Raspberry Pi is dormant requiring a power cycle to boot.
Note that if a shutdown command was issued, the inbuilt Raspberry Pi watchdog is disabled, so this can't be used to detect a dormant device, to restart the Raspberry Pi, the power must be cycled, initiating a boot process.

Circuit Operation
With the SW1 in the OFF condition a ground is applied to B4, this signal indicates that power is turned off by the Operator, also initiating a power down if the Raspberry Pi was running.

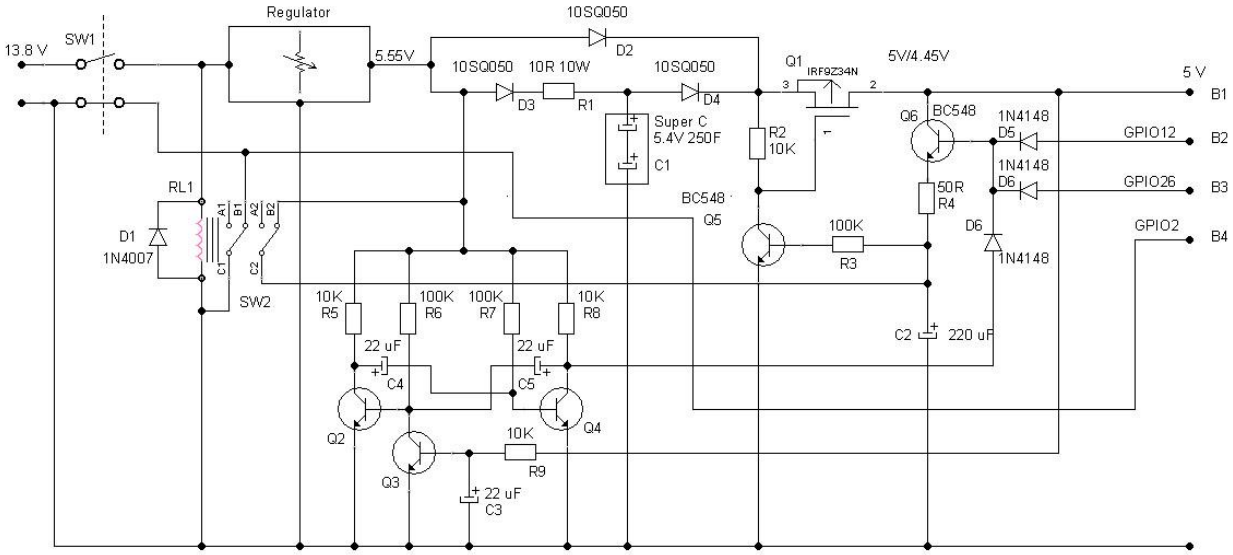
When SW1 is turned ON, The regulated 5.55 Volts from the buck inverter, is applied to C2, charging C2 instantaneously, this is possible because of the lag in the relay armature, at the same time the ground on B4 is removed. The charge in C2 with R3, causes Q5 to saturates, the FET is turned on, 5 Volts is now applied to the Raspberry Pi. The source of this voltage is via D2, making the cathode of D4 more positive than the anode, thus D4 is turned off, D3 and R1 are now charging the super capacitor.
The initial charge in C2 allows 20 seconds of operation, the activity signal of the SD card during the boot process, further adds to this charge extending the time, insuring a proper boot-up.
Once the Raspberry Pi has booted, the Heart Tick signal via B3 keeps charging C2 every Second for 500 mS. sustaining the power to the Raspberry Pi.

Now lets consider a power-off situation, SW1 is turned off, the super capacitor is now supplying energy via D4, the ground applied to B4 initiates the Raspberry Pi shutdown procedure. The SD card activity is high during shutdown process, this pulses B2, toping up the charge in C2 via Q6, extending the power on time.
When the Raspberry Pi goes dormant, the Heart Tick and SD card activity ceases, C2 discharges fully, Q5 turns off and the FET also turns off, the 5 Volts is now removed from the Raspberry Pi.

Now we consider the operation of the circuit during a power fail.
If the voltage falls below the holding voltage of the relay, the NC contact is made, this applies a ground to B4, signalling the Raspberry Pi to commence the shutdown procedure.
As long as the power remains off the system will shutdown as if the operator had turned SW1 off.

Auto Boot
The Auto Boot takes place when power is interrupted initiating the shutdown procedure, but power returns, resulting in a dormant Raspberry Pi. In this condition, C2 is discharging; the discharge time is approximately 1 minute. Once the 5 Volt to the Raspberry Pi falls to zero, C3 discharges taking approximately 200 mS to turn Q3 off, the astable Q2 and Q4 is now allowed to cycle, pulsing a charge into C2. This action causes the 5 Volts to the Raspberry Pi to be turned off and back on after 200 mS. initiating the boot process.

Action Times
Reboot: 1 minute 30seconds
Off to On: 1 minute 10 seconds
Switch Off: 5 seconds
Times will vary according to the services and task been performed by the Raspberry Pi



Concluding.
This power supply takes care of power control or failure conditions, shutting down the Raspberry Pi in a safe manner, plus rebooting if power is present but the Raspberry Pi is shutdown

I can provide the C code for the control features of this power supply upon request.
Hope you find this useful.
73's
Robert Campiciano