# 5 BIT PROGRAMMABLE SYNCHRONOUS BUCK PLUS TRIPPLE LDO CONTROLLER

**PRELIMINARY DATASHEET**

## FEATURES

- **Provides Single Chip Solution for Vcore, GTL+ ,AGP Bus, and 1.8V**
- **Automatic Voltage Selection for AGP slot Vddq supply**
- **Linear regulator controller on board for 1.8V**
- **Designed to meet Intel Latest VRM specification for next generation micrprocessors**
- **On board DAC programs the output voltage from 1.3V to 3.5V**
- **Linear regulator controller on board for 1.5V GTL+ supply**
- **Loss less Short Circuit Protection for all outputs**
- **Synchronous operation allows maximum efficiency**
- **Patented architecture allows fixed frequency operation as well as 100% duty cycle during dynamic load**
- **Minimum part count**
- **Soft Start**
- **High current totem pole driver for direct driving of the external Power MOSFET**
- **Power Good function Monitors all Outputs**
- **OVP Circuitry Protects the Switcher Output and generates a Fault output**

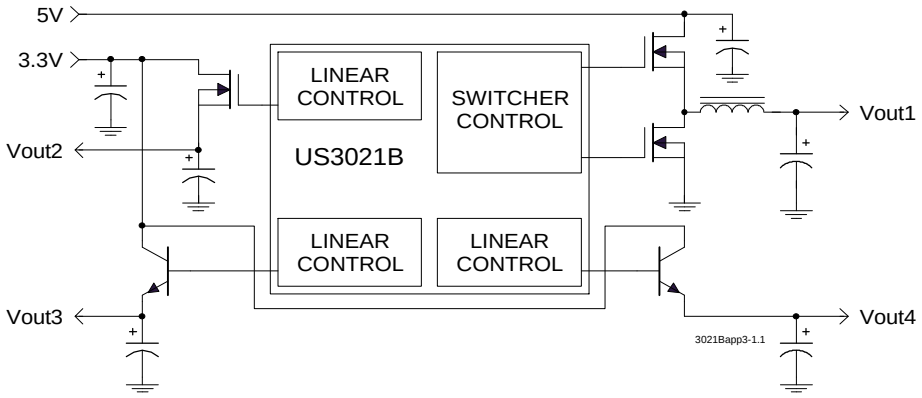
## APPLICATIONS

- Total Power Soloution for Next Generation Intel Processor application

## DESCRIPTION

The US3021B controller IC is specifically designed to meet Intel specification for next generation microprocessor applications requiring multiple on board regulators . **The US3021B provides a single chip controller IC for the Vcore , 3LDO controllers, one with the automatic select pin that connects to the TYPE DETECT pin of the AGP slot for the AGP Vddq supply, one for GTL+ and the other for the 1.8V chip set regulator as required for the next generation PC applications**. **The US3021B typically uses Bipolar transistors for Vout3(1.5V) and Vout4(1.8V) however if Vaux pin is connected to 12V, then MOSFETs can also be used as external pass elements. No external resistor divider is necessary for any of the regulators.** The switching regulator feature a patented topology that in combination with a few external components as shown in the typical application circuit ,will provide well in excess of 20A of output current for an on- board DC/DC converter while automatically providing the right output voltage via the 5 bit internal DAC .The US3021B also features, **loss less current sensing for both switcher by using the Rds-on of the high side Power MOSFET as the sensing resistor, an output under voltage shutdown that detects short circuit condition for the linear outputs and latches the system off, and** a Power Good window comparator that switches its open collector output low when any one of the outputs is outside of a pre programmed window.

## TYPICAL APPLICATION




## PACKAGE ORDER INFORMATION

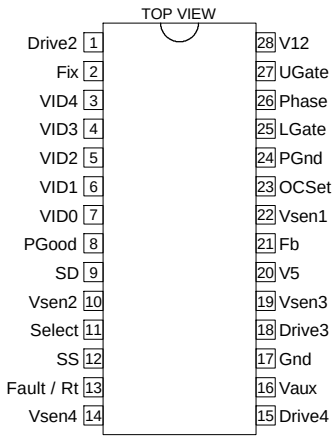
| Ta (°C) | Device | Package |
|---|---|---|
| 0 TO 70 | US3021BCW | 28 pin Plastic SOIC WB |

## ABSOLUTE MAXIMUM RATINGS

V5 supply Voltage ..... 7V
V12 Supply Voltage ..... 20V
Storage Temperature Range ..... -65 TO 150°C
Operating Junction Temperature Range ..... 0 TO 125°C

## PACKAGE INFORMATION

28 PIN WIDE BODY PLASTIC SOIC (W)




$\theta_{JA}$ =80°C/W

## ELECTRICAL SPECIFICATIONS

Unless otherwise specified ,these specifications apply over ,V12 = 12V, V5 = 5V and Ta=0 to 70°C. Typical values refer to Ta =25°C. Low duty cycle pulse testing are used which keeps junction and case temperatures equal to the ambient temperature.

| PARAMETER | SYM | TEST CONDITION | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **Supply UVLO Section** | | | | | | |
| UVLO Threshold-12V | | Supply ramping up | | 10 | | V |
| UVLO Hysterises-12V | | | | 0.6 | | V |
| UVLO Threshold-5V | | Supply ramping up | | 4.4 | | V |
| UVLO Hysterises-5V | | | | 0.3 | | V |
| **Supply Current** | | | | | | |
| Operating Supply Current | | V12<br>V5 | | 6<br>30 | | mA |
| **Switching Controllers; Vcore (Vsen 1) and AGP (Vsen 2)** | | | | | | |
| **VID Section (Vcore only)** | | | | | | |
| DAC output voltage (note 1) | | | 0.99Vs | Vs | 1.01Vs | V |
| DAC Output Line Regulation | | | | 0.1 | | % |
| DAC Output Temp Variation | | | | 0.5 | | % |
| VID Input LO | | | | | 0.8 | V |
| VID Input HI | | | 2 | | | V |
| VID input internal pull-up resistor to V5 | | | | 27 | | kΩ |
| Vsen2 Voltage | | Select<0.8V<br>Select>2V | | 1.5<br>3.3 | | V<br>V |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Error Comparator Section** | | | | | | |
| Input bias current | | | | | 2 | uA |
| Input Offset Voltage | | | -2 | | +2 | mV |
| Delay to Output | | Vdiff=10mV | | | 100 | nS |
| **Current Limit Section** | | | | | | |
| C.S Threshold Set Current | | | | 200 | | uA |
| C.S Comp Offset Voltage | | | -5 | | +5 | mV |
| Hiccup Duty Cycle | | Css=0.1 uF | | 10 | | % |
| **Output Drivers Section** | | | | | | |
| Rise Time | | CL=3000pF | | 70 | | nS |
| Fall Time | | CL=3000pF | | 70 | | nS |
| Dead band Time Between High side and Synch Drive (Vcore Switcher Only) | | CL=3000pF | | 200 | | nS |
| **Oscillator Section (internal)** | | | | | | |
| Osc Frequency | | Rt=Open | | 217 | | Khz |
| **1.8V Regulator (Vsen 4)** | | | | | | |
| Vsense Voltage | Vo4 | Ta=25, Drive4 = Vsen4 | | 1.800 | | V |
| Vsense Voltage | | | | 1.800 | | V |
| Input bias current | | | | | 2 | uA |
| Output Drive Current | | Vaux-Vdrive>0.6V | 50 | | | mA |
| **1.5V Regulator (Vsen 3)** | | | | | | |
| Vsense Voltage | Vo3 | Ta=25, Drive3 = Vsen3 | | 1.500 | | V |
| Vsense Voltage | | | | 1.500 | | V |
| Input bias current | | | | | 2 | uA |
| Output Drive Current | | Vaux-Vdrive>0.6V | 50 | | | mA |
| **Power Good Section** | | | | | | |
| Vsen1 UV lower trip point | | Vsen1 ramping down | | 0.90Vs | | V |
| Vsen1 UV upper trip point | | Vsen1 ramping up | | 0.92Vs | | V |
| Vsen1 UV Hysterises | | | | .02Vs | | V |
| Vsen1 HV upper trip point | | Vsen1 ramping up | | 1.10Vs | | V |
| Vsen1 HV lower trip point | | Vsen1 ramping down | | 1.08Vs | | V |
| Vsen1 HV Hysterises | | | | .02Vs | | V |
| Vsen2 trip point | | Select<0.8V<br>Select>2V | | 1.100<br>2.560 | | V<br>V |
| Vsen4 trip point | | Fix=GND<br>Fix=Open | | 0.920<br>1.320 | | V<br>V |
| Vsen3 trip point | | Fix=GND<br>Fix=Open | | 0.920<br>1.140 | | V<br>V |
| Power Good Output LO | | RL=3mA | | 0.4 | | V |
| Power Good Output HI | | RL=5K pull up to 5V | | 4.8 | | V |
| **Fault (Overvoltage) Section** | | | | | | |
| Core O.V. upper trip point | | Vsen1 ramping up | | 1.17Vs | | V |
| Core O.V. lower trip point | | Vsen1 ramping down | | 1.15Vs | | V |
| FAULT Output HI | | Io=3mA | | 10 | | V |
| **Soft Start Section** | | | | | | |
| Soft Start Current | | OCset=0V , Phase=5V | | 20 | | uA |

Note 1: Vs refers to the set point voltage given in Table 1.

| D4 | D3 | D2 | D1 | D0 | Vs |
|---|---|---|---|---|---|
| 0 | 1 | 1 | 1 | 1 | 1.30 |
| 0 | 1 | 1 | 1 | 0 | 1.35 |
| 0 | 1 | 1 | 0 | 1 | 1.40 |
| 0 | 1 | 1 | 0 | 0 | 1.45 |
| 0 | 1 | 0 | 1 | 1 | 1.50 |
| 0 | 1 | 0 | 1 | 0 | 1.55 |
| 0 | 1 | 0 | 0 | 1 | 1.60 |
| 0 | 1 | 0 | 0 | 0 | 1.65 |
| 0 | 0 | 1 | 1 | 1 | 1.70 |
| 0 | 0 | 1 | 1 | 0 | 1.75 |
| 0 | 0 | 1 | 0 | 1 | 1.80 |
| 0 | 0 | 1 | 0 | 0 | 1.85 |
| 0 | 0 | 0 | 1 | 1 | 1.90 |
| 0 | 0 | 0 | 1 | 0 | 1.95 |
| 0 | 0 | 0 | 0 | 1 | 2.00 |
| 0 | 0 | 0 | 0 | 0 | 2.05 |

| D4 | D3 | D2 | D1 | D0 | Vs |
|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 2.0 |
| 1 | 1 | 1 | 1 | 0 | 2.1 |
| 1 | 1 | 1 | 0 | 1 | 2.2 |
| 1 | 1 | 1 | 0 | 0 | 2.3 |
| 1 | 1 | 0 | 1 | 1 | 2.4 |
| 1 | 1 | 0 | 1 | 0 | 2.5 |
| 1 | 1 | 0 | 0 | 1 | 2.6 |
| 1 | 1 | 0 | 0 | 0 | 2.7 |
| 1 | 0 | 1 | 1 | 1 | 2.8 |
| 1 | 0 | 1 | 1 | 0 | 2.9 |
| 1 | 0 | 1 | 0 | 1 | 3.0 |
| 1 | 0 | 1 | 0 | 0 | 3.1 |
| 1 | 0 | 0 | 1 | 1 | 3.2 |
| 1 | 0 | 0 | 1 | 0 | 3.3 |
| 1 | 0 | 0 | 0 | 1 | 3.4 |
| 1 | 0 | 0 | 0 | 0 | 3.5 |

Table 1 - Set point voltage vs. VID codes

## PIN DESCRIPTIONS

| PIN# | PIN SYMBOL | Pin Description |
|---|---|---|
| 7 | VID0 | LSB input to the DAC that programs the output voltage. This pin is TTL compatible that realizes a logic “1” as either HI or Open. When left open,his pin is pulled up internally by a 27kΩ resistor to 5V supply. |
| 6 | VID1 | Input to the DAC that programs the output voltage. This pin is TTL compatible that realizes a logic “1” as either HI or Open. When left open,his pin is pulled up internally by a 27kΩ resistor to 5V supply. |
| 5 | VID2 | Input to the DAC that programs the output voltage. This pin is TTL compatible that realizes a logic “1” as either HI or Open. When left open,his pin is pulled up internally by a 27kΩ resistor to 5V supply. |
| 4 | VID3 | MSB input to the DAC that programs the output voltage. This pin is TTL compatible that realizes a logic “1” as either HI or Open. When left open,his pin is pulled up internally by a 27kΩ resistor to 5V supply. |
| 3 | VID4 | This pin selects a range of output voltages for the DAC.When in the LOW state the range is 1.3V to 2.05V and when it switches to HI state the range is 2.0V to 3.5V. This pin is TTL compatible that realizes a logic “1” as either HI or Open. When left open,his pin is pulled up internally by a 27kΩ resistor to 5V supply. |
| 8 | PGOOD | This pin is an open collector output that switches LO when any of the outputs are outside of the specified under voltage trip point. It also switches low when Vsen1 pin is more than 10% above the DAC voltage setting. |
| 21 | FB | This pin provides the feedback for the synchronous switching regulator. Typically this pin can be connected directly to the output of the switching regulator. However, a resistor divider is recommended to be connected from this pin to vout1 and GND to adjust the output voltage for any drop in the output voltage that is caused by the trace resistance. The value of the resistor connected from Vout1 to FB1 must be less than 1000Ω. |
| 1 | Drive2 | This pin controls the gate of an external MOSFET for the AGP linear regulator. |
| 9 | SD | This pin provides shutdown for all the regulatos. A TTL compatible, logic level high applied to this pin disables all the outputs and discharges the soft start capacitor. The SD signal turns off the synchronous allowing body diode to conduct and discharge the output cap. |

| PIN# | PIN SYMBOL | Pin Description |
|---|---|---|
| 22 | Vsen1 | This pin is internally connected to the undervoltage and overvoltage comparators sensing the Vcore status. It must be connected directly to the Vcore supply. |
| 10 | Vsen2 | This pin provides the feedback for the AGP linear regulator. The Select pin when connected to the "Type Detect" pin of the AGP slot automatically selects the right voltage for the AGP Vddq. |
| 15 | Drive4 | This pin controls the gate of an external MOSFET for the 1.8V chip set linear regulator. |
| 23 | OCSET | This pin is connected to the Drain of the power MOSFET of the Core supply and it provides the positive sensing for the internal current sensing circuitry. An external resistor programs the C.S threshold depending on the Rds of the power MOSFET. An external capacitor is placed in parallel with the programming resistor to provide high frequency noise filtering. |
| 26 | PHASE | This pin is connected to the Source of the power MOSFET for the Core supply and it provides the negative sensing for the internal current sensing circuitry. |
| 12 | SS | This pin provides the soft start for all the regulators. An internal current source charges an external capacitor that is connected from this pin to GND which ramps up the outputs of the regulators, preventing the outputs from overshooting as well as limiting the input current. The second function of the Soft Start cap is to provide long off time (HICCUP) for the synchronous MOSFET during current limiting. |
| 13 | FAULT/Rt | This pin has dual function. It acts as an output of the OVP circuitry or it can be used to program the frequency using an external resistor . When used as a fault detector, if any of the switcher outputs exceed the OVP trip point, the FAULT pin switches to 12V and the soft start cap is discharged. If the FAULT pin is to be connected to any external circuitry, it needs to be buffered. |
| 18 | Drive3 | This pin controls the gate of an external transistor for the 1.5V GTL+ linear regulator. |
| 19 | Vsen3 | This pin provides the feedback for the linear regulator that its output drive is Drive3. |
| 16 | Vaux | This pin is normally connected to 3.3V or 5V input. When connected to the 12V supply, it provides gate drive voltage for the # 3 and #4 (Drive 3 and 4) linear regulator's pass transistors in case MOSFET transistors are being used instead of Bipolars. |
| 14 | Vsen4 | This pin provides the feedback for the linear regulator that its output drive is Drive4. |
| 17 | GND | This pin serves as the ground pin and must be connected directly to the ground plane. |
| 24 | PGND | This pin serves as the Power ground pin and must be connected directly to the GND plane close to the source of the synchronous MOSFET. A high frequency capacitor (typically 1 uF) must be connected from V12 pin to this pin for noise free operation. |
| 25 | LGATE | Output driver for the synchronous power MOSFET for the Core supply. |
| 27 | UGATE | Output driver for the high side power MOSFET for the Core supply. |
| 28 | V12 | This pin is connected to the 12 V supply and serves as the power Vcc pin for the output drivers. A high frequency capacitor (typically 1 uF) must be placed close to this pin and PGND pin and be connected directly from this pin to the GND plane for the noise free operation. |
| 20 | V5 | 5V supply voltage. A high frequency capacitor (0.1 to 1 uF) must be placed close to this pin and connected from this pin to the GND plane for noise free operation. |
| 11 | Select | This pin provides automatic voltage selection for the AGP switching regulator. When it is pulled LO, the voltage is 1.5V and when left open or pulled to HI, the voltage is 3.3V. |
| 2 | FIX | Leaving this pin open provides fixed output voltages of the 1.5V and 1.8V for the #3 and #4 linear regulators. When this pin is grounded the reference to the linear regulators are set to 1.26V and therefore the output of the regulators can be programmed to any voltages above the 1.26V using; Vout=1.26*(1+Rtop/Rbot)<br>Where:<br>Rtop=Top resistor connected from the output to the Vsense pin<br>Rbot=Bottom resistor connected from the Vsense pin to ground. |

# BLOCK DIAGRAM

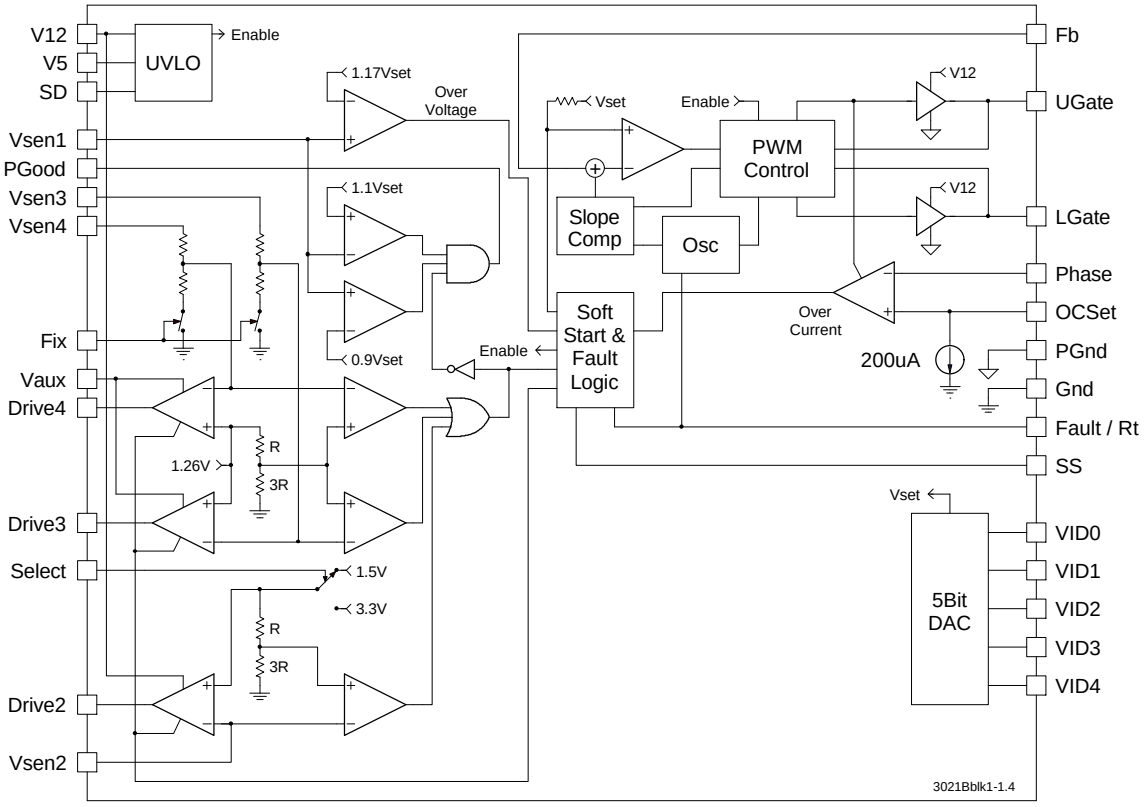



Figure 1 - Simplified block diagram of the US3021.

# TYPICAL APPLICATION

**(Dual Layout with HIP6021)**

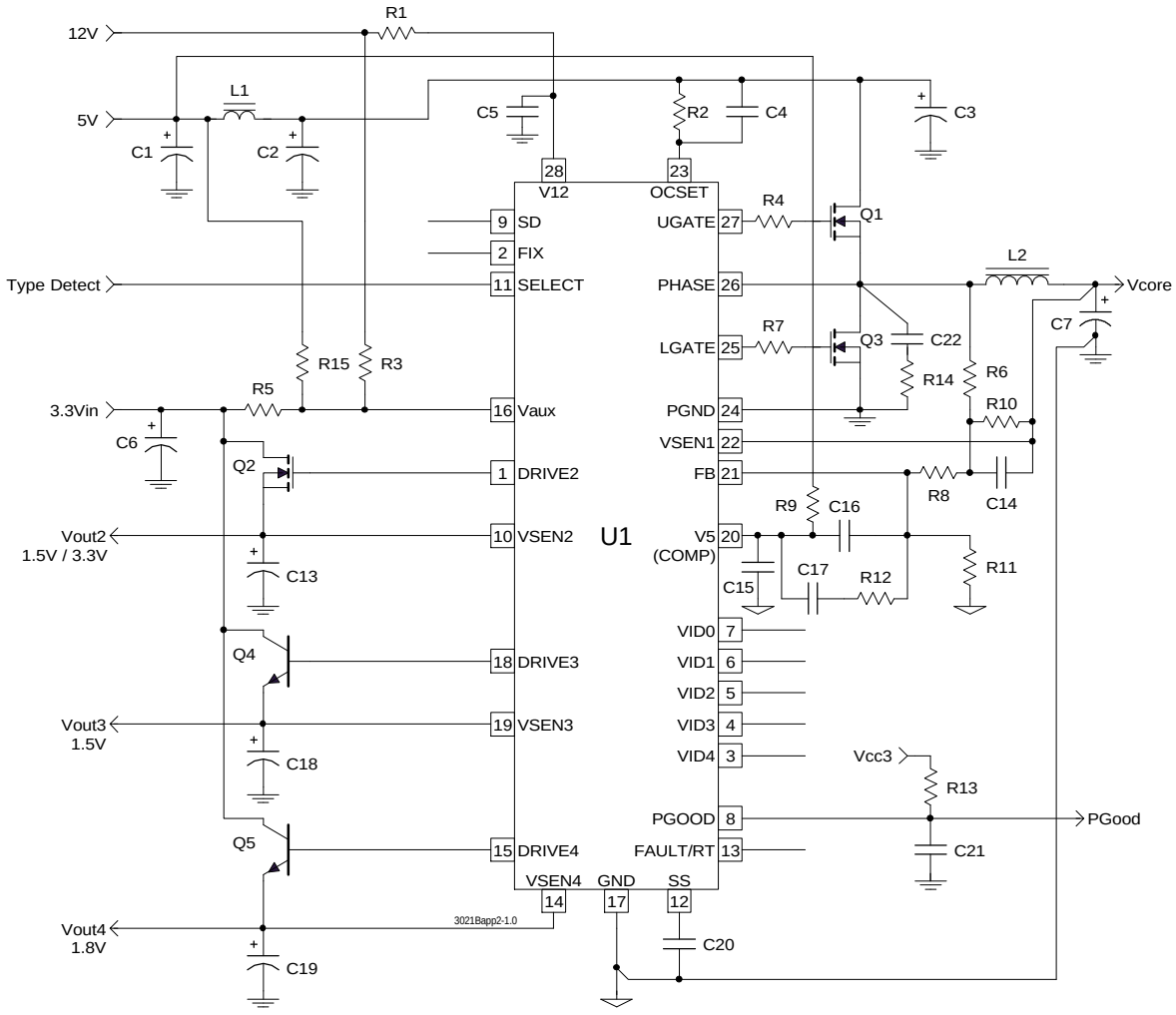



Figure 2 - Typical application of US3021B in a dual layout with HIP6021 for an on board DC-DC converter providing power for the Vcore , GTL+, 1.8V chip set supply as well as auto select AGP supply for the next generation PC applications.

| Part# | R3 | R5 | R9 | R10 | R15 | C15 | C16 | C17 |
|---|---|---|---|---|---|---|---|---|
| HIP6021 | O | S | O | V | O | O | V | V |
| US3021B | O | O | O | O | S | V | O | O |

S - Short O - Open V - See Unisem or Harris parts list for the value.

Table 2 - Dual layout component table

Note 1: If Q4 and Q5 are changed to MOSFETs such as IRLR024, then R2 is short and R4 is open.

**US3021M Application Parts List**
**Dual Layout with HIP6021**

| Ref Desig | Description | Qty | Part # | Manuf |
|---|---|---|---|---|
| Q1 | MOSFET | 1 | IRL3103S, TO263 package | IR |
| Q2 | MOSFET | 1 | IRLR3103, TO252 package | IR |
| Q3 | MOSFET with Schottky | 1 | IRL3103D1S, TO263 package | IR |
| Q4,5 | Transistor | 2 | 2SD1760, TO252 package | ROHM |
| L1 | Inductor | 1 | L=1uH, 5052 core with 4 turns of 1.0mm wire | Micro Metal |
| L2 | Inductor | 1 | L=2.7uH, 5052B core with 7 turns of 1.2mm wire | Micro Metal |
| C1 | Capacitor, Electrolytic | 1 | 10MV470GX, 470uF,10V | Sanyo |
| C2,3 | Capacitor, Electrolytic | 2 | 10MV1200GX, 1200uF,10V | Sanyo |
| C4 | Capacitor, Ceramic | 1 | 220pF, 0603 | |
| C5 | Capacitor, Ceramic | 1 | 1uF, 0805 | |
| C6,18 | Capacitor, Electrolytic | 2 | 6MV1000GX, 1000uF,6.3V | Sanyo |
| C7 | Capacitor, Electrolytic | 6 | 6MV1500GX, 1500uF,6.3V, | Sanyo |
| C13,19 | Capacitor, Electrolytic | 1 | 6MV1500GX, 1500uF,6.3V, | Sanyo |
| C14,15 | Capacitor, Ceramic | 2 | 1uF, 0603 | |
| C16,17 | Capacitor, Ceramic | 2 | See Table 2, dual layout component 0603 * 2 | |
| C20,21 | Capacitor, Ceramic | 2 | 0.1uF, 0603 | |
| C22 | Capacitor, Ceramic | 1 | 1000pF, 0603 | |
| R1 | Resistor | 1 | 10Ω, 5%, 0603 | |
| R2 | Resistor | 1 | 3.3kΩ, 5%, 0603 | |
| R3,5,12 | Resistor | 3 | See Table 2, dual layout component 0603 * 3 | |
| R4,7,14 | Resistor | 3 | 4.7Ω, 5%, 1206 | |
| R6,8,10 | Resistor | 3 | 2.2kΩ, 1%, 0603 | |
| R9 | Resistor | 1 | 0Ω, 0603 | |
| R11 | Resistor | 1 | 220kΩ, 1%, 0603 | |
| R13 | Resistor | 1 | 10kΩ, 5%, 0603 | |
| R15 | Resistor | 1 | 0Ω, 0603 | |