

| DCDC_InnoSwitch3AQ_Flyback_06 0622; Rev.3.4; Copyright Power Integrations 2022 | INPUT | INFO | OUTPUT | UNITS | InnoSwitch3-AQ Flyback Design Spreadsheet |
|---|--------------|-------------|---------------|--------------|--|
| APPLICATION VARIABLES | | | | | Design Title |
| VOUT | 15.00 | | 15.00 | V | Output Voltage |
| OPERATING CONDITION 1 | | | | | |
| VINDC1 | 16.00 | | 16.00 | V | Input DC voltage 1 |
| IOUT1 | 0.500 | | 0.500 | A | Output current 1 |
| POUT1 | | | 7.50 | W | Output power 1 |
| EFFICIENCY1 | | | 0.85 | | Converter efficiency for output 1 |
| Z_FACTOR1 | | | 0.50 | | Z-factor for output 1 |
| OPERATING CONDITION 2 | | | | | |
| VINDC2 | 30.00 | | 30.00 | V | Input DC voltage 2 |
| IOUT2 | 0.500 | | 0.500 | A | Output current 2 |
| POUT2 | | | 7.50 | W | Output power 2 |
| EFFICIENCY2 | | | 0.85 | | Converter efficiency for output 2 |
| Z_FACTOR2 | | | 0.50 | | Z-factor for output 2 |
| OPERATING CONDITION 3 | | | | | |
| VINDC3 | | | 0.00 | V | Input DC voltage 3 |
| IOUT3 | | | 0.000 | A | Output current 3 |
| POUT3 | | | 0.00 | W | Output power 3 |
| EFFICIENCY3 | | | 0.00 | | Converter efficiency for output 3 |
| Z_FACTOR3 | | | 0.00 | | Z-factor for output 3 |
| OPERATING CONDITION 4 | | | | | |
| VINDC4 | | | 0.00 | V | Input DC voltage 4 |
| IOUT4 | | | 0.000 | A | Output current 4 |
| POUT4 | | | 0.00 | W | Output power 4 |
| EFFICIENCY4 | | | 0.00 | | Converter efficiency for output 4 |
| Z_FACTOR4 | | | 0.00 | | Z-factor for output 4 |
| OPERATING CONDITION 5 | | | | | |
| VINDC5 | | | 0.00 | V | Input DC voltage 5 |
| IOUT5 | | | 0.000 | A | Output current 5 |
| POUT5 | | | 0.00 | W | Output power 5 |
| EFFICIENCY5 | | | 0.00 | | Converter efficiency for output 5 |
| Z_FACTOR5 | | | 0.00 | | Z-factor for output 5 |
| OPERATING CONDITION 6 | | | | | |
| VINDC6 | | | 0.00 | V | Input DC voltage 6 |
| IOUT6 | | | 0.000 | A | Output current 6 |
| POUT6 | | | 0.00 | W | Output power 6 |
| EFFICIENCY6 | | | 0.00 | | Converter efficiency for output 6 |
| Z_FACTOR6 | | | 0.00 | | Z-factor for output 6 |
| OPERATING CONDITION 7 | | | | | |
| VINDC7 | | | 0.00 | V | Input DC voltage 7 |
| IOUT7 | | | 0.000 | A | Output current 7 |
| POUT7 | | | 0.00 | W | Output power 7 |

| | | | | | |
|---|------------------|--|------------------|----|--|
| <i>EFFICIENCY7</i> | | | 0.00 | | <i>Converter efficiency for output 7</i> |
| <i>Z_FACTOR7</i> | | | 0.00 | | <i>Z-factor for output 7</i> |
| <i>OPERATING CONDITION 8</i> | | | | | |
| <i>VINDC8</i> | | | 0.00 | V | <i>Input DC voltage 8</i> |
| <i>IOUT8</i> | | | 0.000 | A | <i>Output current 8</i> |
| <i>POUT8</i> | | | 0.00 | W | <i>Output power 8</i> |
| <i>EFFICIENCY8</i> | | | 0.00 | | <i>Converter efficiency for output 8</i> |
| <i>Z_FACTOR8</i> | | | 0.00 | | <i>Z-factor for output 8</i> |
| <i>OPERATING CONDITION 9</i> | | | | | |
| <i>VINDC9</i> | | | 0.00 | V | <i>Input DC voltage 9</i> |
| <i>IOUT9</i> | | | 0.000 | A | <i>Output current 9</i> |
| <i>POUT9</i> | | | 0.00 | W | <i>Output power 9</i> |
| <i>EFFICIENCY9</i> | | | 0.00 | | <i>Converter efficiency for output 9</i> |
| <i>Z_FACTOR9</i> | | | 0.00 | | <i>Z-factor for output 9</i> |
| <i>PRIMARY CONTROLLER SELECTION</i> | | | | | |
| <i>ILIMIT_MODE</i> | <i>INCREASED</i> | | <i>INCREASED</i> | | <i>Device current limit mode</i> |
| <i>VDRAIN_BREAKDOWN</i> | | | 750 | V | <i>Device breakdown voltage</i> |
| <i>DEVICE_GENERIC</i> | | | <i>INN39X7</i> | | <i>Device selection</i> |
| <i>DEVICE_CODE</i> | <i>INN3977CQ</i> | | <i>INN3977CQ</i> | | <i>Device code</i> |
| <i>PDEVICE_MAX</i> | | | 10 | W | <i>Device maximum power capability</i> |
| <i>RDSON_25DEG</i> | | | 1.38 | Ω | <i>Primary switch on-time resistance at 25°C</i> |
| <i>RDSON_125DEG</i> | | | 2.30 | Ω | <i>Primary switch on-time resistance at 125°C</i> |
| <i>ILIMIT_MIN</i> | | | 1.385 | A | <i>Primary switch minimum current limit</i> |
| <i>ILIMIT_TYP</i> | | | 1.523 | A | <i>Primary switch typical current limit</i> |
| <i>ILIMIT_MAX</i> | | | 1.662 | A | <i>Primary switch maximum current limit</i> |
| <i>VDRAIN_ON_PRSW</i> | | | 1.27 | V | <i>Primary switch on-time voltage drop</i> |
| <i>VDRAIN_OFF_PRSW</i> | | | 78 | V | <i>Peak drain voltage on the primary switch during turn-off</i> |
| <i>WORST CASE ELECTRICAL PARAMETERS</i> | | | | | |
| <i>FSWITCHING_MAX</i> | | | 100000 | Hz | <i>Maximum switching frequency at full load and the valley of the minimum input AC voltage</i> |
| <i>VOR</i> | 18.0 | | 18.0 | V | <i>Voltage reflected to the primary winding (corresponding to set-point 1) when the primary switch turns off</i> |
| <i>KP</i> | | | 0.535 | | <i>Measure of continuous/discontinuous mode of operation</i> |
| <i>MODE_OPERATION</i> | | | <i>CCM</i> | | <i>Mode of operation</i> |
| <i>DUTYCYCLE</i> | | | 0.550 | | <i>Primary switch duty cycle</i> |
| <i>TIME_ON_MIN</i> | | | 4.58 | us | <i>Minimum primary switch on-time</i> |
| <i>TIME_ON_MAX</i> | | | 11.60 | us | <i>Maximum primary switch on-time</i> |
| <i>TIME_OFF</i> | | | 4.50 | us | <i>Primary switch off-time</i> |
| <i>LPRIMARY_MIN</i> | | | 107.2 | uH | <i>Minimum primary magnetizing inductance</i> |
| <i>LPRIMARY_TYP</i> | | | 112.8 | uH | <i>Typical primary magnetizing inductance</i> |

| | | | | |
|-------------------------------------|-----------|--------------------|---------------|--|
| LPRIMARY_TOL | | 5.0 | % | Primary magnetizing inductance tolerance |
| LPRIMARY_MAX | | 118.5 | μ H | Maximum primary magnetizing inductance |
| PRIMARY CURRENT | | | | |
| I AVG_PRIMARY | | 1.566 | A | Primary switch average current |
| I PEAK_PRIMARY | | 1.580 | A | Primary switch peak current |
| I PEDESTAL_PRIMARY | | 0.554 | A | Primary switch current pedestal |
| I RIPPLE_PRIMARY | | 1.566 | A | Primary switch ripple current |
| I RMS_PRIMARY | | 0.787 | A | Primary switch RMS current |
| TRANSFORMER CONSTRUCTION PARAMETERS | | | | |
| CORE SELECTION | | | | |
| CORE | EE13 | EE13 | | Core selection |
| CORE NAME | | PC40EE13-Z | | Core code |
| AE | | 17.1 | mm^2 | Core cross sectional area |
| LE | | 30.2 | mm | Core magnetic path length |
| AL | | 1130 | nH | Ungapped core effective inductance per turns squared |
| VE | | 517 | mm^3 | Core volume |
| BOBBIN NAME | | BE13-1110 CPSFR | | Bobbin name |
| AW | | 22.3 | mm^2 | Bobbin window area |
| BW | | 7.40 | mm | Bobbin width |
| MARGIN | | 0.0 | mm | Bobbin safety margin |
| PRIMARY WINDING | | | | |
| NPRIMARY | | 33 | | Primary winding number of turns |
| BPEAK | | 3572 | Gauss | Peak flux density |
| BMAX | | 3282 | Gauss | Maximum flux density |
| BAC | | 1623 | Gauss | AC flux density (0.5 x Peak to Peak) |
| ALG | | 104 | nH | Typical gapped core effective inductance per turns squared |
| LG | | 0.188 | mm | Core gap length |
| SECONDARY WINDING | | | | |
| NSECONDARY | | 27 | | Secondary winding number of turns |
| BIAS WINDING | | | | |
| NBIAS | | 18 | | Bias winding number of turns |
| PRIMARY COMPONENTS SELECTION | | | | |
| LINE UNDERVOLTAGE/OVERVOLTAGE | | | | |
| UVOV Type | UV Only | UV Only | | Input Undervoltage/Overvoltage protection type |
| UNDERVOLTAGE PARAMETERS | | | | |
| BROWN-IN REQUIRED | | 15.20 | V | Required DC bus brown-in voltage threshold |
| UNDERVOLTAGE ZENER DIODE | BZM55C9V1 | BZM55C9 V1 | | Undervoltage protection zener diode |
| VZ | | 9.10 | V | Zener diode reverse voltage |

| | | | | | |
|--------------------------------|------|------|--------------------|------------|--|
| VR | | | 6.80 | V | Zener diode reverse voltage at the maximum reverse leakage current |
| ILKG | | | 2.00 | μ A | Zener diode maximum reverse leakage current |
| BROWN-IN ACTUAL | | | 11.08 - 14.9 | V | Actual brown-in voltage range using standard resistors |
| BROWN-OUT ACTUAL | | | 10.05 - 13.42 | V | Actual brown-out voltage range using standard resistors |
| OVERVOLTAGE PARAMETERS | | | | | |
| OVERVOLTAGE REQUIRED | | Info | | V | For UV Only design, overvoltage feature is disabled |
| OVERVOLTAGE DIODE | | Info | | | OV diode is used only for the overvoltage protection circuit |
| VF | | | | V | OV diode forward voltage |
| VRRM | | | | V | OV diode reverse voltage |
| PIV | | | | V | OV diode peak inverse voltage |
| LINE_OVERVOLTAGE | | | | V | For UV Only design, line overvoltage feature is disabled |
| DC BUS SENSE RESISTORS | | | | | |
| RLS_H | | | 0.18 | M Ω | DC bus upper sense resistor to the V-pin for the required UV/OV threshold |
| RLS_L | | | 255 | k Ω | DC bus lower sense resistor to the V-pin for the required UV/OV threshold |
| BIAS WINDING | | | | | |
| VBIAS | | | 9.00 | V | Rectified bias voltage |
| VF_BIAS | | | 0.70 | V | Bias winding diode forward drop |
| VREVERSE_BIASDIODE | | | 25.36 | V | Bias diode reverse voltage (not accounting parasitic voltage ring) |
| CBIAS | | | 22 | μ F | Bias winding rectification capacitor |
| CBPP | | | 4.70 | μ F | BPP pin capacitor |
| SECONDARY COMPONENTS SELECTION | | | | | |
| FEEDBACK COMPONENTS | | | | | |
| RFB_UPPER | | | 100.00 | k Ω | Upper feedback resistor (connected to the output terminal) |
| RFB_LOWER | | | 9.31 | k Ω | Lower feedback resistor |
| CFB_LOWER | | | 330 | pF | Lower feedback resistor decoupling capacitor |
| MULTIPLE OUTPUT PARAMETERS | | | | | |
| OUTPUT 1 | | | | | |
| VOUT1 | | | 15.00 | V | Output 1 voltage |
| IOUT1 | | | 0.500 | A | Output 1 current |
| POUT1 | | | 7.50 | W | Output 1 power |
| IRMS_SECONDARY1 | | | 0.870 | A | Root mean squared value of the secondary current for output 1 |
| IRIPPLE_CAP_OUTPUT1 | | | 0.711 | A | Current ripple on the secondary waveform for output 1 |
| NSECONDARY1 | | | 27 | | Number of turns for output 1 |
| VREVERSE_RECTIFIER1 | | | 39.55 | V | SRFET reverse voltage (not accounting parasitic voltage ring) for output 1 |
| SRFET1 | AUTO | | RSR030N0 6HZGTL | | Secondary rectifier (Logic MOSFET) for output 1 |

| | | | | | |
|-----------------------------------|------|--|-------|----|--|
| VF_SRFET1 | | | 1.20 | V | SRFET on-time drain voltage for output 1 |
| VBREAKDOWN_SRFET1 | | | 60 | V | SRFET breakdown voltage for output 1 |
| RDSON_SRFET1 | | | 85 | mΩ | SRFET on-time drain resistance at 25degC and VGS=4.4V for output 1 |
| | | | | | |
| OUTPUT 2 | | | | | |
| VOUT2 | | | 0.00 | V | Output 2 voltage |
| IOUT2 | | | 0.000 | A | Output 2 current |
| POUT2 | | | 0.00 | W | Output 2 power |
| IRMS_SECONDARY2 | | | 0.000 | A | Root mean squared value of the secondary current for output 2 |
| IRIPPLE_CAP_OUTPUT2 | | | 0.000 | A | Current ripple on the secondary waveform for output 2 |
| NSECONDARY2 | | | 0 | | Number of turns for output 2 |
| VREVERSE_RECTIFIER2 | | | 0.00 | V | SRFET reverse voltage (not accounting parasitic voltage ring) for output 2 |
| SRFET2 | AUTO | | N/A | | Secondary rectifier (Logic MOSFET) for output 2 |
| VF_SRFET2 | | | N/A | V | SRFET on-time drain voltage for output 2 |
| VBREAKDOWN_SRFET2 | | | N/A | V | SRFET breakdown voltage for output 2 |
| RDSON_SRFET2 | | | N/A | mΩ | SRFET on-time drain resistance at 25degC and VGS=4.4V for output 2 |
| | | | | | |
| OUTPUT 3 | | | | | |
| VOUT3 | | | 0.00 | V | Output 3 voltage |
| IOUT3 | | | 0.000 | A | Output 3 current |
| POUT3 | | | 0.00 | W | Output 3 power |
| IRMS_SECONDARY3 | | | 0.000 | A | Root mean squared value of the secondary current for output 3 |
| IRIPPLE_CAP_OUTPUT3 | | | 0.000 | A | Current ripple on the secondary waveform for output 3 |
| NSECONDARY3 | | | 0 | | Number of turns for output 3 |
| VREVERSE_RECTIFIER3 | | | 0.00 | V | SRFET reverse voltage (not accounting parasitic voltage ring) for output 3 |
| SRFET3 | AUTO | | N/A | | Secondary rectifier (Logic MOSFET) for output 3 |
| VF_SRFET3 | | | N/A | V | SRFET on-time drain voltage for output 3 |
| VBREAKDOWN_SRFET3 | | | N/A | V | SRFET breakdown voltage for output 3 |
| RDSON_SRFET3 | | | N/A | mΩ | SRFET on-time drain resistance at 25degC and VGS=4.4V for output 3 |
| | | | | | |
| PO_TOTAL | | | 7.50 | W | Total power of all outputs |
| NEGATIVE OUTPUT | N/A | | N/A | | If negative output exists, enter the output number; e.g. If VO2 is negative output, select 2 |
| | | | | | |
| | | | | | |
| INPUT VOLTAGE SET-POINTS ANALYSIS | | | | | |
| TOLERANCE CORNER | | | | | |
| USER_VINDC | 16 | | 16 | V | Input DC voltage corner to be evaluated |
| USER_ILIMIT | MIN | | 1.385 | A | Current limit corner to be evaluated |
| USER_LPRIMARY | MIN | | 107.2 | uH | Primary inductance corner to be evaluated |
| | | | | | |
| OPERATING CONDITION SELECTION | | | | | |
| POUT | | | 7.50 | W | Output power to be evaluated |
| EFFICIENCY | | | 0.85 | | Converter efficiency to be evaluated |
| Z FACTOR | | | 0.50 | | Z-factor to be evaluated |

| | | | | | |
|------------------------------|--|--|--------|-------|---|
| <i>FSWITCHING</i> | | | 100000 | Hz | Maximum switching frequency at the output power to be evaluated |
| <i>KP</i> | | | 0.545 | | Measure of continuous/discontinuous mode of operation |
| <i>MODE_OPERATION</i> | | | CCM | | Mode of operation |
| <i>DUTYCYCLE</i> | | | 0.550 | | Primary switch duty cycle |
| <i>TIME_ON</i> | | | 5.50 | us | Primary switch on-time |
| <i>TIME_OFF</i> | | | 4.50 | us | Primary switch off-time |
| <i>PRIMARY CURRENT</i> | | | | | |
| <i>I AVG_PRIMARY</i> | | | 0.554 | A | Primary switch average current |
| <i>I PEAK_PRIMARY</i> | | | 1.385 | A | Primary switch peak current |
| <i>I PEDESTAL_PRIMARY</i> | | | 0.630 | A | Primary switch current pedestal |
| <i>I RIPPLE_PRIMARY</i> | | | 0.756 | A | Primary switch ripple current |
| <i>I RMS_PRIMARY</i> | | | 0.765 | A | Primary switch RMS current |
| <i>MAGNETIC FLUX DENSITY</i> | | | | | |
| <i>B PEAK</i> | | | 2693 | Gauss | Peak flux density |
| <i>B MAX</i> | | | 2632 | Gauss | Maximum flux density |
| <i>B AC</i> | | | 718 | Gauss | AC flux density (0.5 x Peak to Peak) |
| | | | | | |
| | | | | | |