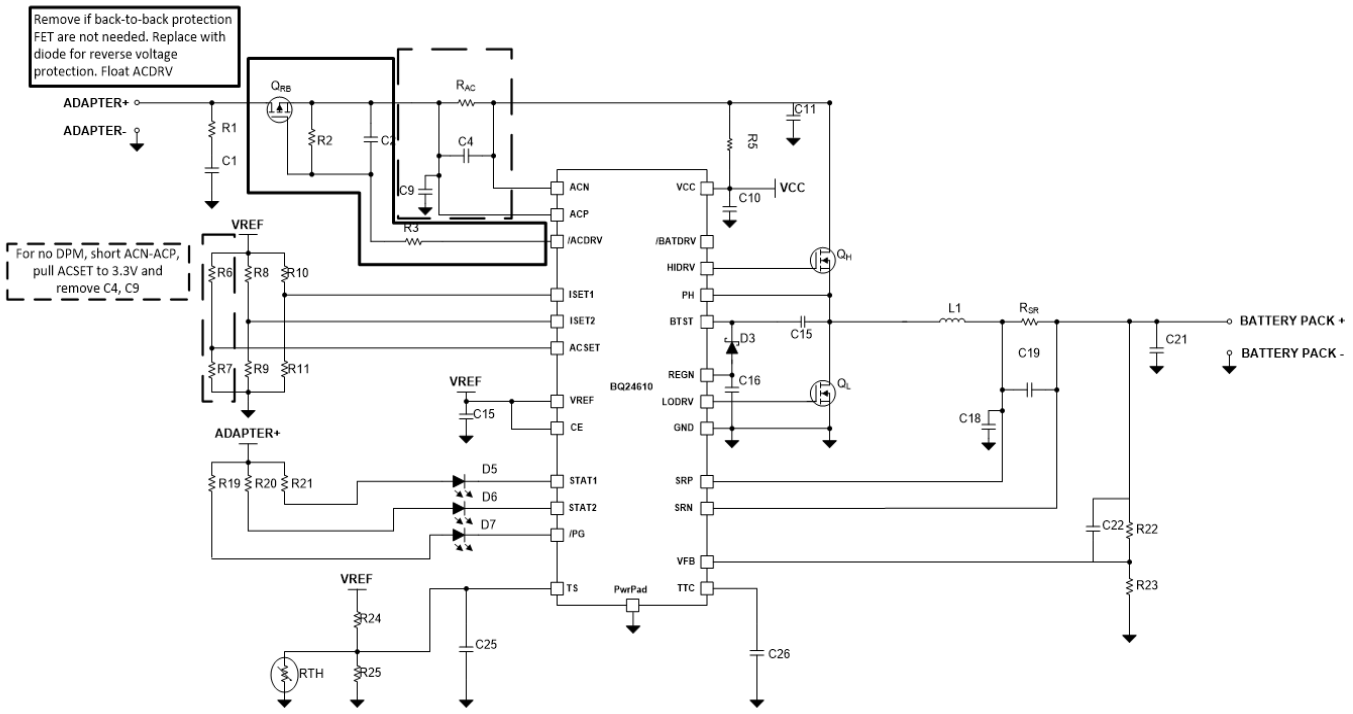
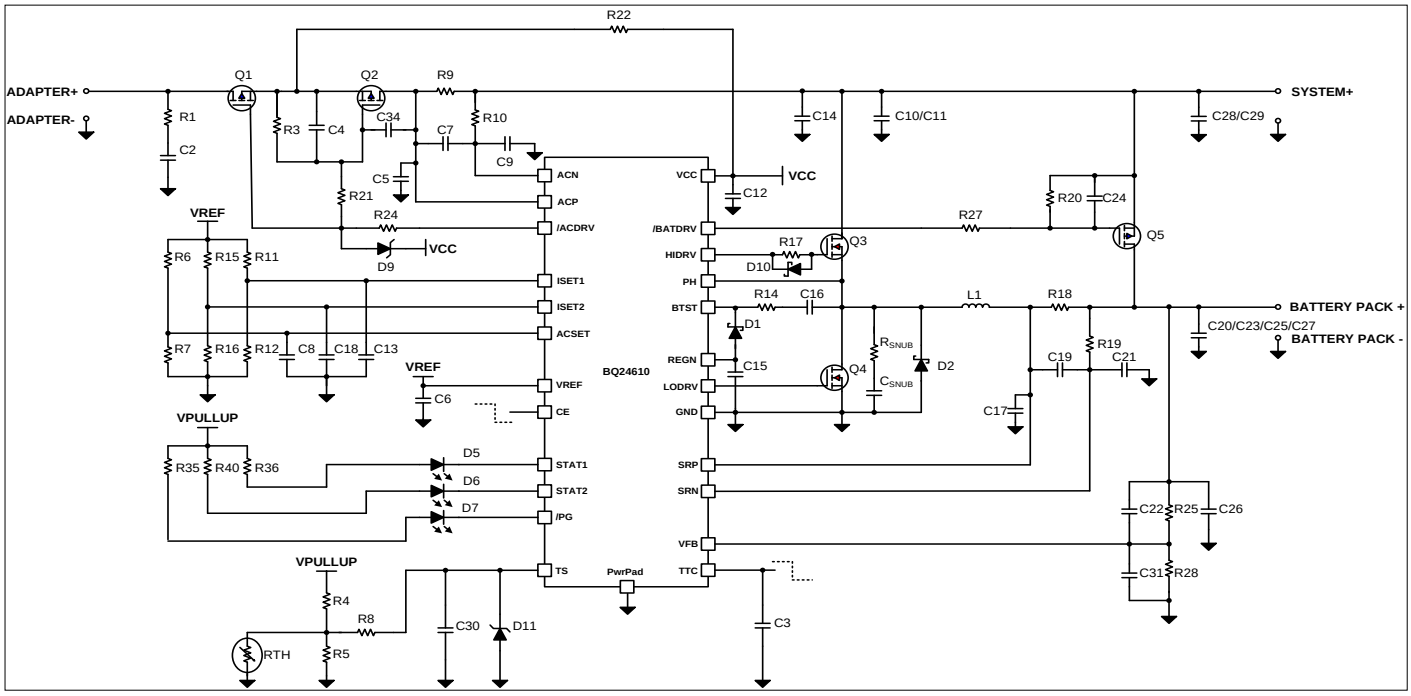
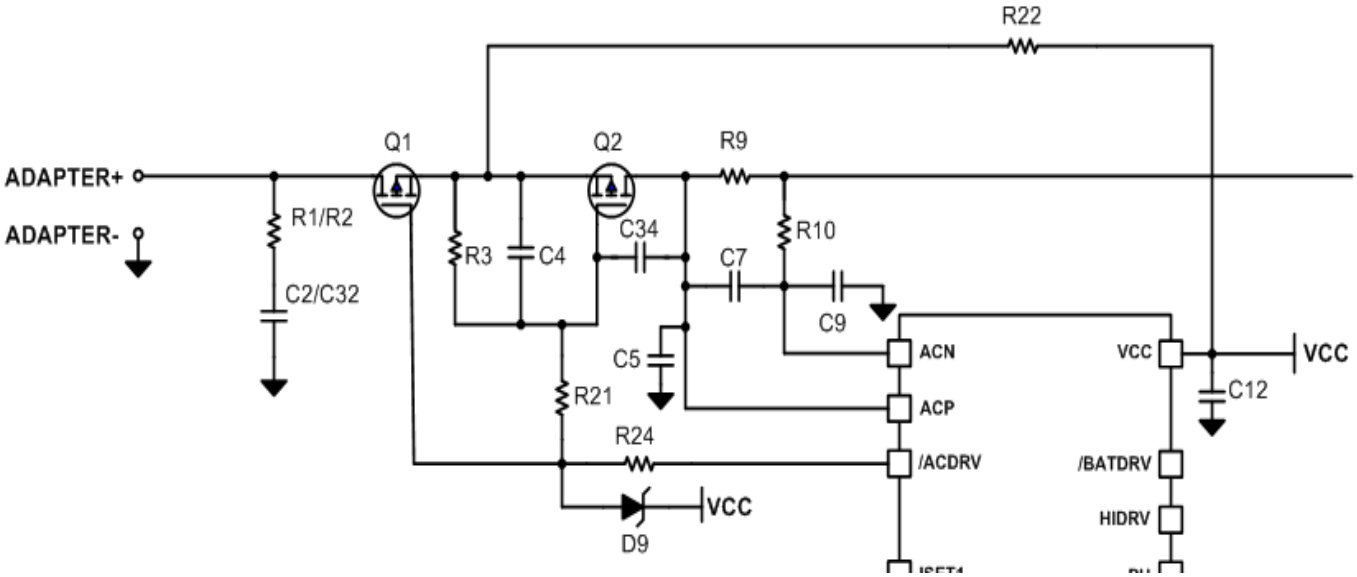
BQ24610 Simplified Non PowerPath



BQ24610 Schematic

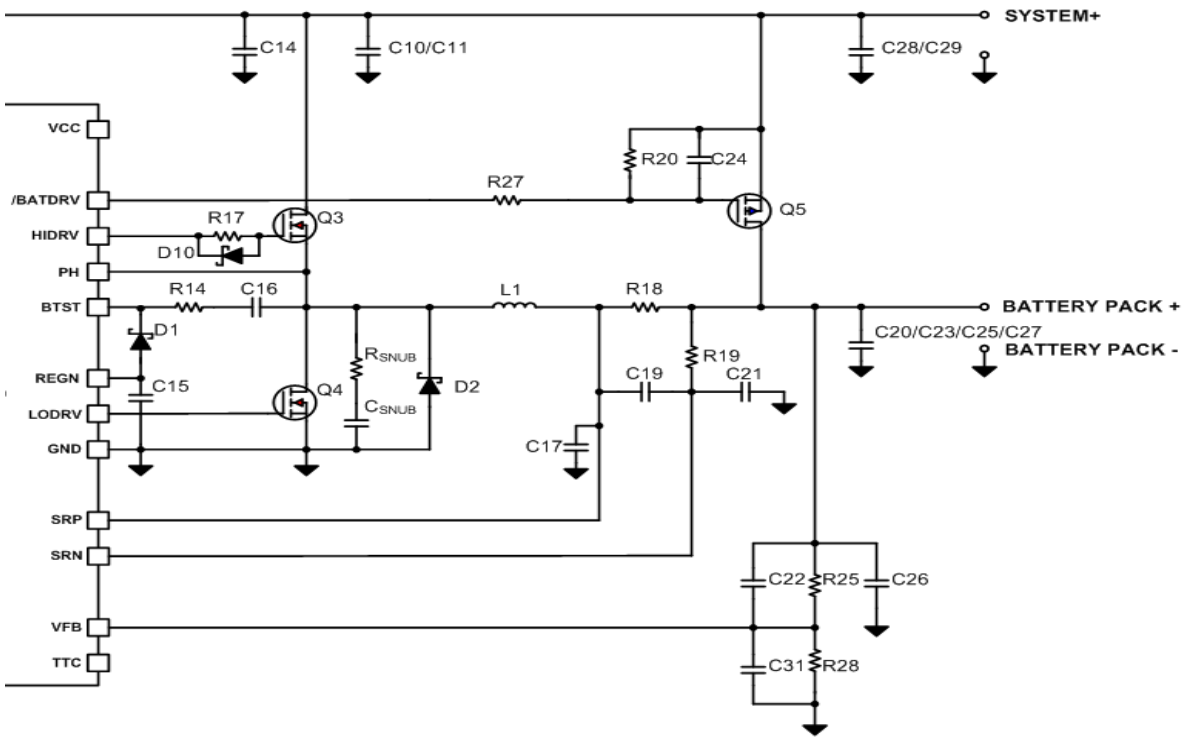


BQ24610 - Input Power Design



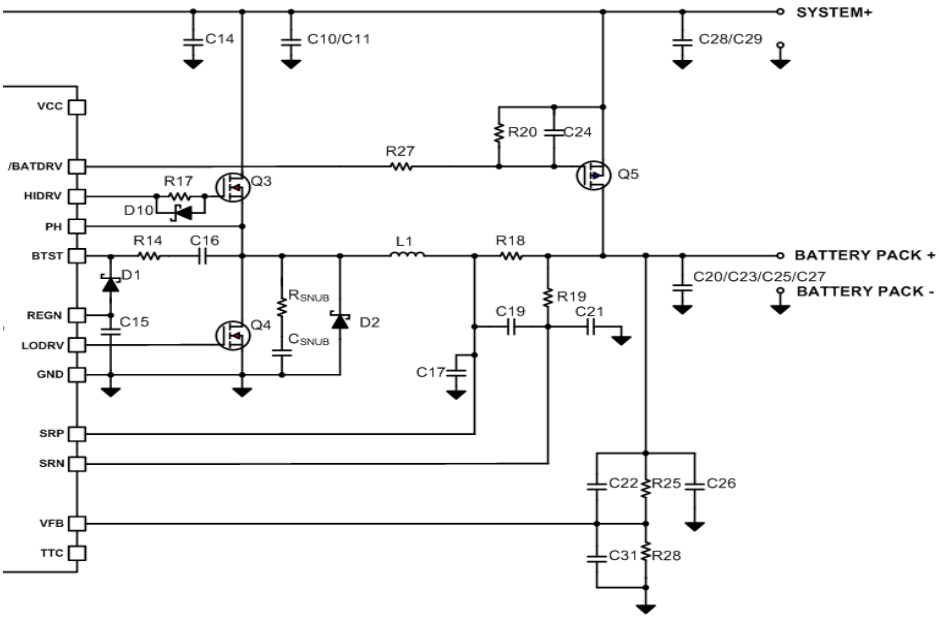
INPUT POWER - DESIGN CHECKLIST								
PIN NAME		**REQUIREMENT**	**COMPONENT**	**MIN**	**TYP**	**MAX**	**DESCRIPTION**	**COMMENTS AND RELEVANT EQUATIONS**
ADAPTER+ / ADAPTER-	-						**Input source to the charger**	
		Recommended	Q1		-		Back-to-back input protection P-Channel MOSFETs	Used to isolate the battery and adapter. This blocks reverse current from the battery back the input. If Q1 not included, use diode to block reverse current
			Q2		-			Used to isolate the battery and adapter. This also limits inrush current to the system by providing limited dI/dt when connecting the adapter to the system by controlling the FET turn-on time
		Recommended	R1/R2		2 Ω		Input hot-plug snubber circuit	Used to dampen ringing due to input inrush current
			C2/C32		2.2 uF			
		Recommended	R3		100 kΩ		Input MOSFETs turn-on/turn-off delay	
			C4		0.1 uF			
		Optional	R21					Additional turn-on delay for Q2 to further limit dI/dt and limit inrush current
			C34					
ACP-ACN	1-2						**Differential input current sensing**	
		Required	R9 (R_{AC})		10 mΩ		Input current sensing resistor	$I_{DPM} = \frac{V_{ACSET}}{20 \times R_{AC}}$
		Recommended	C7		0.1 uF		Differential mode noise filtering	Filter differential-mode voltage to avoid amplification of high frequency signals, for more accurate current sensing
		Recommended	C5		0.1 uF		Common mode noise filtering	Filter common-mode voltage to avoid amplificaiton of high frequency signals, for more accurate current sensing
		Optional	C9		0.1 uF			
		Optional	R10					
/ACDRV	3						**P-Channel MOSFET input protection gate driver**	
		Recommended	R24		1 kΩ		Input MOSFETs gate drive strength limiting resistor	Increase turn-on time to limit inrush current
		Optional	D9				Input MOSFETs gate-source Zener clamp	Clamp Vgs under MOSFET abs. max. Vgs to protect MOSFET
VCC	24						**IC power positive supply**	
		Required	R22		10 Ω		VCC inrush current limiting	
		Required	C12		1.0 uF		VCC decoupling capacitor	

BQ24610 - Output Power Design



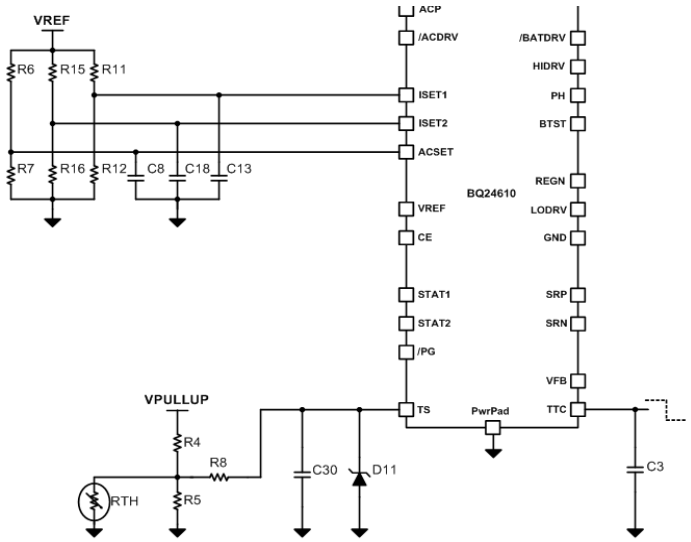
PIN NAME		REQUIREMENT	COMPONENT	MIN	TYP	MAX	DESCRIPTION	COMMENTS AND RELEVANT EQUATIONS
SYSTEM+	-						**System output either from input source or battery**	
		Required	C10/C11		10 uF		High frequency converter input capacitor(s)	
		Required	C28/C29		10 uF		System output noise filtering capacitor(s)	
		Recommended	C14		10 nF		High frequency noise decoupling capacitor	
/BATDRV	23						**P-Channel BATFET power path gate driver**	
		Recommended	Q5		-		External P-Channel BATFET for power path	If power path is not needed, remove Q5 and float BATDRV as shown in BQ24610 Simplified Non PowerPath
		Recommended	R27		1 kΩ		Input MOSFETs gate drive strength limiting resistor	Increase turn-on time to limit shoot-through current
		Recommended	R20		100 kΩ		External BATFET turn-on/turn-off delay	
			C24		0.1 uF			
BATTERY PACK+ / BATTERY PACK-	-						**Battery or battery pack connection to the charger**	
		Required	C20/C23/C25/C27		*uF		Converter ouput filtering capacitor(s)	$f_o = \frac{1}{2 \cdot \pi \cdot \sqrt{L_{out} \cdot C_{out}}}$ **Recommended: 12 kHz < fo < 17 kHz**
VFB	12						**Battery regulation voltage feedback**	
		Required	R25		*kΩ		Resistor divider feedback for battery voltage regulation setting	$V_{BATREG} = (1 + \frac{R_{25}}{R_{28}}) \times 2.1V$ $V_{RECHG} = (1 + \frac{R_{25}}{R_{28}}) \times 2.05V$ $V_{BATLOWV} = (1 + \frac{R_{25}}{R_{28}}) \times 1.55V$
			R28		*kΩ			
		Optional	C26		100 nF		High frequency noise decoupling capacitor	
		Optional	C22		22pF			
		Optional	C31		DNP			

OUTPUT POWER - DESIGN CHECKLIST



SRP-SRN	13-14						**Differential charge current sensing**	
		Required	R18 (R_{SR})		10 mΩ		Charge current sensing resistor	$I_{CHARGE} = \frac{V_{ISET\ 1}}{20 \times R_{SR}}$
		Recommended	C19		0.1 uF		Differential mode noise filtering	Filter differential-mode voltage to avoid amplification of high frequency signals, for more accurate current sensing
		Recommended	C17		0.1 uF		Common mode noise filtering	Filter common-mode voltage to avoid amplificaiton of high frequency signals, for more accurate current sensing
		Optional	C21		0.1 uF			
		Optional	R19		DNP			
REGN	18						**Internal LDO output**	
		Required	C15		1.0 uF		Internal LDO output stabilizing capacitor	
		Required	D1				Bootstrap capacitor refresh and blocking Schottky diode	Schottky diodes reduce the risk associated with charge supplied back to the gate driver supply from the bootstrap capacitor and minimize leakage current. Fast reverse recovery minimizes losses
LODRV	19						**Converter Low-Side N-Channel MOSFET gate driver**	
		Required	Q4		-		Converter synchronous Low-Side N-Channel MOSFET	
PH & BTST	20 & 22						**PH node**	
		Required	L1		*uH		Converter output filtering inductor	$f_o = \frac{1}{2 \cdot \pi \cdot \sqrt{L_{out} \cdot C_{out}}}$ **Recommended: 12 kHz < fo < 17 kHz**
		Required	C16		0.1 uF		Converter bootstrap capacitor for High-Side N-Channel MOSFET gate driver	
		Recommended	R14		10 Ω		Bootstrap capacitor discharge current limiting resistor	Limits peak current through bootstrap diode, and also reduces switch node ringing by slowing down turn-on of HSFET
		Recommended	R_{SNUB}		DNP		Switching converter snubber circuit	Reduce switch node ringing on HSFET turn-on. Recommended to include footprint for evaluation, in case parasitic components from layout result in higher than expected ringing cuasing switching loss and EMI noise.
			C_{SNUB}		DNP			
		Recommended	D2				Fast recovery and asynchronous rectifier Schottky diode	Reduce reverse recovery loss as compared to internal body diode of LSFET, which helps reduce switch node ringing, as well as increase efficiency due to lower forward voltage drop of schottky as compared to forward voltage drop of internal body diode
HIDRV	21						**Converter High-Side N-Channel MOSFET gate driver**	
		Required	Q3		-		Converter active High-Side N-Channel MOSFET	
		Recommended	R17				Converter active High-Side MOSFET gate drive strength limiting resistor	Increase turn-on time of HSFET to reduce ringing at PH node. Also increases turn-off time and reduces efficiency
		Optional	D10				Diode for fast High-Side MOSFET turn-off	Adding gate resistor limits turn-on and turn-off of HSFET resulting in lower efficiency. Diode allows fatser turn-off and slower turn-on, reducing ringing on HSFET turn-on, and also reducing effects on efficiency by turning off faster.
GND	17						**IC Ground return**	

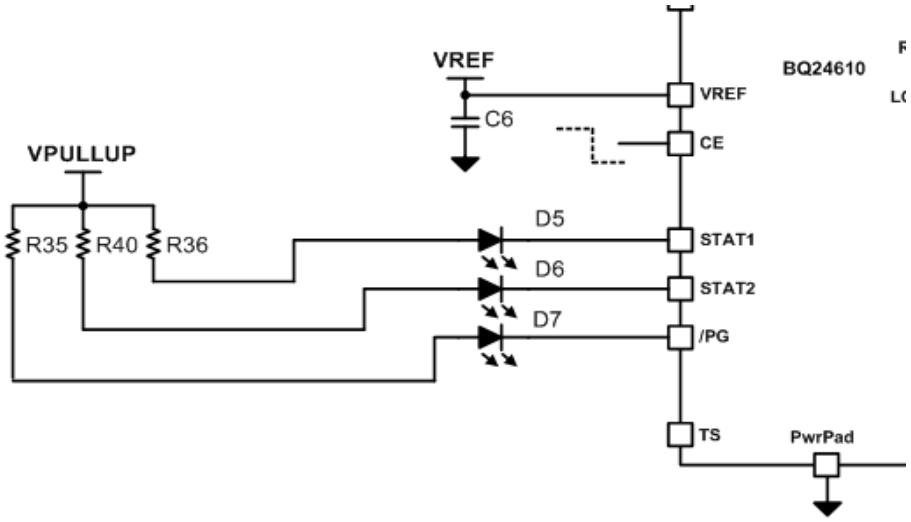
BQ24610 - Hardware Programmed Input Design



HARDWARE PROGRAMMED INPUT - DESIGN CHECKLIST

PIN		REQUIREMENT	COMPONENT	MIN	TYP	MAX	DESCRIPTION	COMMENTS AND RELEVANT EQUATIONS
TS	6						**Battery thermistor temperature qualification window setting resistor network**	
		Required	R4		*Ω		Resistor network to set window for thermistor temperature-based battery charging profile	
		Required	R5		*Ω			
		Recommended	RTH		*Ω		External battey thermistor	
		Recommended	R8		100 Ω		Current limiting resistor for TS pin transient	
		Recommended	C30		0.1 uF		High freqnecy noise decoupling and/or thermistor detach delay capacitor	
		Recommended	D11				Zener clamp protection for TS pin	
TTC	7						**Safety timer and termination setting and disable**	
		Recommended	C3 (C_{TTC})		*nF		Safety timer setting capacitor	Cannot be floating HIGH disables safety timer LOW disables termination and safety timer Capacitor sets safety timer duration See Electrical Characterisitics table for minimum and maximum fast charge safety timer settings $t_{CHARGE} = C_{TTC} \times K_{TTC}$
ISET1	11						**Fast charge current reference setting**	
		Required	R11		*Ω		Resistor divider network for fast charge current setting	$I_{CHARGE} = \frac{V_{ISET\_1}}{20 \times R_{SR}}$
			R12		*Ω			
		Recommended	C13		0.1 uF		High frequency noise decoupling capacitor	
ISET2	15						**Pre-charge and termination current reference setting**	
		Required	R15		*Ω		Resistor divider network for pre-charge and termination current setting	$I_{TERM} = \frac{V_{ISET\_2}}{100 \times R_{SR}}$ $I_{PRECHARGE} = \frac{V_{ISET\_2}}{100 \times R_{SR}}$
			R16		*Ω			
		Recommended	C18		0.1 uF		High frequency noise decoupling capacitor	
ACSET	16						**Input current limit reference setting**	
		Required	R6		*Ω		Resistor divider network for input current limit setting	$I_{DPM} = \frac{V_{ACSET}}{20 \times R_{AC}}$
			R7		*Ω			
		Recommended	C8		0.1 uF		High frequency noise decoupling capacitor	

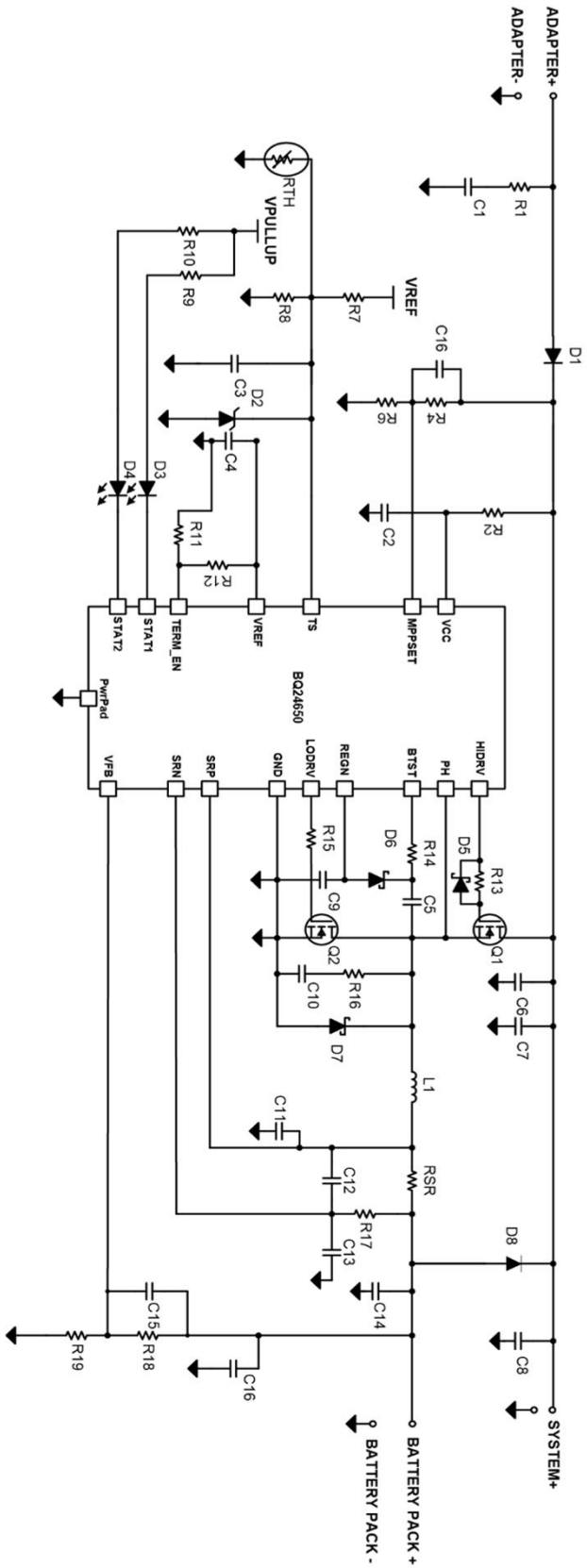
BQ24610 - Hardware Programmed Input Design



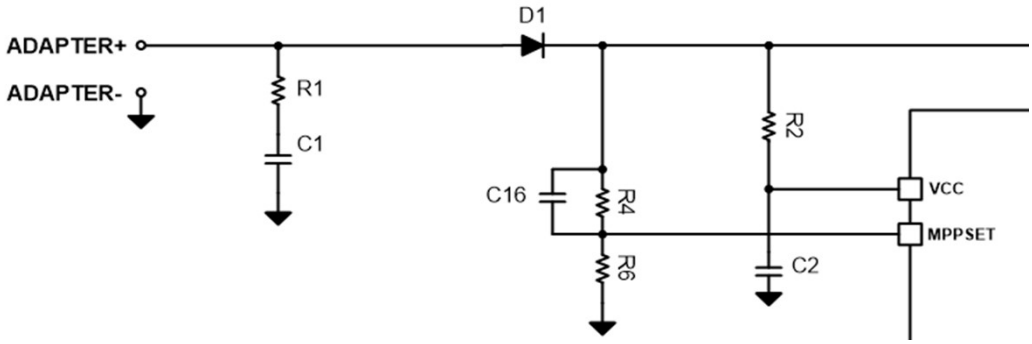
COMMUNICATION AND MISC INPUT/OUTPUT SIGNAL - DESIGN CHECKLIST

PIN NAME		REQUIREMENT	COMPONENT	MIN	TYP	MAX	DESCRIPTION	COMMENTS AND RELEVANT EQUATIONS
CE	4						**Active HIGH input signal pin to enable charge**	Cannot be floating HIGH enables charging LOW disables charging
STAT1	5						**Open-drain output signal for charging status**	Refer to Datasheet Table 2 for description
		Recommended	R36		10 kΩ		Charging status indicating LED	
		Optional	D5				Charging status indicating LED	
STAT2	9						**Open-drain output signal for charging status**	Refer to Datasheet Table 2 for description
		Recommended	R40		10 kΩ		Charging status indicating LED	
		Optional	D6				Charging status indicating LED	
/PG	8						**Open-drain output signal for input power status**	
		Recommended	R35		10 kΩ		Input status indicating LED	
		Optional	D7				Input status indicating LED	
VREF	10						**Internal 3.3V LDO**	
		Required	C6				Internal 3.3V LDO output stabilizing capacitor	
PwrPad	-						**IC Thermal dissipation pad**	

BQ24650 Schematic



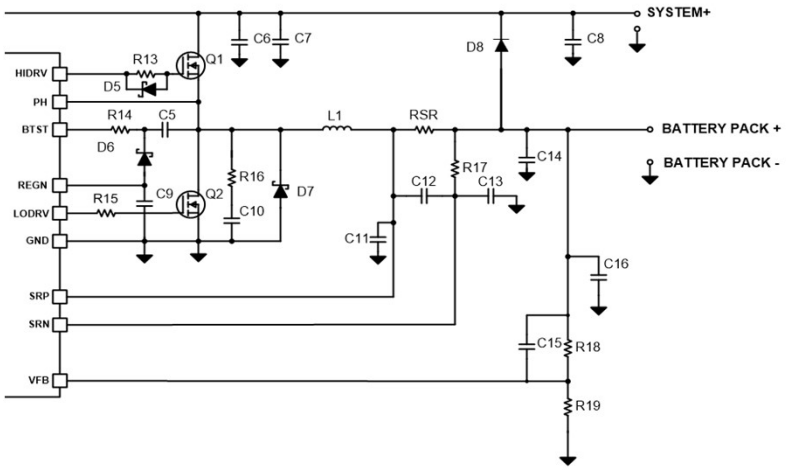
BQ24650 - Input Power Design



INPUT POWER - DESIGN CHECKLIST

PIN NAME		REQUIREMENT	COMPONENT	MIN	TYP	MAX	DESCRIPTION	COMMENTS AND RELEVANT EQUATIONS
ADAPTER+ / ADAPTER-	-						**Input source to the charger**	
		Required	D1		-		Reverse-blocking diode	Blocks reverse current from the battery back to the input, and provides reverse voltage protection for the VCC pin
		Recommended	R1		2 Ω		Input hot-plug snubber circuit	Used to dampen ringing due to input inrush current
			C1		2.2 uF			
VCC	1						**IC power positive supply**	
		Required	R2		10 Ω		VCC inrush current limiting	
		Required	C2		1.0 uF		VCC decoupling capacitor	
MPPSET	2						**Input Regulation (DPM)**	
		Required	R4		* Ω		Input Voltage Regulation setpoint	$Vmpp = \left(1 + \frac{R4}{R6}\right) \times 1.2$
		Required	R6		* Ω			
		Optional	C2		22 pF			

BQ24650 - Output Power Design



OUTPUT POWER - DESIGN CHECKLIST

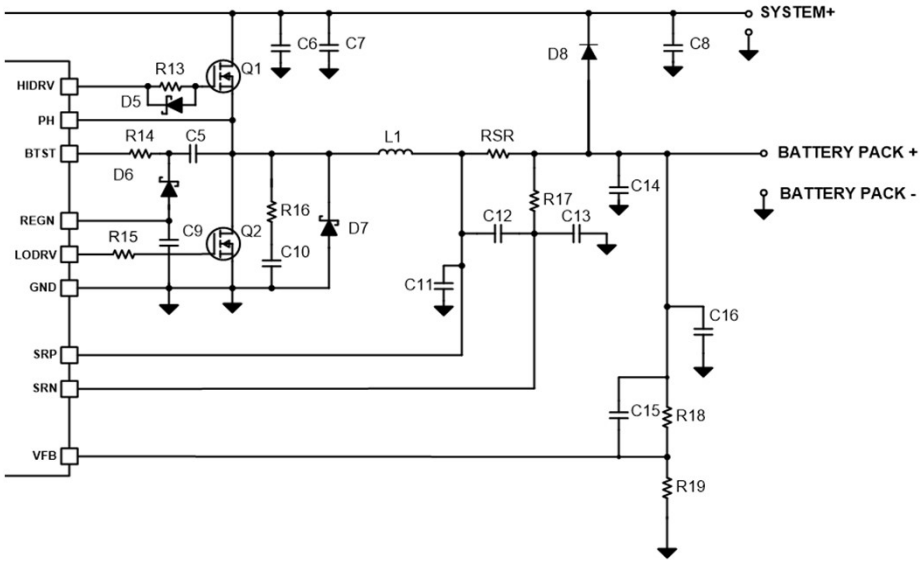
PIN NAME		REQUIREMENT	COMPONENT	MIN	TYP	MAX	DESCRIPTION	COMMENTS AND RELEVANT EQUATIONS
SYSTEM+	-						**System output either from input source or battery**	
		Required	C6/C7		10 uF		High frequency converter input capacitor(s)	
		Required	C8		10 uF		System output noise filtering capacitor(s)	
		Required	D8				Power-path Diode	Remove if powerpath is not required. Provides battery voltage to system when adapter is absent
BATTERY PACK+ / BATTERY PACK-	-						**Battery or battery pack connection to the charger**	
		Required	C14		*uF		Converter ouput filtering capacitor(s)	

Charge Current	1A	2A	4A	8A
Output Inductor Lo	15µH	10µH	6.8µH	3.3µH
Output Capacitor Co	10µF	15µF	20µF	40µF
Sense Resistor	40mΩ	20mΩ	10mΩ	5mΩ

Recommended: 12 kHz < fo < 17 kHz

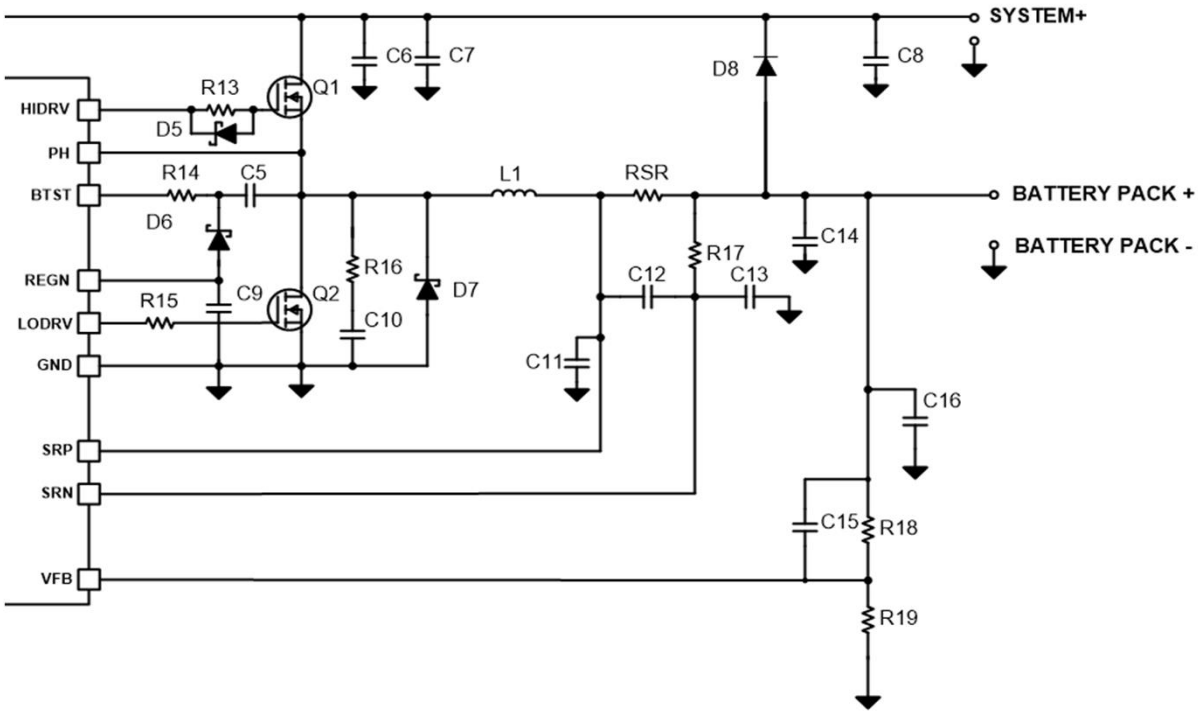
$$f_o = \frac{1}{2 \cdot \pi \cdot \sqrt{L_{out} \cdot C_{out}}}$$

OUTPUT POWER - DESIGN CHECKLIST



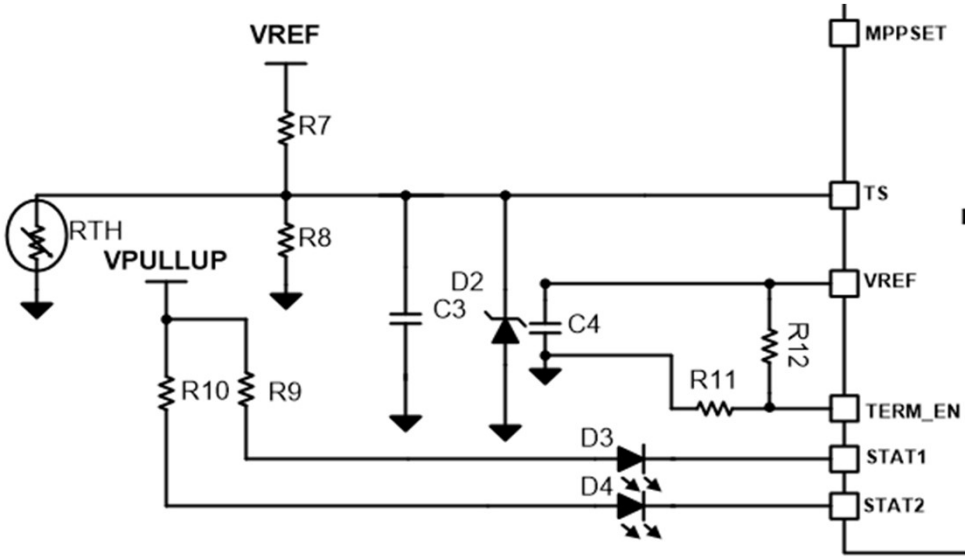
VFB	8						**Battery regulation voltage feedback**	
		Required	R18		*kΩ		Resistor divider feedback for battery voltage regulation setting	$Vbatreg = \left(1+\frac{R18}{R19}\right)\times 2.1$ $Vrechg = \left(1+\frac{R18}{R19}\right)\times 2.05$ $Vbatlowv = (1+\frac{R18}{R19})\times 1.55$
			R19		*kΩ			
		Optional	C16		100 nF		High frequency noise decoupling capacitor	
		Optional	C15		22pF			
SRP-SRN	9 10						**Differential charge current sensing**	
		Required	R_{SR}		* mΩ		Charge current sensing resistor	$I_{CHARGE} = \frac{40\ mV}{R_{SR}}$ $Iprechg = Iterm = {}^{Ichg}/_{10}$
		Recommended	C12		0.1 uF		Differential mode noise filtering	Filter differential-mode voltage to avoid amplification of high frequency signals, for more accurate current sensing
		Recommended	C11		0.1 uF		Common mode noise filtering	Filter common-mode voltage to avoid amplificaiton of high frequency signals, for more accurate current sensing
		Optional	C13		0.1 uF			
		Optional	R17		DNP			
REGN	12						**Internal LDO output**	
		Required	C9		1.0 uF		Internal LDO output stabilizing capacitor	
		Required	D6				Bootstrap capacitor refresh and blocking Schottky diode	Schottky diodes reduce the risk associated with charge supplied back to the gate driver supply from the bootstrap capacitor and minimize leakage current. Fast reverse recovery minimizes losses
LODRV	13						**Converter Low-Side N-Channel MOSFET gate driver**	
		Required	Q2		-		Converter synchronous Low-Side N-Channel MOSFET	
PH & BTST	14 & 16	Required	L1		*uH		Converter output filtering inductor	Charge Current: 1A / 2A / 4A / 8A; Output Inductor Lo: 15µH / 10µH / 6.8µH / 3.3µH; Output Capacitor Co: 10µF / 15µF / 20µF / 40µF; Sense Resistor: 40mΩ / 20mΩ / 10mΩ / 5mΩ. **Recommended: 12 kHz < fo < 17 kHz** $f_o = \frac{1}{2\cdot\pi\cdot\sqrt{L_{out}\cdot C_{out}}}$
		Required	C5		0.1 uF		Converter bootstrap capacitor for High-Side N-Channel MOSFET gate driver	
		Recommended	R14		10 Ω		Bootstrap capacitor discharge current limiting resistor	Limits peak current through bootstrap diode, and also reduces switch node ringing by slowing down turn-on of HSFET
		Recommended	R16		DNP		Switching converter snubber circuit	Reduce switch node ringing on HSFET turn-on. Recommended to include footprint for evaluation, in case
			C10		DNP			
		Recommended	D7				Fast recovery and asynchronous rectifier Schottky diode	Reduce reverse recovery loss as compared to internal body diode of LSFET, which helps reduce switch node ringing, as well as increase efficiency due to lower forward voltage drop of schottky as compared to forward voltage drop of internal body diode

OUTPUT POWER - DESIGN CHECKLIST



HIDRV	15						**Converter High-Side N-Channel MOSFET gate driver**	
		Required	Q1		-		Converter active High-Side N-Channel MOSFET	
		Recommended	R13				Converter active High-Side MOSFET gate drive strength limiting resistor	Increase turn-on time of HSFET to reduce ringing at PH node. Also increases turn-off time and reduces efficiency
		Optional	D5				Diode for fast High-Side MOSFET turn-off	Adding gate resistor limits turn-on and turn-off of HSFET resulting in lower efficiency. Diode allows fatser turn-off and slower turn-on, reducing ringing on HSFET turn-on, and also reducing effects on efficiency by turning off faster.
GND	11						**IC Ground return**	

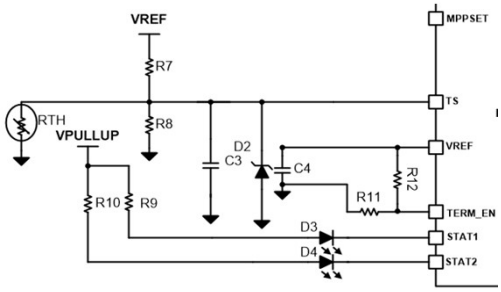
BQ24650 - Hardware Programmed Input Design



HARDWARE PROGRAMMED INPUT - DESIGN CHECKLIST

PIN		REQUIREMENT	COMPONENT	MIN	TYP	MAX	DESCRIPTION	COMMENTS AND RELEVANT EQUATIONS
TS	4						**Battery thermistor temperature qualification window setting resistor network**	
		Required	R7		*Ω		Resistor network to set window for thermistor temperature-based battery charging profile	
		Required	R8		*Ω			
		Recommended	RTH		*Ω		External battey thermistor	
		Recommended	C3		0.1 uF		High freqnecy noise decoupling and/or thermistor detach delay capacitor	
		Recommended	D2				Zener clamp protection for TS pin	

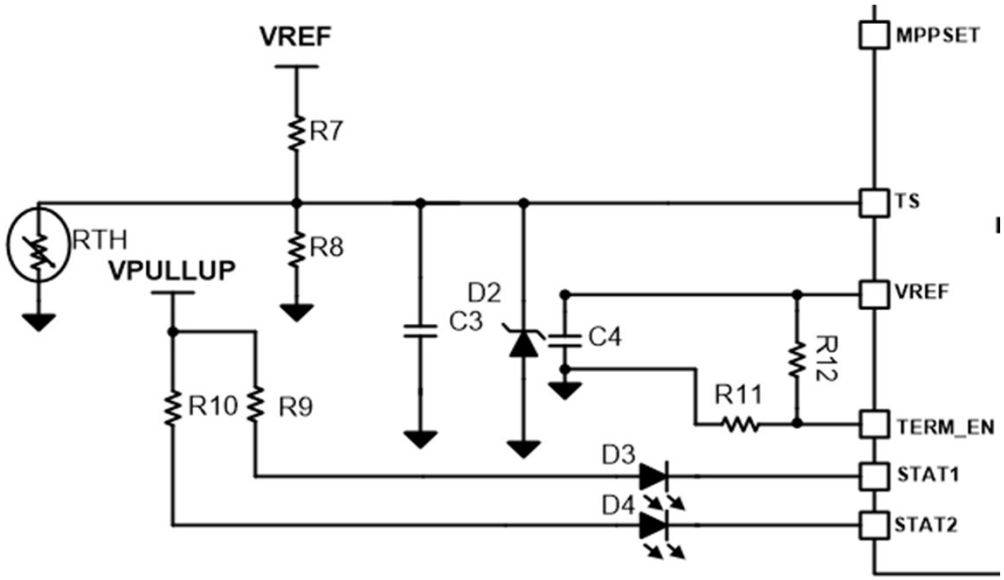
BQ24650 - Hardware Programmed Input Design



COMMUNICATION AND MISC INPUT/OUTPUT SIGNAL - DESIGN CHECKLIST

PIN NAME		REQUIREMENT	COMPONENT	MIN	TYP	MAX	DESCRIPTION	COMMENTS AND RELEVANT EQUATIONS
STAT1	3						**Open-drain output signal for charging status**	Refer to Datasheet Table 2 for description
		Recommended	R9		10 kΩ		Charging status indicating LED	
		Optional	D3				Charging status indicating LED	
STAT2	5						**Open-drain output signal for charging status**	Refer to Datasheet Table 2 for description
		Recommended	R10		10 kΩ		Charging status indicating LED	
		Optional	D4				Charging status indicating LED	

BQ24650 - Hardware Programmed Input Design



TERM_EN	7						**Charge termination enable**	
		Recommended	R11				Pull TERM_EN to GND	Disable Charge Termination. Must be terminated and cannot be left floating
		Optional	R12				Pull TERM_EN to VREF	Enable Charge Termination. Must be terminated and cannot be left floating
VREF	6						**Internal 3.3V LDO**	
		Required	C4				Internal 3.3V LDO output stabilizing capacitor	
PwrPad	-						**IC Thermal dissipation pad**	