Application Note ANP-50

XR76117 / XR76121 and IR3894 / IR3895 Board Stuffing

Introduction

The MaxLinear XR76117 / 21 Series is very similar to the Infineon IR3894 / 95 Series in form, fit and function. Besides similar output current and input and output voltages, both series offer programmable switching frequency, soft-start, current limiting, enable input with voltage monitor, OCP, OTP, OVP, SCP, UVLO, integrated bootstrap diode / FET, and programmable power good. This document will provide a detailed description of the product similarities and differences, discuss how both Series can occupy the same socket on a PCB, and highlight the advantages of the MaxLinear regulators.

Major Specifications

The XR76117 and XR76121 are identical to each other except for their output current rating. Similarly, the IR3894 / 95 are identical to each other except for the differences shown in this section. Major specifications of each series are summarized in Table 1.

Spec	MaxLinear XR76117 / XR76121	Infineon IR3894 / IR3895
Max I_{OUT}	15A (XR76117); 20A (XR76121)	12A (IR3894); 16A (IR3895)
V_{IN} range	4.5V to 22V	5V to 21V
V_{OUT} range	0.6V to 18V	0.5V to 0.86 x V_{IN}
Frequency range	200kHz to 1MHz	Up to 1.5MHz
Temperature range	-40°C to 125°C	-40°C to 125°C
Supply current	17 mA	14 / 20mA (dynamic)

Table 1: Major Specification Comparison

The XR76117 / XR76121 can be soldered into a IR3894 / 95 socket, only minor board stuff options are required. The following discusses how both series can occupy the same socket on a PCB.

Pin-Out Comparison

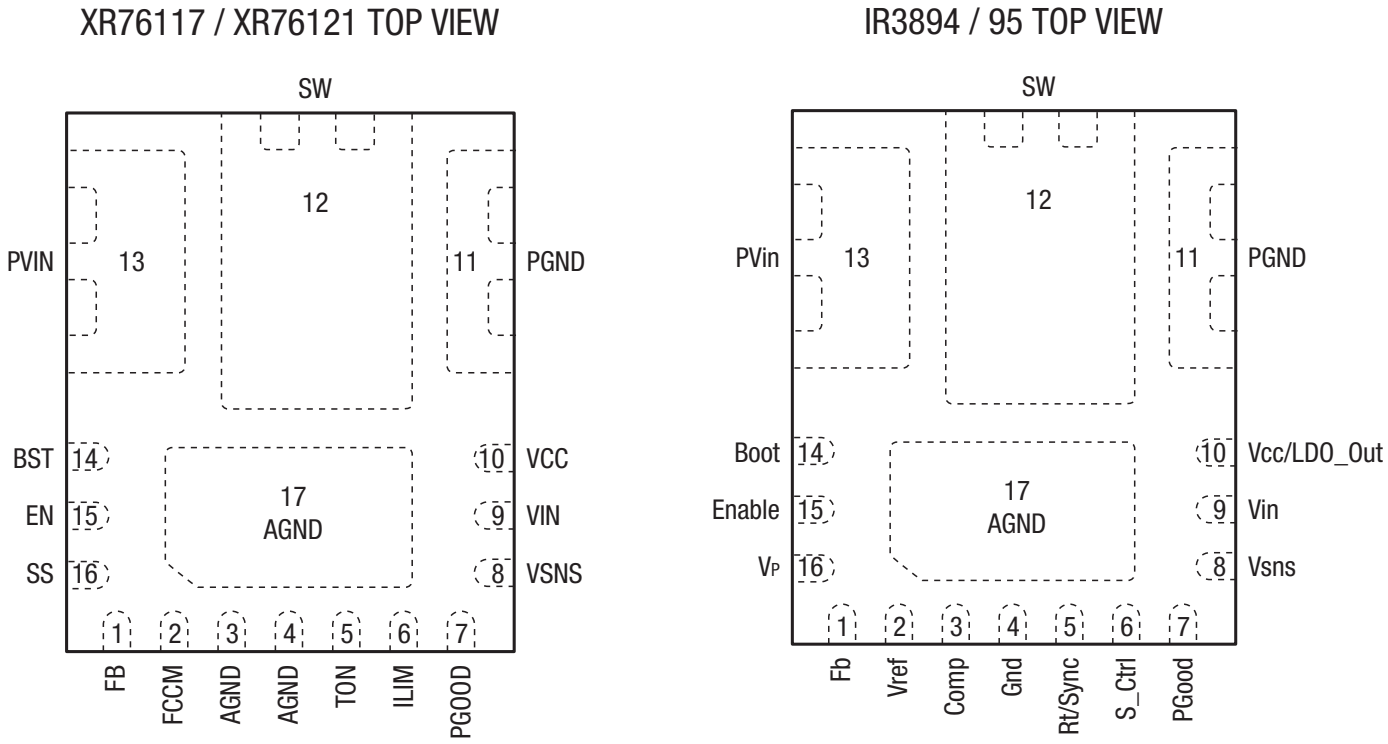


Figure 1: Pin-Out Comparison

Pin	XR76117 / XR76121	IR3894 / IR3895	Same function / same connection?	Comments
1	FB	Fb	Yes/Yes	Both provide feedback voltage and connect to the regulator output via a resistor divider.
2	FCCM	Vref	No/Mode(1)	For XR76117 / XR76121, pulling FCCM below 0.4V enables DCM and significantly increases light-load efficiency. Use a pull-up or pull-down. For IR3894 / IR3895, Vref requires a 100pF capacitor to GND in normal mode and sequencing operation. Connect directly to ground in tracking mode. See Table 3 below.
3	AGND	Comp	No/No	Stuff a 0Ω resistor to jumper pin3 to pin4 and do not stuff compensation for XR76117 / XR76121.
4	AGND	Gnd	Yes/Yes	Small signal component GND. Must be isolated and connected to PGND via a 0Ω resistor.
5	TON	Rt / Sync	No/Mode(1)	Both require a resistor to GND to set free running frequency. A different value must be used for each solution. For XR76117 / XR76121, a resistor to GND selects switching frequency. For IR3894 / IR3895, a resistor to GND selects free running switching frequency. If external synchronization, remove the resistor to GND and apply the external Sync signal through diode.
6	ILIM	ILIM	Yes/No	ILIM sets the current limit for both. For XR76117 / XR76121, stuff a resistor from ILIM to the SW node to set the OCP limit. The lower the resistor value, the lower the OCP trip point. For IR3894 / IR3895, stuff a resistor to VCC or GND to set the OCP limit. S_Ctrl is for Soft start / stop.
7	PGOOD	PGood	Yes/Yes	Both are Power Good status, open drain.
8	VSNS	Vsns	Yes/Yes	OVP sense pin, both connect to voltage divider from Vout to GND.
9	VIN	Vin	Yes/Yes	Both are controller input voltage and require a capacitor to ground.

Pin-Out Comparison, Continued

Pin	XR76117 / XR76121	IR3894 / IR3895	Same function / same connection?	Comments
10	VCC	Vcc/ LDO_Out	Yes/Yes	Both are the LDO output and require a capacitor to GND.
11	PGND	PGnd	Yes/Yes	Power Stage GND.
12	SW	SW	Yes/Yes	Both are switch node where MOSFETs connect and go to output inductor.
13	PVIN	PVin	Yes/Yes	Both are input voltage for the power stage.
14	BST	Boot	Yes/Yes	Both are the high-side driver supply pin and require a capacitor to ground.
15	EN	Enable	Yes/Yes	Both enable the device and can be connected to PVin via a voltage divider for UVLO.
16	SS	V_P	No/No	For XR76117 / XR76121, connect to a capacitor to GND to program soft start. This feature is useful when sequencing other controllers. For IR3894 / IR3895, leave floating for normal operation. In tracking or sequencing mode, connect the external signal to this pin.
17	AGND PAD	GND	Yes/Yes	Small signal reference GND. Connect to pin 3 and pin 4 with a short trace.

NOTE:

1. Depends on mode used.

Table 2: Side-by-Side Pin-out Descriptions

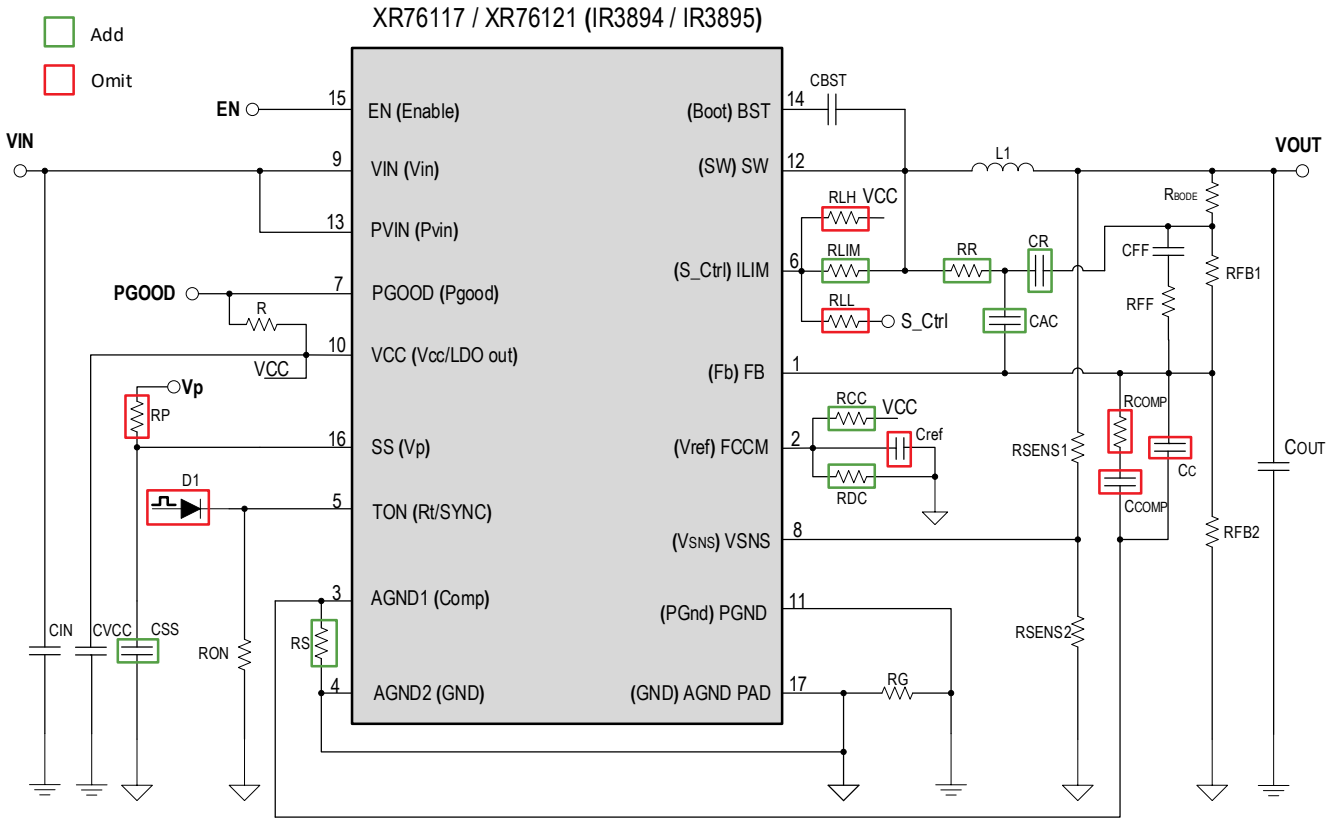
FCCM used?	Normal or Tracking Mode?	Comments
No	Tracking	Connect this pin to ground.
No	Normal	A pull-down for XR76117 / XR76121 can replace the capacitor to ground for IR3894 / IR3895.
Yes	Tracking	Use a jumper to Vcc for XR76117 / XR76121 or to ground for IR3894 / IR3895.
Yes	Normal	A pull-up can be populated for XR76117 / XR76121 instead of a capacitor to ground for IR3894 / IR3895.

Table 3: Pin 2 Implementation

Board Stuff Option Schematic

The PCB board can be easily designed to drop-in the XR76117 or XR761121 while maintaining compatibility to the IR3894 / IR3895. In Figure 2 below, pinning for both series are represented. The Maxlinear XR76117 and XR76121 pin names do not have parenthesis, and the same corresponding pins for the IR3894 / IR3895 are in parenthesis. As shown in the legend, the components in green boxes are added, and the ones in red boxes are omited when using the XR76117 / XR76121. External components on pin 2, 5, 6, and 16 may be simplified depending on mode of operation.

Applications Schematic



NOTES:

1. For more information, see the XR76117 or XR76121 datasheet.

Figure 2: External Components

Component Number	Reference Designator	Stuffing Option for IR3894 / IR3895	Stuffing Option for XR76117 / XR76121	Comment
1	L1	L1	L1	Inductor L is selected based on frequency, efficiency, output power and maximum ripple current.
2	COUT	COUT	COUT	Output capacitors. These capacitors must have low ESR to meet the ripple and transient requirements.
3	CIN	CIN	CIN	Provides ripple current during ON time of the control FET. The use of ceramic capacitors is recommended due to their peak current capabilities and low ESR / ESL at high frequencies.
4	RFB1	RFB1	RFB1	External voltage divider used to set VREF and program V_{OUT}. **V_{OUT} = VREF(1 + R1/R2)**
5	RFB2	RFB2	RFB2	
6	RSENS1	RSENS1	RSENS1	Resistor divider network used to monitor V_{OUT} and set PGOOD and OVP flags.
7	RSENS2	RSENS2	RSENS2	
8	CFF	CFF	CFF	Feed Forward compensation components. Please see the External Compensation section to determine which option to stuff.
9	RFF	RFF	RFF	
10	RR	-	RR	Ripple Injection components. Please see the External Compensation section to determine which option to stuff.
11	CR	-	CR	
12	CAC	-	CAC	
13	CBST	CBST	CBST	
14	RCOMP	RCOMP	-	Feedback compensation. Not stuffed if IR to XR migration.
15	CCOMP	CCOMP	-	
16	CC	CC	-	
17	RLH	RLH	-	Sets OCP tripping point for IR parts. Not stuffed in XR solution which uses RLIM between ILIM and SW to set OCP.
18	RLL	RLL	-	
19	RLIM	-	RLIM	Sets OCP tripping point. Tunable parameter.
20	RCC	-	RCC	CCM / DCM stuffing option. RCC selects CCM mode.
21	RDC	-	RDC	
22	CREF	CREF		Not stuffed in XR solution which does not support external Vref / Vp input.
23	R	R	R	Connects open drain PGOOD signal to VCC.
24	CVCC	CVCC	CVCC	LDO bypass capacitor. If IR to XR migration, a 4.7µF from this pin to PGND is required.
25	CSS	-	CSS	Soft start capacitor. Tunable parameter. Very useful if sequencing various regulators.
26	RP	RP		XR76117 and XR76121 do not support external Vref / Vp input.
27	RON	RON	RON	Tunable parameter used to set duty cycle and frequency.
28	RBODE	RBODE	RBODE	AC signal insertion for loop gain test. RBODE = 10Ω.
29	D1	D1		Not stuffed in XR solution which does not support external f_{SW} synchronization.
30	RS	-	RS	RS connects pin 3 (NC) to GND for IR to XR migration. RS = 0Ω.
31	RG	RG	RG	Single point connection for system GND and power stage GND. RG = 0Ω.

Table 4: Stuffing Options

External Compensation

To achieve fast transient response and accurate output regulation, external compensation is recommended. The goal of this compensation circuit is to provide loop stability with the highest bandwidth, and phase margin greater than 45 degrees. The XR76117 and XR76121 devices offer 2 external compensation options which can used to meet target board requirements. These 2 options are Feed Forward and Ripple Injection.

Feed Forward adds a capacitor across RFB1. The technique introduces a zero-pole pair at F = 1/(2 * π * CFF * RFB1) and F = 1/(2 * π * CFF * RFB1 || RFB2), that adds both phase lead and lag. Of the zero-pole pair, it is the zero that adds the most benefit to the phase margin results. The pole, which has the opposite effect, will cancel this benefit if placed too close to it. Therefore for best results, these 2 frequencies need to be far apart, which can only happen when RFB1 > RFB2. The greater RFB1 is in relation to RFB2, the farther apart these 2 frequencies are and the higher the output voltage seen at the output of the regulator is. The higher the output voltage, the higher the effectiveness of feed forward compensation in the loop. In the case of the XR76117 / XR76121 devices, bench results show that the minimum RFB1 to RFB2 ratio for feed forward to be effective is greater than 2.345. This means minimum output voltage where feed forward is still effective is V_{OUT} > 0.6*(1 + 2.345) = 2V.

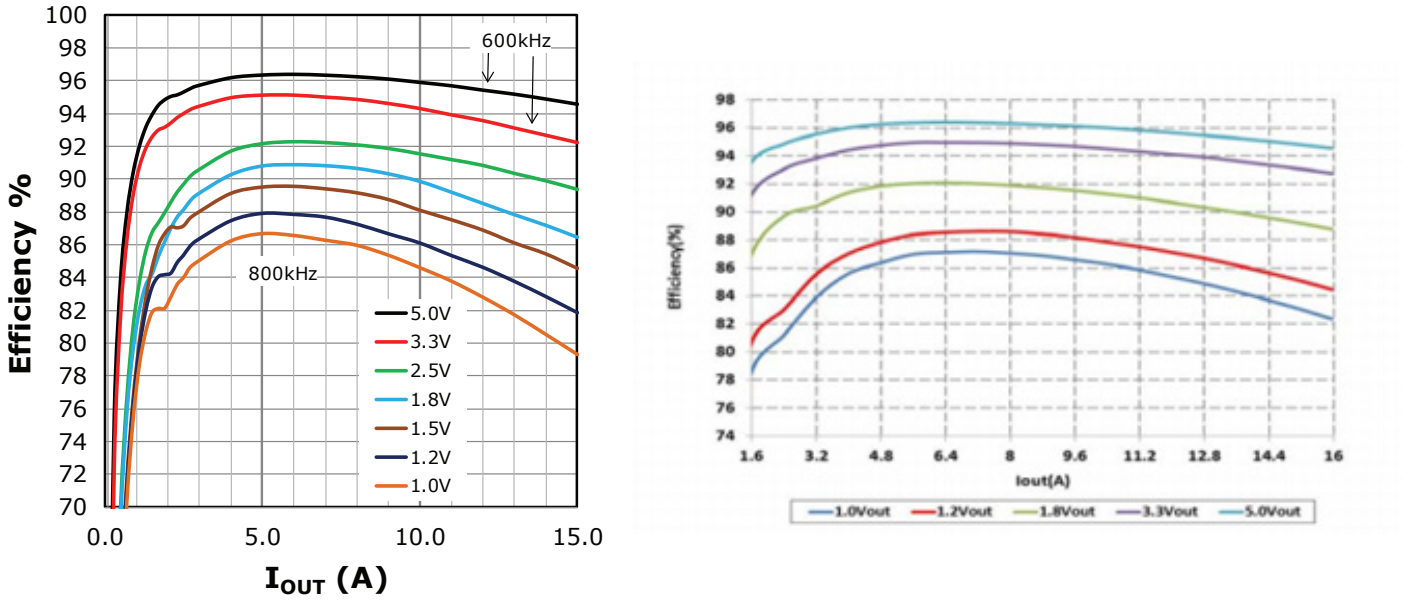
For V_{OUT} > 2.0V --> The Feed Forward Option is recommended and both CFF and RFF are stuffed. This option can be used if C_{OUT} * ESR > t_{ON}/2.

For V_{OUT} ≤ 2.0V --> The Ripple Injection is recommended and RR, CR and CAC components are stuffed.

Performance

The MaxLinear XR76117 and XR76121 share the same features as the IR3894/ IR3895 and offer the following advantages:

1. Requires no loop compensation for most cases, simplifying circuit implementation and reducing component count. 3 components can be eliminated, depending on use.
2. Offers the option to force CCM mode for constant frequency applications.
3. Features more programmability of current limit value selection.
4. Provides adjustable soft-start duration which is better for controlling the sequencing of multiple regulators.
5. Power Good is low impedance when IC is unpowered. This prevents false good signals from occurring if a redundant supply goes down.
6. Transient performance is superior with the XR76117/ XR76121's proprietary COT control.
7. XR76117 and XR76121 have 0.1% load and line regulation.
8. Below is an efficiency comparison of the 15A XR76117 and 16A IR3895 devices:



Note: This document is meant for guidance purposes only. Refer to the most current device datasheet on the web for any functionality or specifications.

Figure 3: Efficiency Comparison

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