

# Current sense... DCRsense

**Current Sense Type:** can be selected between DCR sense (as shown), DCR Shunt or Non-DCR ( i.e. Powerstage with internal current sense).

The graphical figure will change to match selection made. Here DCR sense is shown.

The screenshot shows the 'Current Sense Design Tool' window. The 'Current Sense Type' is set to 'DCR Sense'. The 'Power Stage' is 'N/A (DCR)'. A circuit diagram shows the DCR sense configuration with components  $L$ ,  $DCR$ ,  $R_{pcb,L}$ ,  $C_b$ , and  $R_c$ . The 'Existing Network' section shows parameters:  $C_b = 0.22 \mu F$ ,  $R_b = 2360 \Omega$ ,  $R_c = 1 \Omega$ , and  $\tau (network) mismatch measured = 2 \%$ . The 'Current Reading Tuning' section shows 'Isen Gain' as 0.4902 and 'Isen Gain TC' as 3906.25 ppm/°C. The 'Calculated Characteristics' section shows  $DCR_{eff@25^\circ C} = 0.306 m\Omega$ ,  $L_{eff@25^\circ C} = 156 nH$ ,  $\tau (L/DCR) = 509 \mu s$ ,  $\tau (network) = 519 \mu s$ ,  $I_{max} digitized Capability = 66.699 A/ph$ , and  $Min. I_{max} requirement = 44 A/ph$ .

**Power stage.** When Current sense Type is selected to be Non-DCR then the family of powerstage used can be selected here. In this example grayed out and not selectable as DCRsense is selected.

**$C_b$  and  $R_b$ :** Enter the real values used on the PCB for capacitor and resistor

**$T$  ( Network) mismatch measured:** This is the mismatch in the two timeconstants  $R_b * C_b$  and  $L/DCR$  for the real components. Explanation follows on next 2 pages

# Current sense... Current sense design tool

A tool to help calculate current sense parameters. Use knowledge from the 3 following theory slides to find suitable numbers to enter.

**First** enter some basic numbers for the design

**2nd step.** Enter Data for inductor used  
And the Cb capacitor 0.22uF  
recommended. T margining typical 2%

**3rd step.** Enter Data for Rb resistor

Current Sense Design Tool

Current Sense Type: DCR

Current Sense Circuit Diagram

Enter Design Targets:

DCR: 0.34 mΩ

L: 150 nH

Desired Imax: 43.46 A/φ

τ margin: 2% %

Recommended Sense Network:

Cb: 0.22 μF

Rb: 2.03 kΩ

Rc: N/A kΩ

Calculated Characteristics:

Isense Gain to Use: 0.44

τ (L/DCR): 438.60 μs

τ (network): 442.20 μs

τ margin: 0.82 %

Imax Digitized: 59.67 A/φ

Use Rc: ☐

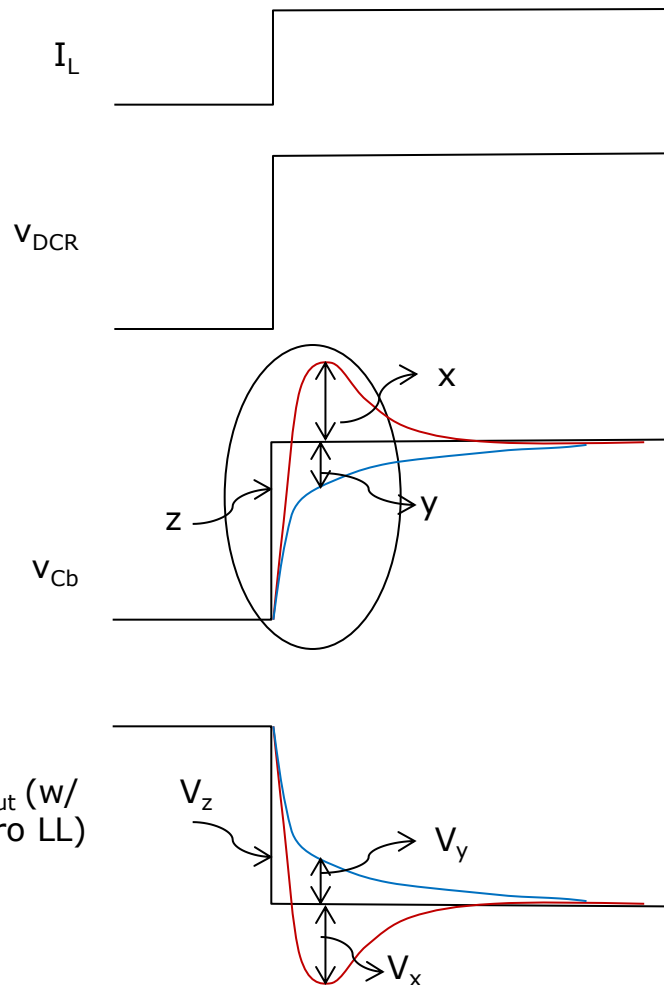
Selected Sense Network based on recommended

**Use Rc.** If there is a high DCR value the sense voltage may be needed to be divided down by using resistor Rc. If this is used mark the box and enter a number in the **Rc** field

**Isense gain.** Calculated value that can be used as Isense gain in the current sense window. It is to be used as starting point as final gain is determined by testing.

# Current sense... dynamic response: $R_b * C_b$ time constant

$$v_{Cb_x} = v_{DCR_x} * \frac{L / DCR}{R_b * C_b}, \quad s \rightarrow \infty$$



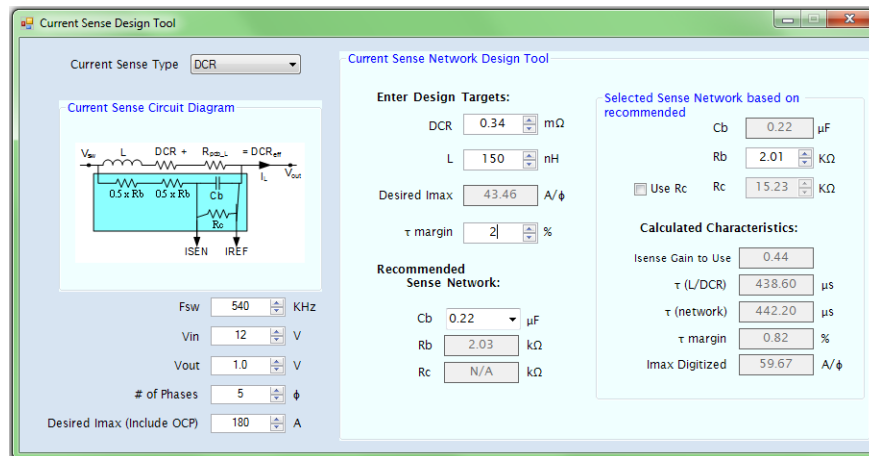
› Impact of how  $R_b * C_b$  compared to  $L / DCR_{eff}$ :

- If  $R_b * C_b = L / DCR_{eff}$ ,  $v_{Cb}$  will be the same  $v_{DCR}$  at any frequency
- If  $R_b * C_b < L / DCR_{eff}$ ,  $v_{Cb}$  will underdamp  $v_{DCR}$  which leads to overshoot/undershoot during transient when LL is non-zero.

To adjust time constant:

- $(R_b * C_b)_{new} = (R_b * C_b)_{orig} * (1 + x/z)$
- If  $R_b * C_b > L / DCR$ ,  $v_{Cb}$  will overdamp  $v_{DCR}$ . To adjust time constant:
- $(R_b * C_b)_{new} = (R_b * C_b)_{orig} * (1 - y/z)$

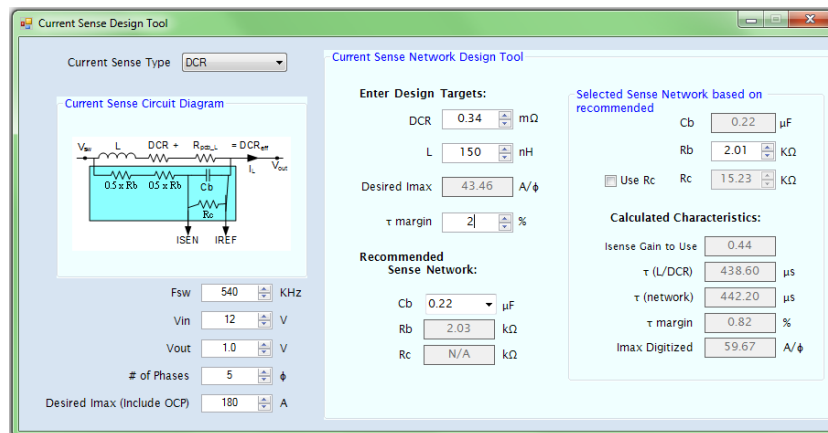
# Current sense... Adjust DCR sense network time constant – method 1: using transient waveforms with non-zero LL slope (1 of 2)



- › The DC current sense gain must be tuned before adjusting time constant → actual DCR on board  
$$DCR_{eff@25degC} = DCR_L + DCR_{trace}$$
can be calculated
- › Step 1: enter  $C_b$  and  $R_b$  values used on the board
- › Step 2: set up transient load from 5% TDC to 55% TDC and measure z and x or y in previous page
- › Step 3: if  $V_{Cb}$  overshoots  $V_{DCR}$ , enter x/z to "τ mismatch measured"; otherwise, enter -y/z to "τ mismatch measured" → actual L can be calculated

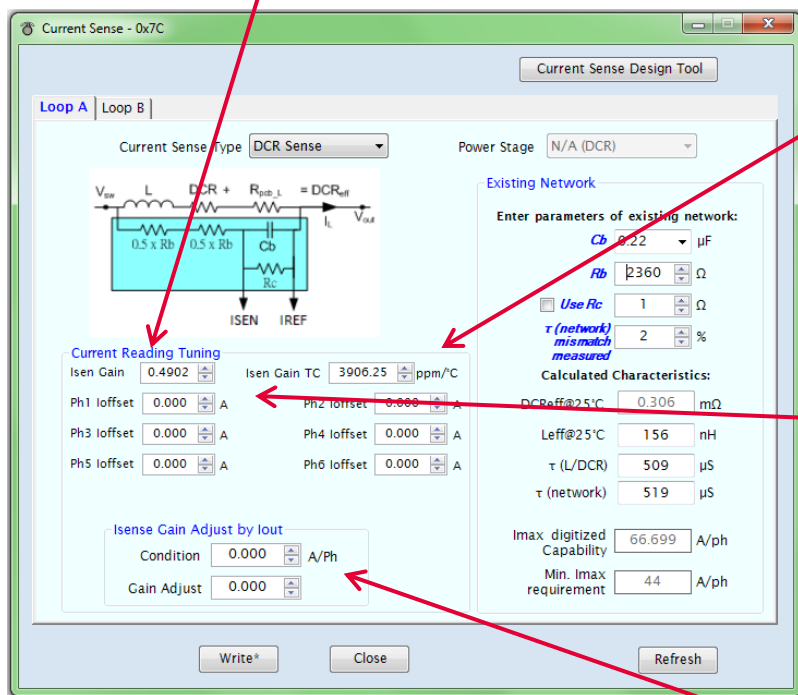
# Current sense... Adjust DCR sense network time constant – method 1: using transient waveforms with non-zero LL slope (2 of 2)

- › Step 5: Select the desired  $C_b$  value and then  $R_b$  will be calculated automatically
  - Tip: recommend to keep the same  $C_b$  value and only adjust  $R_b$  value to minimize modifications on board
- › Step 7: change the  $R_b$  or  $C_b$  to the new values on the board and verify DC current reading and time constants matching again
  - Iteration of DC current reading and time constant adjustments might be necessary



# Current sense... DCRsense

**Isen Gain.** The gain factor for the measured voltage across  $C_b$  that represent the current through the Inductor. Tuning this value such that the current reading gain is accurate from 0A to 2/3 of TDC with Isen gain TC set at 3906.25ppm/degC when temp change in inductor is small.  
To get a starting value set the gain=0.15mV/DCR



**Isen Gain TC** (Temperature Coefficient) This setting value is between 2000 ~ 4000 ppm/degC typically. Use the idea copper TC=3906.25 first and then based on temperature compensation result of inductor DCR to trim this value. This value could be different by layout.

**Ph1 (Phase1) Ioffset.** Additional offset for reported value. Behavior does depend on if current sharing is active or not. When no current sharing each phase get the individual offset. When current sharing active then any offset entered is shared equal between all active phases even if offset is only entered for one phase.

## Isense Gain Adjust by Iout

- Applies an optional gain adjustment to the current sense based on Iout
- For load currents greater than the specified A/ph Condition, the specified **Gain Adjust** value will be applied
- Recommended setting for **Integrated Current Sense Type (A)** is 16A/ph

$$\text{Isen Gain @ } I_x \text{ per phase} = \text{Isen Gain} * (I_x - I_{\text{condition}}) * (1 + \text{GainAdjust})$$