Bias-T Inductor Design Support Tool
Operation Manual

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Murata Manufacturing Co., Ltd.
Tool Overview

Find optimal products combination for PoC bias-T inductors by simple operations.

**Operations**
- setting conditions (circuit, criteria, current, cable (In case selected “with cable”))
- pressing the Optimize button to discover

**Result**
- optimal products combination
- the graph display of S21 (IL), S11 (RL), S21/S11, Z
- Pass/Fail for standards that are to be cleared
- the smallest margin, total DCR/area of filters, largest height
1. Introduction
   1. What Is PoC
   2. Typical Circuit Diagram of PoC Systems
   3. Effects Bias-T Inductor Characteristics Apply on Signal Quality
   4. Importance of PoC Bias-T Filter Selection

2. Tool Functions
   1. Circuits That Can Be Simulated
   2. Criteria
   3. Cables
   4. Stray Capacitance Settings of the Board
   5. Selection of Automatic Optimization

3. Tool Overview
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4. Tool Use Cases
   1. Use Case 1 (Automatic selection with “with cable” circuit)
   2. Use Case 2 (Automatic selection with “without cable” circuit)
   3. Use Case 3 (Change optimization method and Compare)
   4. Use Case 4 (Reselect L from inductor list)
   5. Use Case 5 (Relax the set up condition after the result become “Fail”)
   6. Use Case 6 (Reduce parallel R)
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1-1, What Is PoC

PoC (power over coaxial) is a technology that transmits both power and signal simultaneously through 1 coaxial cable. (This contributes to reduce the number of cables)
The high frequency signal and DC power are separated through the Bias-T circuit.
1-3, Roles of PoC System Bias-T Inductors

It is particularly necessary to select a Bias-T inductor since it greatly affects transmission characteristics.

Prevents inflow of DC components to the IC with the capacitor and prevents inflow of high frequency components to the power line with the inductor.
1-4, Effects Bias-T Inductor Characteristics Apply on Signal Quality

Measuring signal quality

It is required to select a Bias-T inductor that can ensure signal quality.
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2-1, Circuits That Can Be Simulated

Simulation with 3 types of circuits available.

[1] With cable
[3] Only circuit
2-2, Criteria

S21, S11, S21/S11 criteria values that must be cleared to ensure signal quality are set by each IC manufacturers or customers.

Automatically selects products combinations that clear these criteria.

This tool can be selected from the following.

- Select the IC manufacturer recommended criteria
- Select the criteria set by MURATA
- Upload your criteria
2-3, Coaxial Cable

Loss varies by cable type and length. To run simulations on circuits with cables, settings considering cable characteristics must be applied.

Relationship between cable length and S-parameter

2 types of cables can be selected on this simulator.

Input an applicable value for cable length. (Usually about 15 m or less)
2-4, Current, Temperature, and Size Settings

Inductors that match the conditions set in condition settings are provided. Applying less options for ambient temperature conditions and current conditions provide more inductors that can be selected.
2-5, Serial Connection of Bias-T Inductors

In Bias-T circuits, to ensure signal quality by reducing loss in wide bandwidths ranging from low frequencies to high frequencies, **Multiple inductors must be used in series.**

Loss in wide bandwidths can be reduced by combining the following:
- Large L inductors that cover low frequencies
- Medium L inductors that cover intermediate frequencies
- Ferrite beads that cover high frequencies

Simulations with up to 5 parallelly connected inductors are available on this tool. Bias-T inductors are automatically selected.
2-6, How to Select Parallel Resistances

Anti-resonance will occur when several Bias-T inductors are connected serially. By adding a parallel resistance to each inductor, anti-resonance can be suppressed. On the other hand, characteristics other than anti-resonance will deteriorate. By selecting a suitable resistance value, a filter characteristic that fulfills the target characteristic will be achieved.

The following are results when “L1: LQW18CNR47” and “L2: LQW32FT100” are used, and their parallel resistances R1 and R2 are Open, 1000 ohm, 2000 ohm, or 4000 ohm.

![Graph showing anti-resonance and parallel resistances](https://ds.murata.co.jp/bist/?lcid=en-us)
2-7, Effects of Board Stray Capacitance 1

A difference in characteristic results occurs between the simulation value (ideal state) and actual value (board implementation). Anti-resonance is present more noticeably in the actual value.
In the actual state, the stray capacitance that occurs between the inductor and inner layer of PCB is present on the characteristic.

If simulations are performed considering the stray capacitance, the calculated value becomes closer to the actual value.

Calculating the stray capacitance from the part size and board information.

\[ C = \varepsilon \times \frac{S}{d} \]  
(S: area)

In this case

<table>
<thead>
<tr>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25pF</td>
<td>1.6pF</td>
<td>1.6pF</td>
<td>1.8pF</td>
</tr>
</tbody>
</table>

Reflected on the simulation

This simulator enables stray capacitance setting that allows calculation of results close to the actual characteristic.
2-7, Effects of Board Stray Capacitance 2

The smaller stray capacitance is, anti-resonance becomes smaller as well. **Deleting the interior ground of the board suppresses anti-resonance.**

The stray capacitance value of the improved board is set as the default value on this simulator. Since the values change depending on the part size and board characteristics, simulations can be performed with the users freely changing the values.
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3-1, User Interface

Condition setting up section

Each elements setting and selected part number displaying section

Result section

Green cell: Required
Yellow cell: Editable
Gray cell: Uneditable
3-2, Details of each sections
Condition setting up section

Circuit and criteria

- Selectable circuit
  - With cable
  - Without cable
  - Only circuit

- Selectable criteria
  - The IC manufacturer recommended criteria
  - The criteria set by MURATA
  - Upload your criteria

Circuits and criteria can be selected from the pull-down menu.
3-2, Details of each sections

Condition setting up section

Current and Ambient temperature, cable conditions

<- Input a rated current value required for parts
<- Select Ambient temperature
(selectable from 25, 85, 105, 115, 125°C)

In case selected “with cable ” as the circuit

< Select cable (High speed:Max20GHz, Low speed:Max8.5GHz)
< Input cable length

Cable factor (editing available if “Edit” is selected in cable selection)

- Z0: Characteristic impedance
- Relative permittivity: Cable permittivity
- Damping constant: Cable loss
3-2, Details of each sections
Each elements setting and selected part number displaying section

Perform automatic selection of optimal part number combinations

Copy selected item
Paste copied item
Delete selected item

Delete all selected items for Sim. 1 to 5

Set height limit of the filter consisting product

Optimization method
- Maximize Margin:
  Find the part numbers combination that provides the best characteristics
- Minimize Size:
  Find a combination of parts numbers with the smallest size that meets the criteria.
3-2, Details of each sections

Each elements setting and selected part number displaying section

L1 - L5 : Part number that consist of the Bias-T filter
R1 - R5 : Parallel resistance
C1 : DC cut capacitor
C2, C3 : Decoupling capacitor
FB : Ferrite Beads as a noise filter

With cable

Without cable
3-2, Details of each sections
Each elements setting and selected part number displaying section

Optimization setup
◎ Status ⇒ Select the status of each elements
- Optim.: Automatically select the optimum product for this element by pressing the “Optimize” button.
- Fix.: Fix product even if the Optimize button is pressed
- None: Does not select automatically

◎ Size code ⇒ Select the size of each elements.
3-2, Details of each sections

Result section

Display S21, S11, S21/S11, Z graphs

Export graph data as CSV

Total DC resistance value of selected part number (Max and typ.)

Minimum margin value against the criteria (Displaying markers in a graph)

Judgment (Pass/Fail) for criteria

List of selected part numbers and links

Like to selected art number
- Reference spec
- Product detail page
- SimSurfing (enables characteristic confirmation of single parts)

Graph smoothing function
When "With cable" is selected, the influence of the reflection due to the cable is applied on the calculation result graph. The graph can be smoothed with the smoothing button.

https://ds.murata.co.jp/bist/?lcid=en-us
3-2, Details of each sections

Other features

- Move by section
- Open and close sections
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6. Use Case 6 (Reduce parallel R)
Use Case 1
(Automatic selection with “with cable” circuit)

PoC Bias-T filter design for ADAS cameras (With cable)
- Current : 300 mA
- Ambient temperature : 105°C
- Cable length : 5 m
- Criteria : Reference criteria
Perform automatic selection

(1) Select With cable/Reference criteria as Circuit & Criteria

(2) Current: Input 300, Temperature: Select 105°C

(3) Cable length: Input 5

(4) Press the “Optimize” button
Use Case 1  
(Automatic selection with “with cable” circuit)

(5) Results are displayed

In this case
L1 : LQW18CNR47J0Z
L2 : LQW32FT470M0H
L3 : LQH3NPZ680MME
FB : BLM18KG102SH1
are automatically selected

S21, S11, S21/S11, Z graphs displayed

Pass or Fail against selected criteria, minimum margin value, total DCR, and total area are displayed
Use Case 2
(Automatic selection with “without cable” circuit)  1/2

PoC Bias-T filter design for ADAS cameras (Without cable)
- Current : 300 mA
- Ambient temperature : 85°C
- Criteria : Reference criteria
Perform automatic selection

(1) Select Without cable/Reference criteria as Circuit & Criteria

(2) Current: Input 300, Temperature: Select 85°C

(3) Press the “Optimize” button
Use Case 2
(Automatic selection with “without cable” circuit)  2/2

(4) Results are displayed
In this case
L1 : LQW18CNR47J0Z
L2 : LQW32FT100M0H
L3 : LQH44PH151HPR
FB : BLM18KG102SH1
are automatically selected

S21, S11, S21/S11, Z graphs displayed

Pass or Fail against selected
criteria, minimum margin value,
total DCR, and total area are
displayed
Use Case 3
(Change optimization method and Compare) 1/2

PoC Bias-T filter design for ADAS cameras (with cable)
- Current: 500 mA
- Ambient temperature: 105°C
- Cable length: 10 m
- Criteria: Reference criteria

**Compare the results when “maximum margin” and “minimum size” are selected as the "Optimization method"**

(1) Select With cable/Reference criteria as Circuit & Criteria

(2) Current: Input 500, Temperature: Select 105°C

(3) Cable length: Input 10

*A message is displayed if the current value before input is smaller than 500 mA. Select the “Delete items that do not meet the condition” option and then click OK.*
Use Case 3
(Change optimization method and Compare) 2/2

(4) Click the Optimize button with
Sim1 Optimization method: Maximize margin
Sim2 Optimization method: Minimize size

(5) Results are displayed
In this case
For “Maximize margin”
L1 : LQW18CNR21J0Z
L2 : LQW32FT220M0H
L3 : LQH44PH330MPR
For “Minimize size”
L1 : BLM18EG181SH1
L2 : LQW18CNR27J0Z
L3 : LQW32FT220M0H
are automatically selected

Graphs, margin values, size images, total DCR values, and total size values can be compared
Use Case 4
(Reselect L from inductor list) 1/3

PoC Bias-T filter design for ADAS cameras (without cable)
- Current : 400mA
- Ambient temperature : 105°C
- Criteria : Reference Criteria

Reselect the L1 element after automatic selection and compare.

(1) Select Without cable/Reference criteria as Circuit & Criteria

(2) Current: Input 500, Temperature: Select 105°C

(3) Press the “Optimize” button

(4) Results are displayed
   In this case
   For “Maximize margin”
   L1 : LQW18CNR39J0Z
   L2 : LQW32FT4R7M0H
   L3 : LQH44PH330MPR
   are selected
Use Case 4
(Reselect L from inductor list)  2/3

(5) Copy product names selected in “Sim1”

(6) Select “Sim2”

(7) Attach the Sim1 part number by clicking Paste

(8) Click “Select” of L1

(9) Select an inductor

Change
LQW18CNR39J0Z to
BLM18HE152SH1
Use Case 4
(Reselect L from inductor list)  3/3

(10) Results are displayed
Comparison of results when LQW18CNR39J0Z or BLM18HE152SH1 is used for L1
Use Case 5
(Relax the set up condition after the result become “Fail”) 1/3

PoC Bias-T filter design for ADAS cameras (With cable)
- Current : 400 mA
- Ambient temperature : 125°C
- Cable length : 15 m
- Criteria : Reference criteria
Relax the set up condition after the result become “Fail”

(1) Select With cable/Reference criteria as Circuit & Criteria

(2) Current: Input 400, Temperature: Select 125°C

(3) Cable length: Input 15

(4) Press the “Optimize” button

(5) Result become “Fail”
In this case, since the temperature condition is 125 °C and the cable length is 15 m, the condition is severe, so there is no combination that passes the criteria.
Use Case 5
(Relax the set up condition after the result become “Fail”) 2/3

(6) Relax the temperature from 125°C to 105°C

(7) Press the “Optimize” button

(8) Results are displayed
In this case:
L1: LQW18CNR33J0Z
L2: LQW32FT220M0H
L3: LQH44PH330MPR
FB1: BLM18KG102SH1
Are selected by relaxing temperature condition and pass the criteria.
Use Case 5
(Relax the set up condition after the result become “Fail”) 3/3

ii. Relax the temperature condition (125℃→105℃) + add element in series

(6) Relax the temperature from 125C to 115C
(There is no combination that pass the criteria just by relaxing at 115℃.)

(8) Press the “Optimize” button

(7) Select "Optim." as L4 status
(Series elements number become 4pcs)

(8) Results are displayed
In this case
L1: BLM18HE152SH1
L2: LQW32FT100M0H
L3: LQM21PH2R2NGC
L4: LQW32FT100M0H

Are selected by relaxing temperature condition and pass the criteria
Use Case 6 (Reduce parallel R) 1/2

PoC Bias-T filter design for ADAS cameras (Without cable)
- Current : 400 mA
- Ambient temperature : 105°C
- Criteria : Reference criteria

Reduce parallel R

(1) Select Without cable/Reference criteria as Circuit & Criteria

(2) Current: Input 400, Temperature: Select 105°C

(3) Press the “Optimize” button

(4) Results are displayed

In this case
L1 : LQW18CNR39J0Z
L2 : LQW32FT2R7M0H
L3 : LQH44PH330HPR
FB : BLM18KG102SH1

are automatically selected
Use Case 6 (Reduce parallel R) 2/2

(5) Select Sim2

(8) Press the “Optimize” button

(7) Select “Maximize margin” as optimization method

(6) Delete the value of R1

④ Results are displayed
In this case
L1 : BLM18HE152SH1
L2 : LQW32FT2R7M0H
L3 : LQH44PH470HPR
FB : BLM18KG102SH1

Are selected by removing the R1

(*) In some cases, selecting ferrite beads for L1 can reduce the parallel resistance (R1) of L1.