



GRL Platform Solutions

GRL-C3-MP Test Tool LCR-JIG User Guide

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Revision History

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1.0	25 th Sep 2023	Harshavardhan G	Initial version of document is created
2.0	31 st Jan 2024	Gils Kuriakose	Added LQK Measurement Procedure
3.0	26 th Sep 2024	Harish N J	- Updated MPP Coil Test Jig Rev.2 Schematic - Added images of MPP Coil Test Jig Rev.2 board - Updated LQK Measurement Procedure to align with MPP Coil Test Jig Rev.2 - Added 1 MHz Resonance Test procedure along with its pass limits
4.0	25 th Jul 2025	G Palanisamy	Added FAQs on LQK measurements in Appendix
5.0	10 th Sep 2025	G Palanisamy	- Updated Introduction section to Overview - Added GRL Platform Solutions TPR#MPP1 and GRL Platform Solutions TPT#MPP1 in LQK Accessories - Added Test Setup Connection - Added ATL Rx & Tx Cable Compensation procedure - Added Rx & Tx Lead Compensation procedure

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1 Overview

This User Guide describes how to perform GRL Platform Solutions LCR Test jig calibration and measure Coupling Property (LQK) parameters based on the MPP TPR/TPT compliance tests requirements.

The LCR meter test procedure as described in this User Guide will be using GRL Platform Solutions test tools to perform LQK measurements based on the following test cases:

- TMBX001/01 — MPP.PTX.LQK_Measurement
- TMBX002/01 — MPP.PTX.LQK_Measurement
- TMBX003/02 — MPP.PTX.LQK_Measurement
- TMBX004/02 — MPP.PTX.LQK_Measurement
- TMBX001/02 — MPP.PTX.Manual_Attach_K-measurement
- TMBX003/03 — MPP.PTX.Manual_Attach_K-measurement
- TAAX001/01 — Average Coupling Factor
- TMBX003/01 — MPP.PTX.LQK_Measurement
- TMBX004/01 — MPP.PTX.LQK_Measurement
- RMBX001/01 — MPP.PRX.LQK_Measurement
- RMBX002/01 — MPP.PRX.LQK_Measurement
- RMBX001/02 — MPP.PRX.Manual_Attach_K-measurement

2 Required Equipment

Ensure that the following equipment are available before proceeding with the steps below.

- GRL-C3-MP-LCR-JIG
- Keysight E4980AL LCR Meter
- GRL Platform Solutions LCR SMA Fixture

3 Calibration Procedure

3.1 GRL-C3-MP-LCR-JIG Schematic

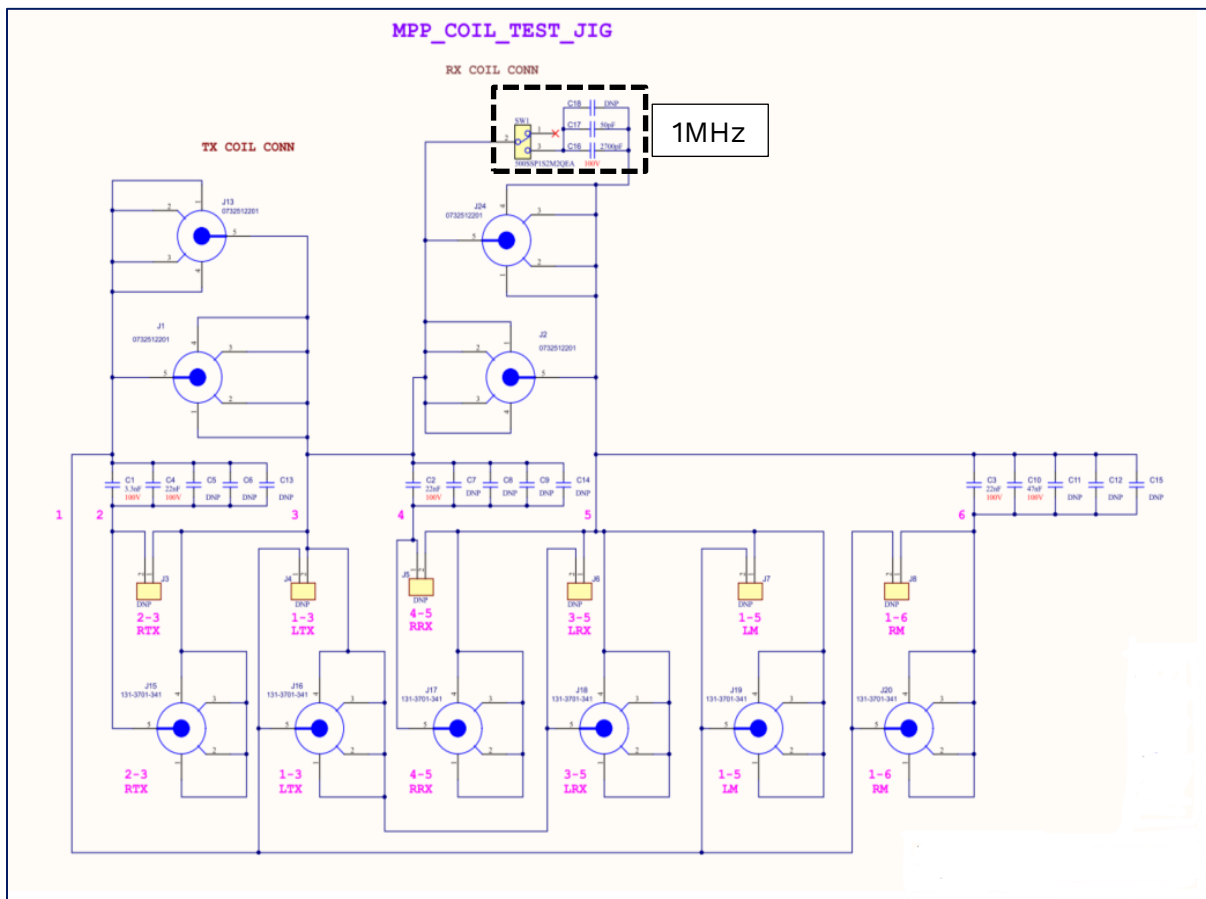
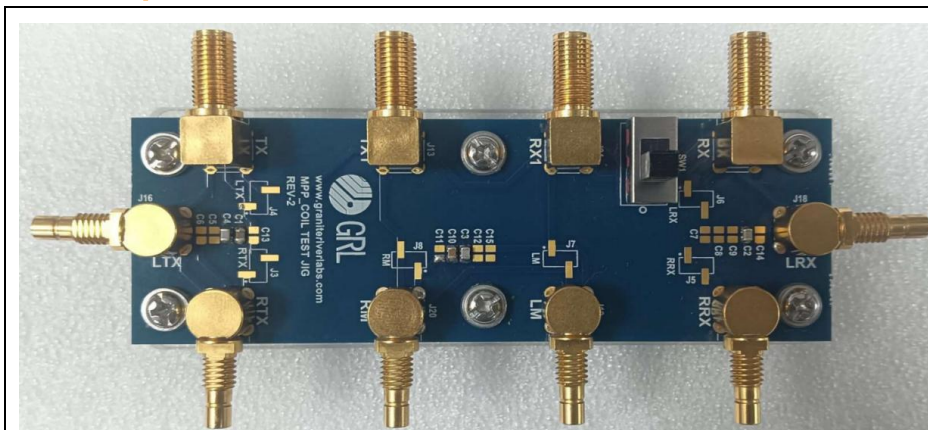
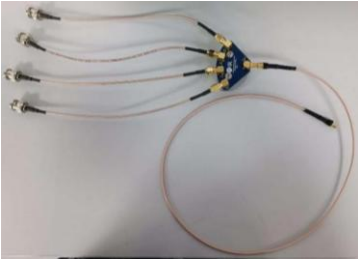
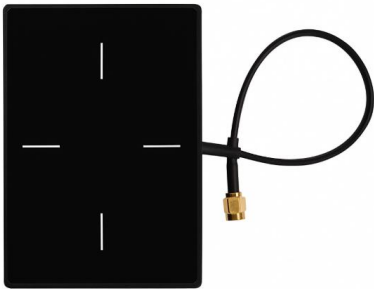
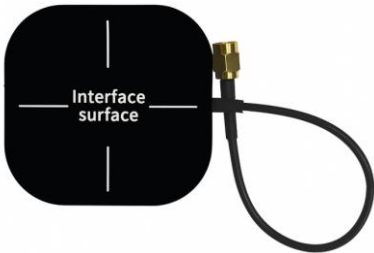


Figure 1. GRL-C3-MP-LCR-JIG Schematic

3.2 LQK Accessories



MPP Coil Test Jig

 	GRL Platform Solutions LCR SMA Fixture
	SMA Zero Ohm Short
	SMB Short
	Keysight 16334A Test Fixture
	GRL Platform Solutions TPR#MPP1 (where it is referred to as 'TPR')
	GRL Platform Solutions TPT#MPP1 (where it is referred to as 'TPT')

3.3 Test Points

The following test points are labeled and mapped the same as the GRL Platform Solutions Coil Test Jig design.

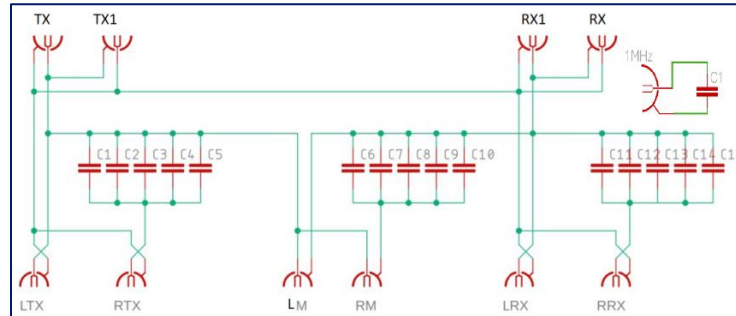


Figure 2. Test Points

3.4 Test Setup Connection

Use the following test connection setup for the PTx or PRx device under test (DUT) respectively:

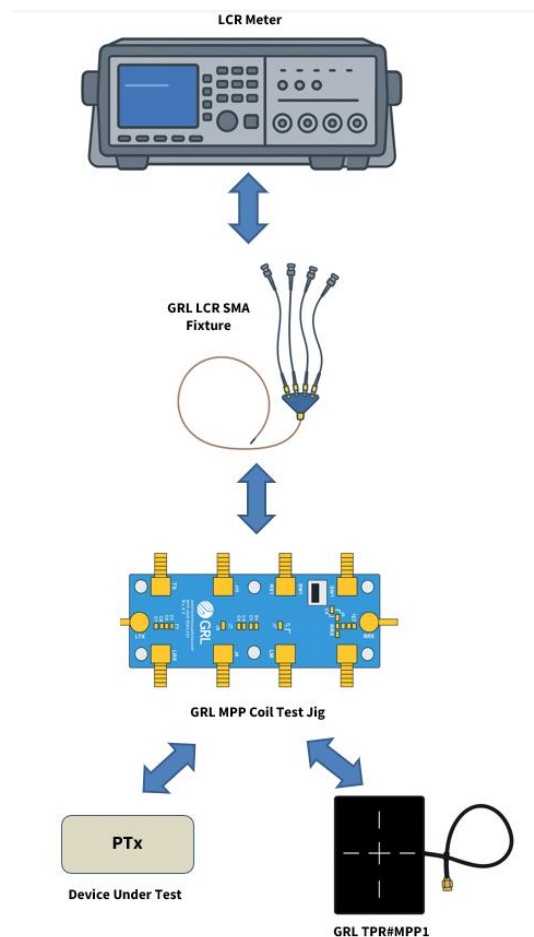


Figure 3. PTx DUT Test Connection Setup

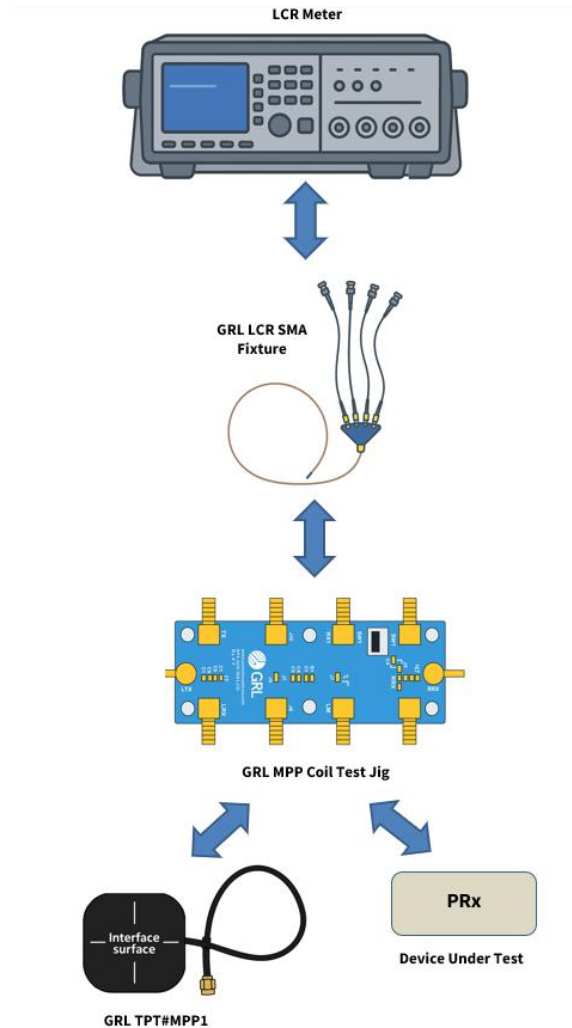


Figure 4. PRx DUT Test Connection Setup

3.5 LCR Meter Calibration with GRL Platform Solutions LCR SMA Fixture

The following procedure describes how to set up and calibrate the LCR meter using the GRL Platform Solutions LCR SMA fixture:

1. Connect the LCR meter to power via an isolation transformer (to avoid a ground loop).
2. Connect the GRL Platform Solutions LCR SMA fixture to the LCR meter as follows (refer to Figure 5 below):
 - Connect the SMA fixture Lcur to the LCR meter Lcur
 - Connect the SMA fixture Lpot to the LCR meter Lpot
 - Connect the SMA fixture Hcur to the LCR meter Hcur
 - Connect the SMA fixture Hpot to the LCR meter Hpot



Figure 5. Connect GRL Platform Solutions LCR SMA Fixture to LCR Meter

3. Connect the SMB cable to the LCR SMA fixture.
4. Set a marker at the desired frequency for the Jig, e.g. 360 kHz on the LCR meter screen.
5. Follow the LCR meter OPEN and SHORT calibration steps (manufacturer-dependent).
 - a) Keep the other end of the SMB cable open when performing the OPEN calibration.



Figure 6. OPEN Calibration

- b) Use the SMB short provided for the SHORT calibration of the LCR meter.



Figure 7. SHORT Calibration

3.6 Coil Test Jig Parasitic Measurement

The following procedure describes how to set up the LCR jig and LCR meter to perform the jig parasitic measurement:

1. Connect the LCR meter to power via an isolation transformer (to avoid a ground loop).
2. Follow the LCR meter calibration steps (manufacturer-dependent).
3. Set a marker at the desired frequency for the LCR jig, e.g. 360 kHz on the LCR meter screen.
4. **Short the TX and RX circuit ports of the LCR jig using a 0 Ω SMA connector (required).** Refer to Figure 8 below.

Note: Disable the switch in the LCR jig when performing the jig parasitic measurement.

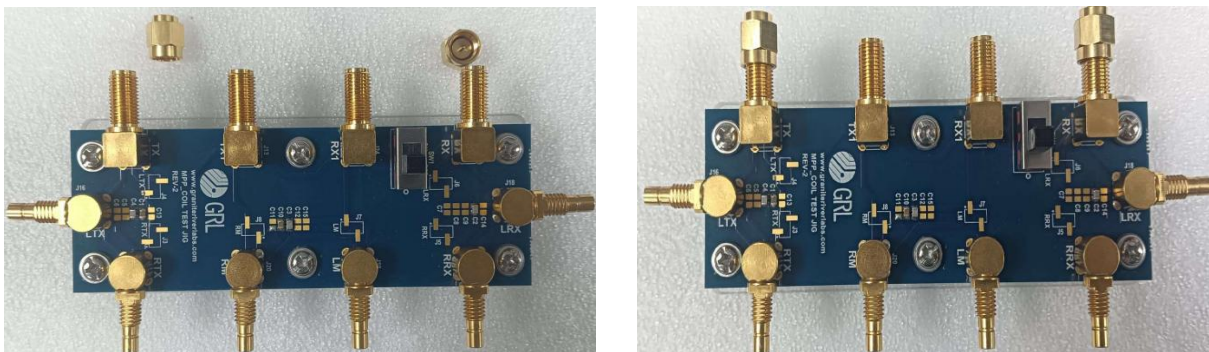


Figure 8. Short LCR Jig TX and RX Circuit Ports with 0 Ω SMA connector

- a) Connect the LCR meter cable to port LTX (Tx Coil Inductance) of the LCR jig. Record the reactance at the desired frequency for the jig. Note this as **Ltx11_parasitic_360k**

- b) Connect the LCR meter cable to port RTX (Tx Coil Resistance) of the LCR jig. Record the resistance at the desired frequency for the jig.
Note this as **Rtx11_parasitic_360k**
- c) Connect the LCR meter cable to port LRX (Rx Coil Inductance) of the LCR jig. Record the reactance at the desired frequency for the jig.
Note this as **Lrx11_parasitic_360k**
- d) Connect the LCR meter cable to port RRX (Rx Coil Resistance) of the LCR jig. Record the resistance at the desired frequency for the jig.
Note this as **Rrx11_parasitic_360k**
- e) Connect the LCR meter cable to port LM (Mutual Inductance) of the LCR jig. Record the reactance at the desired frequency for the jig.
Note this as **Lm11-parasitic_360k**
- f) Connect the LCR meter cable to port RM (Mutual Resistance) of the LCR jig. Record the resistance at the desired frequency for the jig.
Note this as **Rm11_parasitic_360k**

6. Short the TX1 and RX1 circuit ports of the LCR jig using a 0 Ω SMA connector (required).

- a) Connect the LCR meter cable to port LTX of the LCR jig. Record the reactance at the desired frequency for the jig.
Note this as **Ltx22_parasitic_360k**
 - b) Connect the LCR meter cable to port RTX of the LCR jig. Record the resistance at the desired frequency for the jig.
Note this as **Rtx22_parasitic_360k**
 - c) Connect the LCR meter cable to port LRX of the LCR jig. Record the reactance at the desired frequency for the jig.
Note this as **Lrx22_parasitic_360k**
 - d) Connect the LCR meter cable to port RRX of the LCR jig. Record the resistance at the desired frequency for the jig.
Note this as **Rrx22_parasitic_360k**
 - e) Connect the LCR meter cable to port LM of the LCR jig. Record the reactance at the desired frequency for the jig.
Note this as **LM22-parasitic_360k**
 - f) Connect the LCR meter cable to port RM of the LCR jig. Record the resistance at the desired frequency for the jig.
Note this as **Rm22_parasitic_360k**
- 7. Change the frequency to 128 KHz on the LCR meter.
 - 8. Follow the LCR meter calibration steps (manufacturer-dependent).
 - 9. Repeat the same steps as above for 128 KHz and note the parasitic values.
 - 10. Record the measured values for 360 KHz in Step 2 and 128 KHz in Step 8 as shown in Figure 9 and Figure 10 below respectively.

STEP 2 Follow Jig Characterization Procedure at 360k, enter results in this step.					
LCR meter to Shorted Jig	Variable	Description	Unit	360 kHz	Corrected
	L'tx	Inductance at the jig terminal LTX (Jig Characterization)	nH		0.000
	L'rx	Inductance at the jig terminal LRX (Jig Characterization)	nH		0.000
	R'tx	AC resistance at the jig terminal RTX (Jig Characterization)	mΩ		0.000
	R'rx	AC resistance at the jig terminal RRX (Jig Characterization)	mΩ		0.000
	L'm	Mutual inductance at the jig terminal M (Jig Characterization)	nH		0.000
	R'm	AC resistance at the jig terminal RM (Jig Characterization)	mΩ		0.000

Figure 9. Step 2 Sheet for 360 KHz

STEP 8 Follow Jig Characterization Procedure at 128k, enter results in this step.					
LCR meter to Shorted Jig	Variable	Description	Unit	128 kHz	Corrected
		No longer required.			
		No longer required.			
	R'tx	AC resistance at the jig terminal RTX (Jig Characterization)	mΩ		0.000
	R'rx	AC resistance at the jig terminal RRX (Jig Characterization)	mΩ		0.000
		No longer required.			
	R'm	AC resistance at the jig terminal RM (Jig Characterization)	mΩ		0.000

Figure 10. Step 8 Sheet for 128 KHz

3.7 Tx & Rx Coil Cable Parasitic Measurement

The Tx and Rx coil cable parasitic values will be provided by the coil cable manufacturer. For the GRL Platform Solutions Tx/Rx coil cable parasitic values, refer the last two pages in the calibration report).

3.8 ATL Rx Cable Compensation

The following procedure describes how to measure the AC resistance and inductance values of the ATL cable that is used to connect the TPR/PRx coil to the LCR jig for compensation:

1. Disconnect the RX SMA Short cap and connect the ATL cable.
2. At the end of the ATL cable, connect a SMA Short cap.
3. Connect the LCR meter cable to port LRX (Rx Coil Inductance) of the LCR jig.
4. Measure Ls (inductance) on the LCR meter. Record this value as **L_{rxl}** under Step 3a or Step 4a as shown in Figure 11 and Figure 12 below.
5. Connect the LCR meter cable to port RRX (Rx Coil Resistance) of the LCR jig.
6. Measure Rs (AC resistance) on the LCR meter. Record this value as **R_{rxl}** under Step 3a or Step 4a as shown in Figure 11 and Figure 12 below.

STEP 3a Measure the ATL's TPR cable at 360k, enter values in this step.					
Shorted TPR Leads from jig	Variable	Description	Unit	360 kHz	Corrected
	L _{rxl}	Inductance of the TPR coil leads (ATL cable)	nH		0.000
	R _{rxl}	AC resistance of the TPR coil leads (ATL cable)	mΩ		0.000

Figure 11. Step 3a Sheet for PTx

STEP 4a Measure the ATL's PRx cable at 360k, enter values in this step.						
Shorted DUT Leads from jig	Variable	Description	Unit	360 kHz	Corrected	
	L_rxl	Inductance of the DUT coil leads (Client cable)	nH		0.000	
	R_rxl	AC resistance of the DUT coil leads (Client cable)	mΩ		0.000	

Figure 12. Step 4a Sheet for PRx

Note: If there is no ATL cable, you can ignore the above steps — it is not required to fill in Steps 3a and 4a.

3.9 ATL Tx Cable Compensation

The following procedure describes how to measure the AC resistance and inductance values of the ATL cable that is used to connect the TPT/PTx coil to the LCR jig for compensation:

1. Disconnect the TX SMA Short cap and connect the ATL cable.
2. At the end of the ATL cable, connect a SMA Short cap.
3. Connect the LCR meter cable to port LTX (Tx Coil Inductance) of the LCR jig.
4. Measure Ls (inductance) on the LCR meter. Record this value as **L_txl** under Step 3a or Step 4a as shown in Figure 13 and Figure 14 below.
5. Connect the LCR meter cable to port RTX (Tx Coil Resistance) of the LCR jig.
6. Measure Rs (AC resistance) on the LCR meter. Record this value as **R_txl** under Step 3a or Step 4a as shown in Figure 13 and Figure 14 below.

STEP 4a Measure the ATL's PTx cable at 360k, enter values in this step.						
Shorted DUT Leads from jig	Variable	Description	Unit	360 kHz	Corrected	
	L_txl	Inductance of the DUT coil leads (Client cable)	nH		0.000	
	R_txl	AC resistance of the DUT coil leads (Client cable)	mΩ		0.000	

Figure 13. Step 4a Sheet for PTx

STEP 3a Measure the ATL's TPT cable at 360k, enter values in this step.						
Shorted TPT Leads from jig	Variable	Description	Unit	360 kHz	Corrected	
	L_txl	Inductance of the TPT coil leads (ATL cable)	nH		0.000	
	R_txl	AC resistance of the TPT coil leads (ATL cable)	mΩ		0.000	

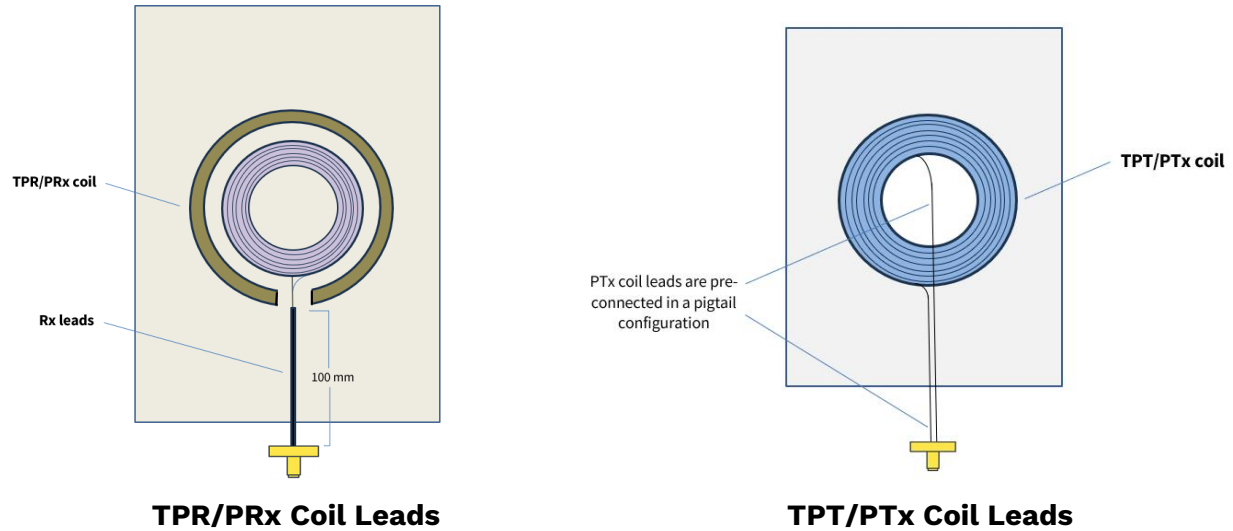
Figure 14. Step 3a Sheet for PRx

Note: If there is no ATL cable, you can ignore the above steps — it is not required to fill in Steps 3a and 4a.

3.10 Rx & Tx Lead Compensation

If an external lead is connected along with the TPR/PRx or TPT/PTx coil, the first lead needs to be measured separately by connecting it to the LCR jig.

After obtaining the measured value, subtract the previously measured LCR jig value from it.



The resulting value from the subtraction can be either L_s , lead inductance (**L_{rxl2}**) or R_s , lead AC resistance (**R_{rxl2}**) for Rx leads. For Tx leads, the value can be either L_s , lead inductance (**L_{txl2}**) or R_s , lead AC resistance (**R_{txl2}**). These values should be updated under Step 3b, 9b, 4b or 10b (as shown below), based on the type of coil measured.

For example, after noting the L_{rxl2} value, you need to measure the R_{rxl2} value in the same way and record it in the R_{rxl2} field.

STEP 3b Enter TPR vendor's coil lead values for 360k in this step.					
TPR internal coil conx.	Variable	Description	Unit	360 kHz	Corrected
	L _{rxl2}	Inductance of the TPR coil leads (TPR internal)	nH	56.0000	0.0560
	R _{rxl2}	AC resistance of the TPR coil leads (TPR internal)	mΩ		0.0000

Figure 15. Step 3b Sheet for PTx (TPR Lead)

STEP 4b Enter the client's PRx coil lead values for 360k in this step.					
DUT internal coil conx.	Variable	Description	Unit	360 kHz	Corrected
	L _{rxl2}	Inductance of the DUT coil leads (Client cable)	nH		0.000
	R _{rxl2}	AC resistance of the DUT coil leads (Client cable)	mΩ		0.000

Figure 16. Step 4b Sheet for PRx (TPR Lead)

STEP 4b Enter the client's PTx coil lead values for 360k in this step.					
DUT internal coil conx.	Variable	Description	Unit	360 kHz	Corrected
	L _{txl2}	Inductance of the DUT coil leads (Client cable)	nH		0.000
	R _{txl2}	AC resistance of the DUT coil leads (Client cable)	mΩ		0.000

Figure 17. Step 4b Sheet for PTx (TPT Lead)

STEP 3b Enter TPT vendor's coil lead values for 360k in this step.					
TPT internal coil conx.	Variable	Description	Unit	360 kHz	Corrected
	L_txl2	Inductance of the TPT coil leads (TPT internal)	nH		0.000
	R_txl2	AC resistance of the TPT coil leads (TPT internal)	mΩ		0.000

Figure 18. Step 3b Sheet for PRx (TPT Lead)

Note: If there is no additional lead, you can ignore these steps — it is not required to fill in Steps 3b, 9b, 4b and 10b.

4 Measurement Procedure at (0,0) Position

The following procedure describes how to set up and perform measurements at the (0,0) position using the LCR meter and GRL Platform Solutions Positioning Tool and LCR jig:

1. Connect the LCR meter to power via an isolation transformer (to avoid an unexpected ground loop).
2. Attach the TX and RX coils into the GRL Platform Solutions Positioning Tool.
3. Connect the TX coil to the **TX** SMA connector and RX coil to the **RX** SMA connector. *[Note: Make sure that the SMA Short caps are removed.]*

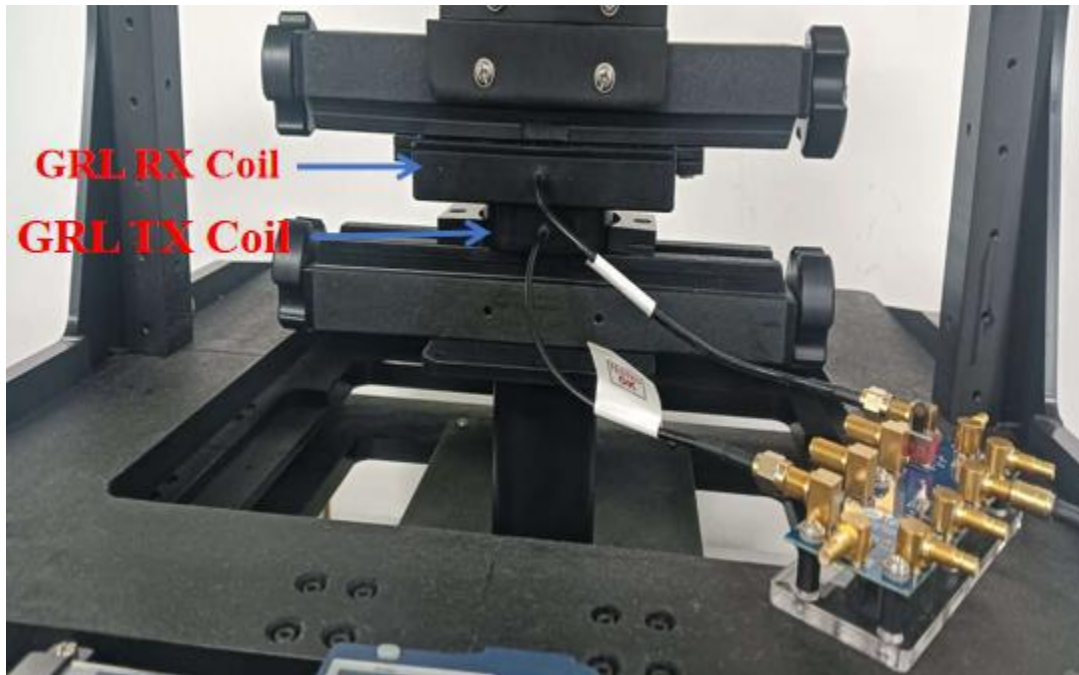


Figure 19. Attach TX and RX Coils Into Positioning Tool

4. Set a marker at the desired frequency for the LCR jig, e.g. 360 kHz on the LCR meter screen.
5. Follow the LCR meter calibration steps (manufacturer-dependent).
6. Disable the switch in the LCR jig when performing the LQK measurement.
7. Connect the LCR meter to **port LM of the LCR jig**.
 - a) Find the smallest LM by adjusting the positioning tool.
 - b) Measure the reactance at the desired frequency for the jig.
 - i. If the value is positive, determine the Compensated Mutual Inductance (LM') with the following equation:

$$LM' = (LM_{360K}) - (L_{tx \text{ Cable parasitic}_{360K}}) - (L_{rx \text{ Cable parasitic}_{360K}}) - (LM_{11 \text{ parasitic}_{360K}})$$

- ii. If the value is higher ($>10 \mu\text{H}$), connect the TX coil at TX1 or the RX coil at RX1. Determine the Compensated Mutual Inductance (LM') with the following equation:

$$LM' = (LM_{360K}) - (L_{tx \text{ Cable parasitic}_{360K}}) - (L_{rx \text{ Cable parasitic}_{360K}}) - (LM_{33 \text{ parasitic}_{360K}})$$

- c) Record the results as LM' .

8. Connect the LCR meter to **port LTX of the jig.**

- a) Measure the reactance at the desired frequency for the jig.
- b) Determine the compensated $L'TX$ with the following equation:

$$L'TX = L_{tx} - (L_{tx11_{360K}} + L_{tx \text{ Cable Parasitic}_{360K}})$$

- c) Record the results as $L'TX$.

9. Connect the LCR meter to **port LRX of the jig.**

- a) Measure the reactance at the desired frequency for the jig.
- b) Determine the compensated $L'RX$ with the following equation:

$$L'RX = L_{rx} - (L_{rx11_{360K}} + L_{rx \text{ Cable Parasitic}_{360K}})$$

- c) Record the results as $L'RX$.

11. Connect the LCR meter to **port RTX of the jig.**

- a) Measure the resistance at the desired frequency for the jig.
- b) Determine the compensated $R'TX$ with the following equation:

$$R'TX = R_{tx} - (R_{tx11_{360K}} + R_{tx \text{ Cable Parasitic}_{360K}})$$

- c) Record the results as $R'TX$.

12. Connect the LCR meter to **port RRX of the jig.**

- a) Measure the resistance at the desired frequency for the jig.
- b) Determine the compensated $R'RX$ with the following equation:

$$R'RX = R_{rx} - (R_{rx11_{360K}} + R_{rx \text{ Cable Parasitic}_{360K}})$$

- c) Record the results as $R'RX$.

13. Connect the LCR meter to **port RM of the jig.**

- a) Measure the resistance at the desired frequency for the jig.
- b) Determine the Compensated Mutual Resistance (RM') with the following equation:

$$RM' = (RM_{360K}) - (R_{tx \text{ Cable parasitic}_{360K}}) - (R_{rx \text{ Cable parasitic}_{360K}}) - (R_{m11 \text{ parasitic}_{360K}})$$

- c) Record the results as RM' .
- d) Compute and record k_i (Inductive Coupling) using the following equations:

$$K_i = \frac{M}{\sqrt{L'_{TX} \cdot L'_{RX}}}$$

$$\text{where } M = (L'_{TX} + L'_{RX} - LM') / 2$$

14. Compute and record Kr (Resistive Coupling) using the following equation:

$$K_r = \frac{R_M}{\sqrt{R'_{TX} \cdot R'_{RX}}}$$

$$\text{where } RM = (R'_{TX} + R'_{RX} - RM') / 2$$

15. Record all the above results for PTx and PRx in Step 5 as shown below:

STEP 5 Follow LCR meter Coil measurement Procedure at 360k, enter results here.					
TMBX001/01 (r=0, z=0)	Variable	Description	Unit	360 kHz	Corrected
	L'tx	Inductance at the coil terminals of the DUT	μH		0.000
	L'rx	Inductance at the coil terminals of the TPR	μH		0.000
	R'tx	AC resistance at the coil terminals of the DUT	mΩ		0.000
	R'rx	AC resistance at the coil terminals of the TPR	mΩ		0.000
	L'm	Inductance at the coil terminals of the mated DUT and TPR	μH		0.000
	R'm	AC resistance at the coil terminals of the mated DUT and TPR	mΩ		0.000
	Ki	Magnetic coupling between the DUT and TPR			#DIV/0!
	Kr	Resistive coupling between the DUT and TPR			#DIV/0!

Figure 20. Step 5 Sheet for PTx

STEP 5 Follow LCR meter Coil measurement Procedure at 360k, enter results here.					
RMBX001/01 (r=0, z=0)	Variable	Description	Unit	360 kHz	Corrected
	L'tx	Inductance at the coil terminals of the TPT	μH		0.000
	L'rx	Inductance at the coil terminals of the PRx	μH		0.000
	R'tx	AC resistance at the coil terminals of the TPT	mΩ		0.000
	R'rx	AC resistance at the coil terminals of the PRx	mΩ		0.000
	L'm	Inductance at the coil terminals of the mated TPT and PRx	μH		0.000
	R'm	AC resistance at the coil terminals of the mated TPT and PRx	mΩ		0.000
	Ki	Magnetic coupling between the TPT and PRx			#DIV/0!
	Kr	Resistive coupling between the TPT and PRx			#DIV/0!

Figure 21. Step 5 Sheet for PRx

- Repeat the above procedure at different frequencies.
- Compare the data with their respective test limits to validate the results.

5 Measurement Procedure at 2,2 Position

The following procedure describes how to set up and perform measurements at the (2,2) position using the LCR meter and GRL Platform Solutions Positioning Tool and LCR jig:

1. Connect the LCR meter to power via an isolation transformer (to avoid an unexpected ground loop).
2. Attach the TX and RX coils into the GRL Platform Solutions Positioning Tool.
3. Connect the TX coil to the **TX** SMA connector and RX coil to the **RX** SMA connector. *[Note: Make sure that the SMA Short caps are removed.]*
4. Place a 2 mm spacer in between the TX and RX coils.

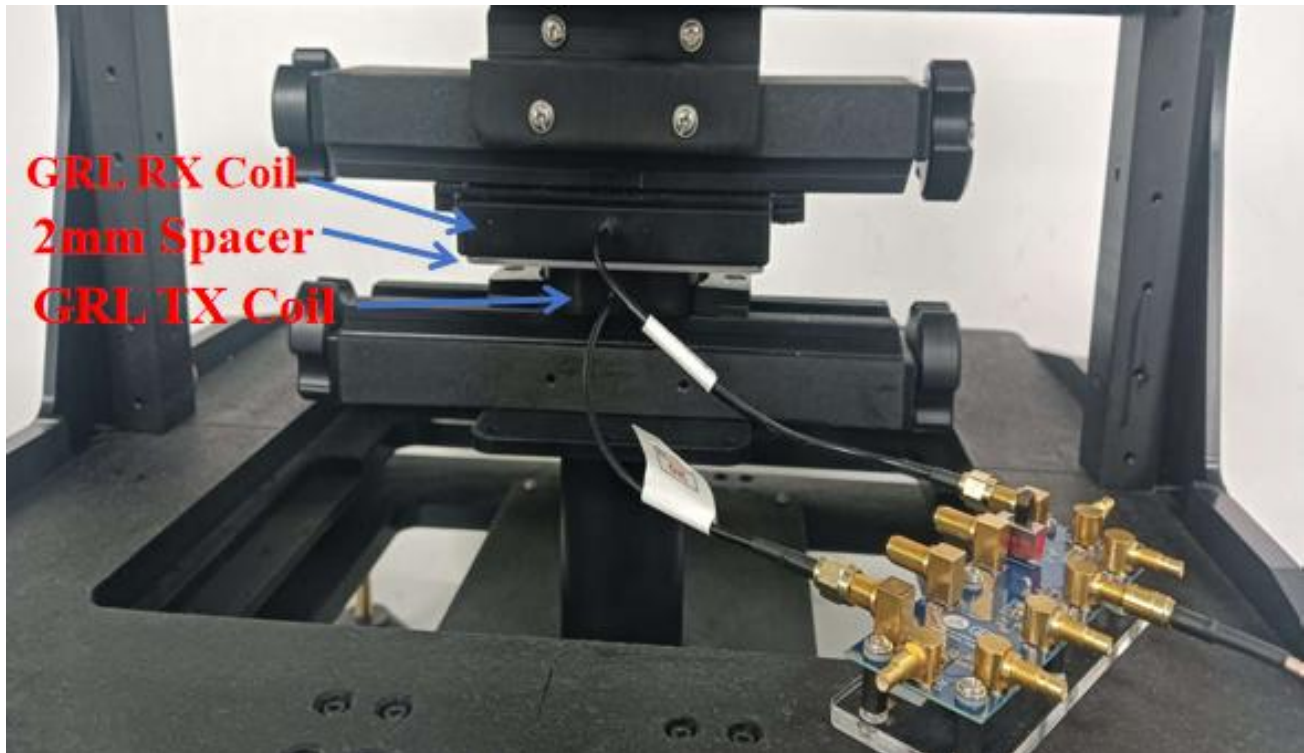


Figure 22. Place 2 mm Spacer in Between TX and RX Coils In Positioning Tool

5. Set a marker at the desired frequency for the LCR jig, e.g. 360 kHz on the LCR meter screen.
6. Follow the LCR meter calibration steps (manufacturer-dependent).
7. Disable the switch in the LCR jig when performing the LQK measurement.
8. Connect the LCR meter to **port LM of the LCR jig**.
 - a) Find the smallest LM by adjusting the positioning tool.
 - b) Set both scales in the positioning tool to zero.
 - c) Move 2 mm towards **X+2** or **X-2** or **Y+2** or **Y-2** in the positioning tool as shown in Figure 23 below:

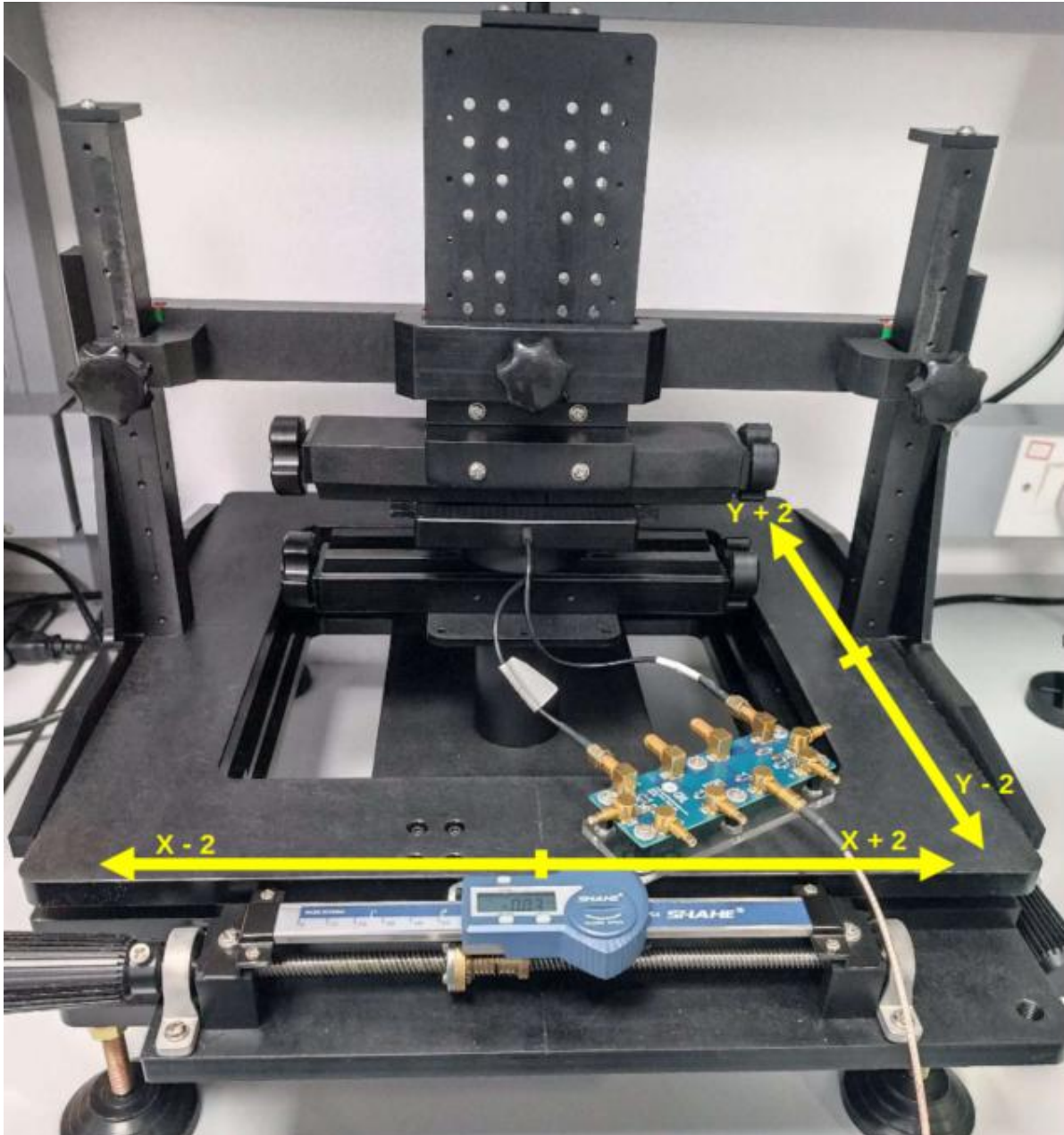


Figure 23. Move 2 mm Towards X+2 or X-2 or Y+2 or Y-2 in Positioning Tool

- d) Measure the reactance at the desired frequency for the jig (LM_360K).
- e) Determine the Compensated Mutual Inductance (LM') with the following equation:

$$LM' = (LM_{360K}) - (L_{tx} \text{ Cable parasitic}_{360K}) - (L_{rx} \text{ Cable parasitic}_{360K}) - (M11 \text{ parasitic}_{360K})$$

- f) Record the results as LM'.

9. Connect the LCR meter to **port LTX of the jig**.

- a) Measure the reactance at the desired frequency for the jig.

- b) Determine the compensated L'TX with the following equation:

$$L'TX = Ltx - (Ltx11_360K + Ltx \text{ Cable Parasitic_360K})$$

- c) Record the results as L'TX.

10. Connect the LCR meter to **port LRX of the jig.**

- a) Measure the reactance at the desired frequency for the jig.
b) Determine the compensated L'RX with the following equation:

$$L'RX = Lrx - (Lrx11_360K + Lrx \text{ Cable Parasitic_360K})$$

- c) Record the results as L'RX.

11. Connect the LCR meter to **port RTX of the jig.**

- a) Measure the resistance at the desired frequency for the jig.
b) Determine the compensated R'TX with the following equation:

$$R'TX = Rtx - (Rtx11_360K + Rtx \text{ Cable Parasitic_360K})$$

- c) Record the results as R'TX.

12. Connect the LCR meter to **port RRX of the jig.**

- a) Measure the resistance at the desired frequency for the jig.
b) Determine the compensated R'RX with the following equation:

$$R'RX = Rrx - (Rrx11_360K + Rrx \text{ Cable Parasitic_360K})$$

- c) Record the results as R'RX.

13. Connect the LCR meter to **port RM of the jig.**

- a) Measure the resistance at the desired frequency for the jig.
b) Determine the Compensated Mutual Resistance (RM') with the following equation:

$$RM' = (RM_360K) - (Rtx \text{ Cable parasitic_360K}) - (Rrx \text{ Cable parasitic_360K}) - (Rm11 \text{ parasitic_360K})$$

- c) Record the results as RM'.

14. Compute and record ki using the following equations:

$$K_i = \frac{M}{\sqrt{L'_{TX} \cdot L'_{RX}}}$$

$$\text{where } M = (L'TX + L'RX - LM') / 2$$

15. Compute and record Kr using the following equation:

$$K_r = \frac{R_M}{\sqrt{R'_{TX} \cdot R'_{RX}}}$$

where $RM = (R'_{TX} + R'_{RX} - RM') / 2$

16. Record all the above results for PTx and PRx in Step 5 as shown below:

STEP 5 Follow LCR meter Coil measurement Procedure at 360k, enter results here.					
TMBX002/01 (r=2, z=2)	Variable	Description	Unit	360 kHz	Corrected
	L'tx	Inductance at the coil terminals of the DUT	μH		0.000
	L'rx	Inductance at the coil terminals of the TPR	μH		0.000
	R'tx	AC resistance at the coil terminals of the DUT	mΩ		0.000
	R'rx	AC resistance at the coil terminals of the TPR	mΩ		0.000
	L'm	Inductance at the coil terminals of the mated DUT and TPR	μH		0.000
	R'm	AC resistance at the coil terminals of the mated DUT and TPR	mΩ		0.000
	Ki	Magnetic coupling between the DUT and TPR			#DIV/0!
	Kr	Resistive coupling between the DUT and TPR			#DIV/0!

Figure 24. Step 5 Sheet for PTx

STEP 5 Follow LCR meter Coil measurement Procedure at 360k, enter results here.					
RMBX002/01 (r=2, z=2)	Variable	Description	Unit	360 kHz	Corrected
	L'tx	Inductance at the coil terminals of the TPT	μH		0.000
	L'rx	Inductance at the coil terminals of the PRx	μH		0.000
	R'tx	AC resistance at the coil terminals of the TPT	mΩ		0.000
	R'rx	AC resistance at the coil terminals of the PRx	mΩ		0.000
	L'm	Inductance at the coil terminals of the mated TPT and PRx	μH		0.000
	R'm	AC resistance at the coil terminals of the mated TPT and PRx	mΩ		0.000
	Ki	Magnetic coupling between the TPT and PRx			#DIV/0!
	Kr	Resistive coupling between the TPT and PRx			#DIV/0!

Figure 25. Step 5 Sheet for PRx

17. Repeat the above procedure at different frequencies.
18. Compare the data with their respective test limits to validate the results.

6 MPP Coil and LCR Jig 1 MHz Resonance Test Procedure

The following procedure describes how to perform the calibration that is required before using the 1 MHz jig:

1. Connect the TPR coil to the test jig (RX-SMA).
2. Enable the slider switch in the coil test jig.
3. Set the LCR meter to measure the impedance and phase shift of the connected network at a frequency range between 800 kHz and 1.2 MHz with a resolution of at least 1 kHz steps.

NOTE: It may be helpful to perform a coarse sweep (e.g. 10 kHz step-size) to locate the approximate resonance frequency, followed by a fine sweep (1 kHz step-size).

4. Connect the LCR meter probe parallel to the cap (C16/C17).

NOTE: Use the Keysight 16334A Test Fixture.

5. Plot the phase-shift as a function of frequency and determine the point where the phase shift crosses the 0° line. Obtain the frequency closest to this zero-crossing and note this value as f_{f1} .
6. Note the dynamic impedance of the network at the frequency obtained in step 5 (f_{f1}) as z_{f1} .
7. Disconnect the coil from the Coil Test Jig and keep the slider switch enabled in the jig.
8. Set the LCR meter to measure the capacitance and AC resistance across C16/C17 at the frequency obtained in step 5 (f_{f1}). Note these values as C_{f1} and R_{cf1} .

NOTE:

- Measure R_{cf1} across the coil connector using the LCR SMA fixture.
- Use the Keysight 16334A Test Fixture.

9. Reconnect the TPR coil and disable the slider switch in the jig.
10. Set the LCR meter to measure the Inductance and AC resistance of the TPR coil across the RX1 connector at the frequency obtained in step 5 (f_{f1}). Note these values as L_{f1} and R_{Lf1} .
11. Make the following calculations:
 - a) Loop resistance: $R_{Loop} = R_{Lf1} + R_{cf1}$
 - b) Quality Factor: $Q = \frac{2 \cdot \pi \cdot f_{f1} \cdot L_{f1}}{R_{Loop}}$
12. Verify that the applicable measurements and the calculated values from step 11 meet the requirements in the table below:

Spec Limits	FF1 (kHz)		Q
	Min	Max	Min
	980	1020	>15

7 References

- MPP TPT / TPR Test Tool Books V3
- MPP Power TPT/TPR Test Tools Qi Specification V2.1

8 Appendix A: FAQ's on LQK Measurements with GRL-C3-MP-LCR-JIG

1. Question:

Where to find the reference video on the LQK measurement process?

Answer:

Refer to <https://youtu.be/0o3l04mXHnw?si=qSmxklt0Wrig8ELp> to understand how the entire LQK measurement process is carried out.

2. Question:

How to calibrate the LCR meter, and how to ensure that it is properly calibrated?

Answer:

After completing the calibration process, the final step involves performing the OPEN and SHORT measurements.

Once the SHORT calibration is done, do not remove the cap connected to the SMB wire. Then, check the values displayed on the LCR meter. If the Ls (inductance) value is in pico henries (pH) and the Rs (resistance) value is in micro ohms ($\mu\Omega$), we can confirm that the calibration has been completed correctly.



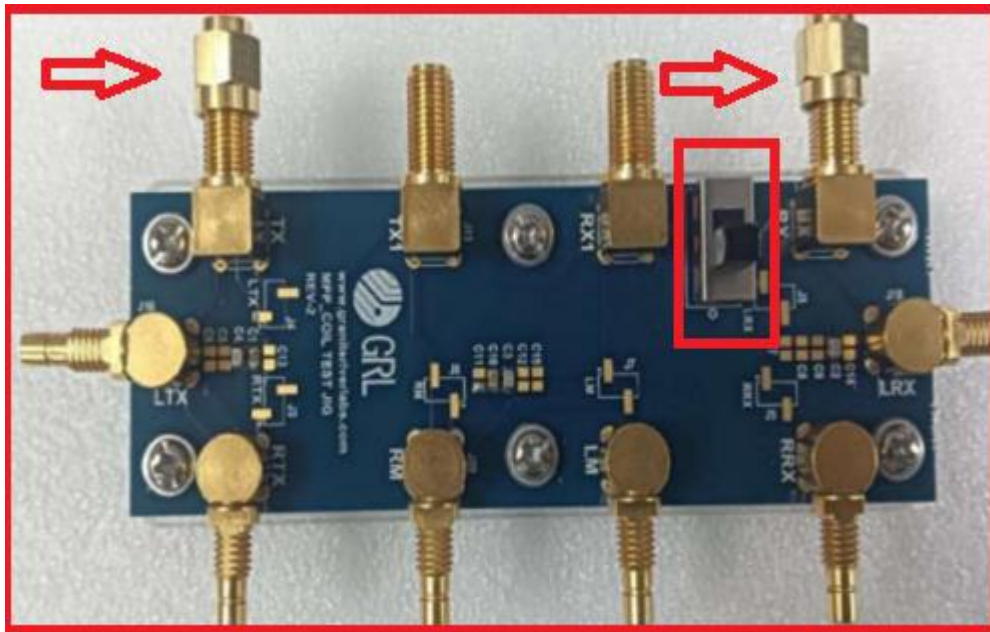
3. **Question:**

What are the jig measurement precautions and how should the jig connection be set up?

Answer:

Before measuring the jig values, connect 0-ohm terminators to both TX and RX ports of the jig, as indicated in the image below.

Ensure that the jig slider switch is turned off throughout the LQK measurement process. If the jig does not have a switch, you may ignore this step.


4. **Question:**

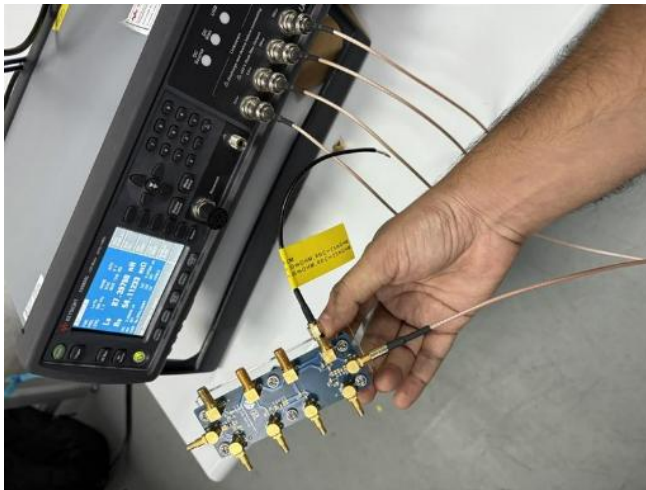
What are Steps 3a, 4a, 9a and 10a, and how are these values measured?

Answer:

If the Tx coil does not have any external leads, for example, in the case of a GRL Platform Solutions Tx coil where the wire is directly connected to the coil, you can simply connect the Tx coil cable wire to the jig and measure L_txl and R_txl. Record these values under Step 3a.

For example, when connecting the Rx coil cable to the test jig — if you connect the SMB wire to the LRX port — only the Ls (inductance) value from the LCR meter should be considered.

Do not consider the Rs (resistance) value in this case.



Note: For the GRL Platform Solutions coil cable values, there is no need to measure them manually, as GRL Platform Solutions has already measured and documented these values in the calibration report.

For example, if you have an Rx device, you must use a GRL Platform Solutions Tx coil. In such cases, the coil number will be printed on the back of the GRL Platform Solutions Tx coil. Using this coil number, the corresponding calibration report should be opened, and the pre-measured values from GRL Platform Solutions should be noted in Step 3a.

For instance, if you are using coil 'GRL-MP1-2024655', then you will need to record the corresponding values for 360 kHz and 128 kHz from the calibration report in Step 3a.

Coil Cable+LCR JIG Parasitic Measurements			
Coil Type	Parameter	Measured @360kHz	Measured @128kHz
ID: GRL-C3-TPT-MP1	L_{txl} (nH)	60+21=81	62+22=84
Sl. No.: GRL-MP1-2024655	R_{txl} (mΩ)	35+20=55	30+21=51

STEP 3a Measure the ATL's TPT cable at 360k, enter values in this step.				
Variable	Description	Unit	360 kHz	Corrected
L _{txl}	Inductance of the TPT coil loads (ATL cable)	nH	81.000	0.081
R _{txl}	AC resistance of the TPT coil loads (ATL cable)	mΩ	55.000	0.055

STEP 9a Measure the ATL's TPT cable at 128k, enter values in this step.				
Variable	Description	Unit	128 kHz	Corrected
L _{txl}	Inductance of the TPT coil loads (ATL cable)	nH	84.000	0.084
R _{txl}	AC resistance of the TPT coil loads (ATL cable)	mΩ	51.000	0.051

For GRL Platform Solutions cables, you can refer to the calibration report to obtain the cable values for the GRL Platform Solutions Tx and Rx coils. These values should be recorded in Steps 3a, 9a and Steps 4a, 10a of the sheet.

If you are a Tx or Rx vendor and do not have the cable values, connect your cable to the jig the same way it is done for the GRL Platform Solutions coils. Measure the values and enter them into the sheet accordingly.

Note: When connecting the cable wire, ensure that the other end of the cable is shorted during the measurement.

5. **Question:**

What are Steps 3b, 4b, 9b and 10b, and how should these values be filled in?

Answer:

If an external bridge wire is connected along with the coil, the first wire needs to be measured separately by connecting it to the jig.

After obtaining the measured value, subtract the previously measured jig value from it.

For example:

If the first wire gives a reading of 80, and the jig measurement (already noted in the sheet) is 24, then the actual value to be recorded is:

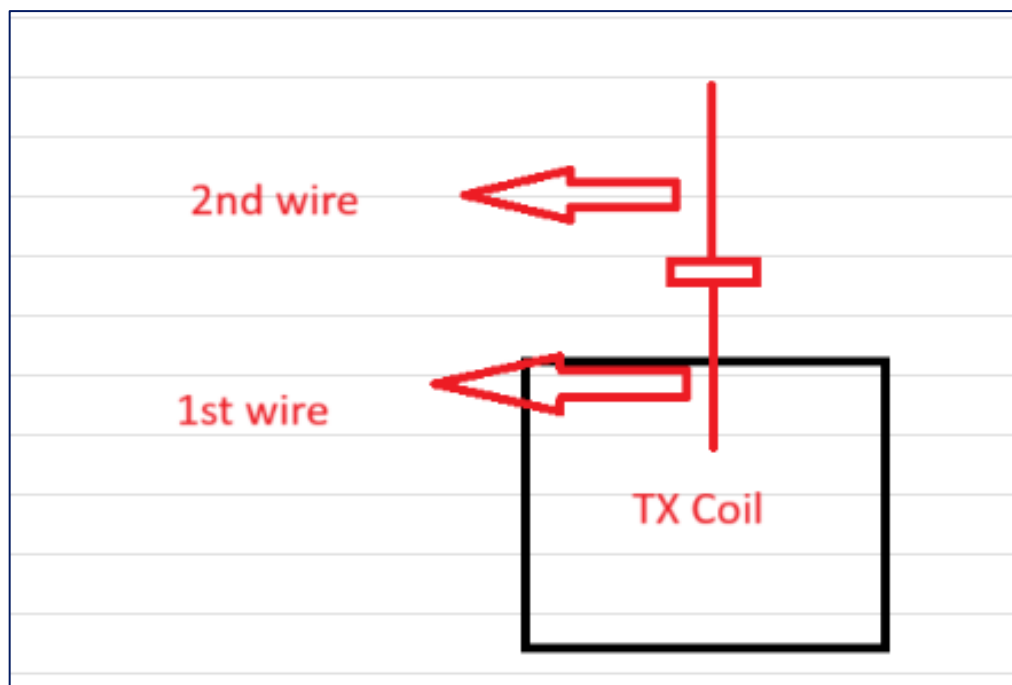
$$80 - 24 = 56$$

The resulting value (56) — whether it is L_{rxl2} or R_{rxl2} — should be updated under Step 3b, 9b, 4b or 10b, based on the type of coil measured.

For example, after noting the L_{rxl2} value, you need to measure the R_{rxl2} value in the same way and record it in the R_{rxl2} field.

STEP 3b Enter TPR vendor's coil lead values for 360k in this step.					
TPR	Variable	Description	Unit	360 kHz	Corrected
internal coil conn.	L _{rxl2}	Inductance of the TPR coil leads (TPR internal)	nH	56.0000	0.0560
	R _{rxl2}	AC resistance of the TPR coil leads (TPR internal)	mΩ		0.0000

Note: If there is no additional lead, you can ignore these steps — it is not required to fill in Steps 3b, 9b, 4b and 10b.



6. Question:

When do the other ports of the test jig need to be shorted and used?

Answer:

In real-world scenarios, test engineers typically do not have visibility into how the coil windings are designed.

In such cases, as recommended, you can short the TX and RX ports as shown in the reference video and outlined in the guidance questions, and then proceed with the measurements.

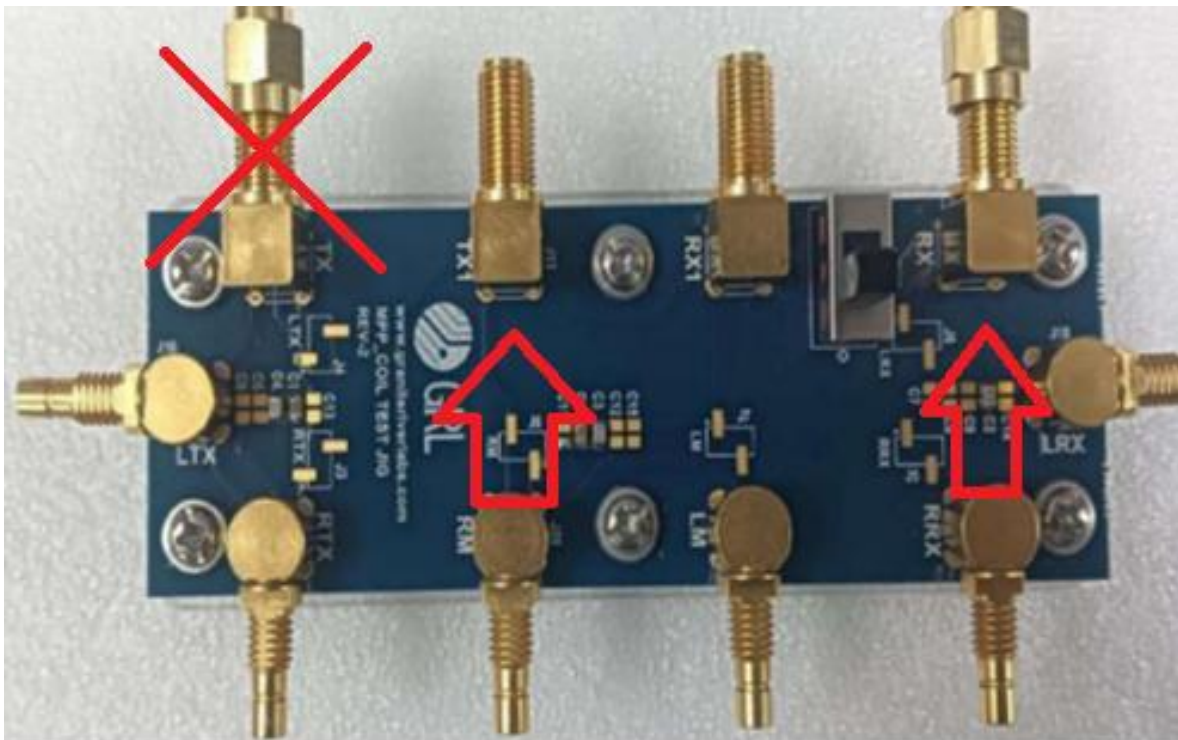
After measuring the values using the LCR meter, if the readings are significantly different (such as the highlighted L'm value shown below), the issue may be due to the coil winding polarity.

STEP 5 Follow LCR meter Coil measurement Procedure at 360k, enter results here.

Variable	Description	Unit	360 kHz	Corrected
L'tx	Inductance at the coil terminals of the DUT	μH	16.183	16.113
L'rx	Inductance at the coil terminals of the TPR	μH	20.329	20.258
R'tx	AC resistance at the coil terminals of the DUT	m Ω	1392.800	1.347
R'rx	AC resistance at the coil terminals of the TPR	m Ω	2257.000	2.215
L'm	Inductance at the coil terminals of the mated DUT and TPR	μH	69.542	-16.473
R'm	AC resistance at the coil terminals of the mated DUT and TPR	m Ω	6704.000	-1.472
Ki	Magnetic coupling between the DUT and TPR			-0.912
Kr	Resistive coupling between the DUT and TPR			-0.852

No Offset (r=0, z=0)

To resolve this, short the TX1 port and RX port as shown in the image below, and restart the procedure from the beginning — including re-measuring the jig values.



7.

Question:**In the WPC LQK spreadsheet, is it allowed to edit fields such as units or formulas?**

Answer:

Ensure that no part of the WPC LQK spreadsheet is modified except the yellow highlighted input boxes, where the readings are typically entered.

Modifying other areas, such as units, formulas, or protected cells can affect the overall calculations and may lead to incorrect results throughout the sheet.

END_OF_DOCUMENT