

Manual for the RLC-Box "Standard" and "Deluxe"



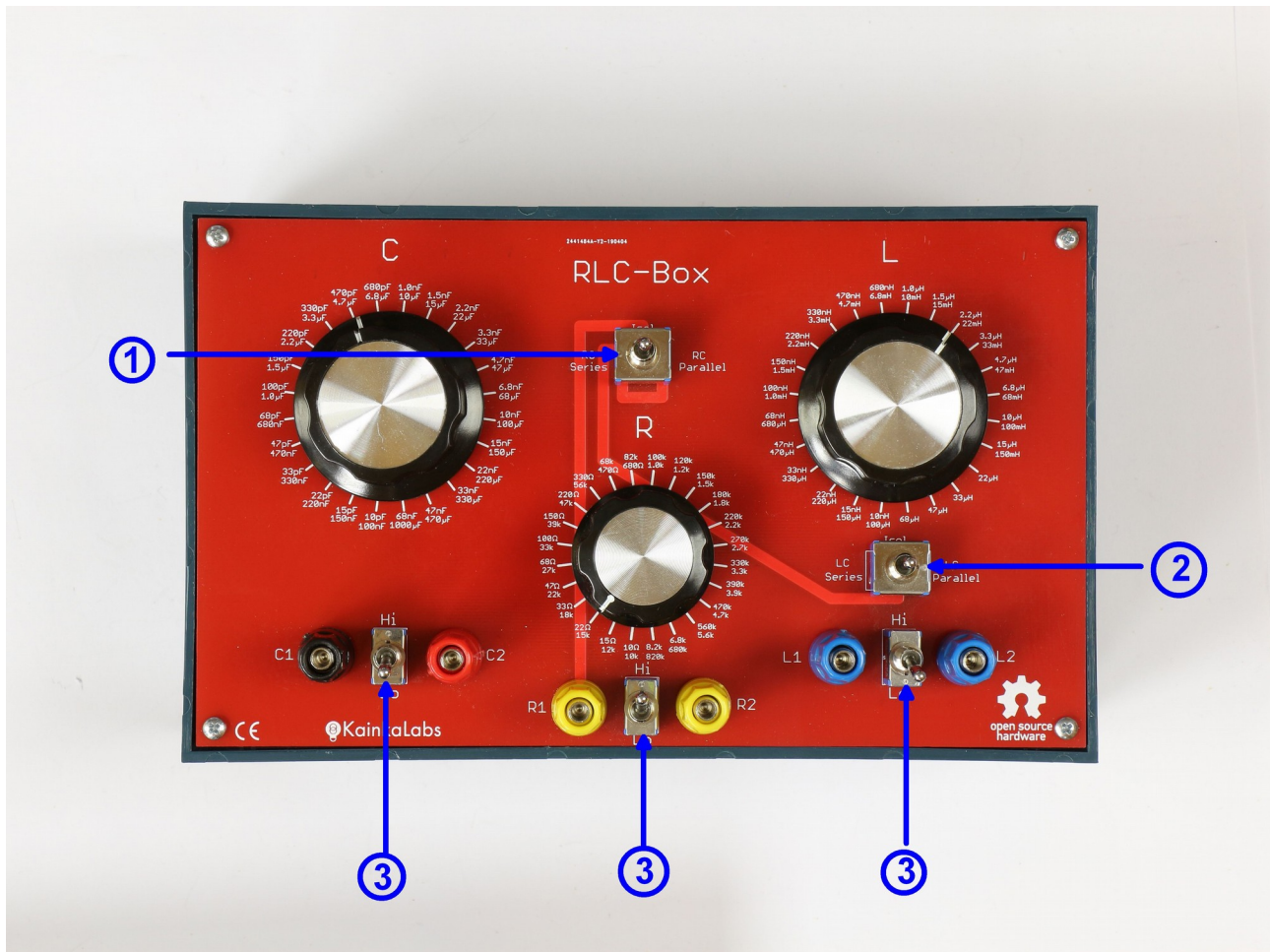
With one of these RLC-Boxes you can quickly select a value out of 48 resistors, 48 capacitors and 44 inductors in a range of up to 6 decades.

The "Deluxe"-version additionally lets you fine-tune the resistance value from 1Ω to $100k\Omega$ with two 10-turn potentiometers with an analog turning knob with a dial for 10 revolutions and 50 divisions per revolution. There you also get a sheet with the measured values of all capacitances and inductances.

The highlight is that you can not only use each of the 3 components (L/R/C) individually at the binding posts, but with the help of only 2 additional toggle-switches you can connect the 3 components in a multitude of serial and parallel combinations.

Thereby you can create RC- and LC-series or parallel connections, 1st and 2nd order high-pass and low-pass filters, band-pass and band-stop filters, RLC-series and parallel tank-circuits etc.

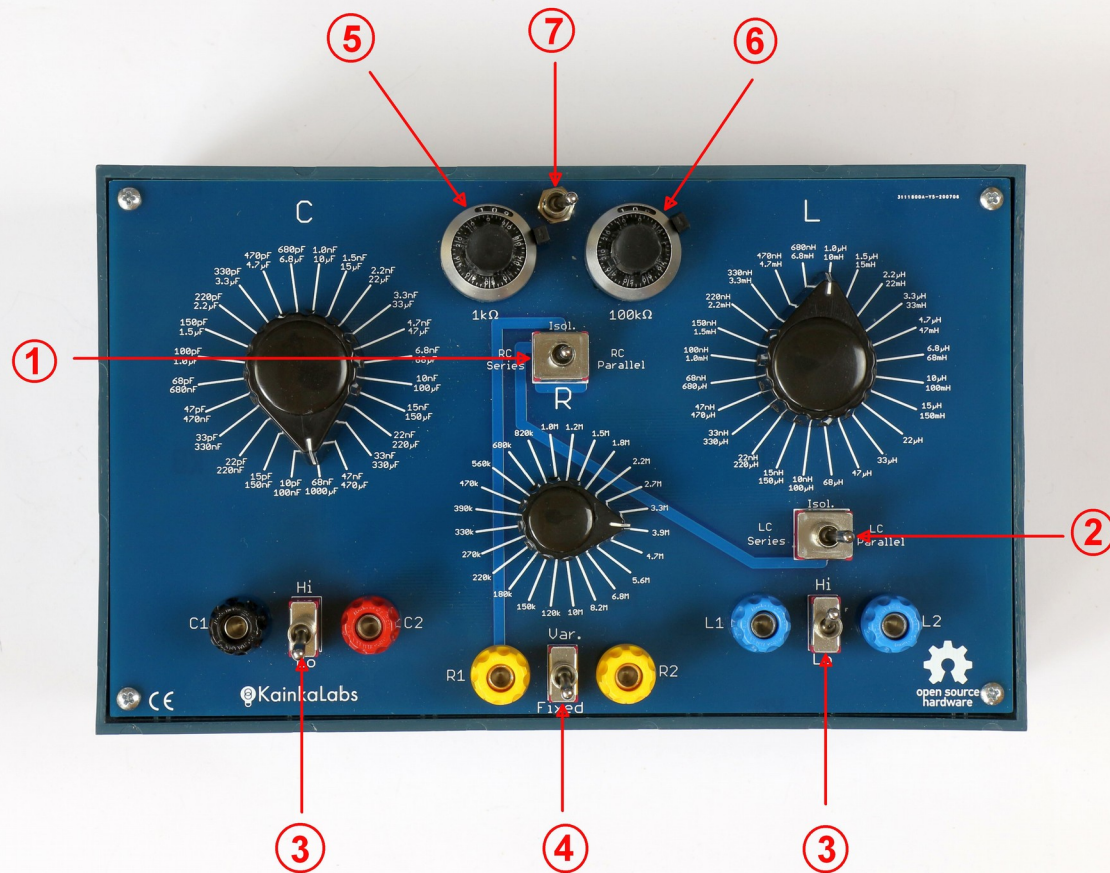
The necessary switch-settings and input, common and output terminals can be read off 4 labels on the sides of the box (or from this manual).



RLC-Box Standard-Version

- (1) Toggle-Switch (DPDT On-None-On) for R+C in parallel, R+C in series or mutually isolated
- (2) Toggle-Switch (DPDT On-None-On) for L+C in parallel, L+C in series or mutually isolated
- (3) Toggle-Switch (SPDT) for upper and lower range of the 24-position rotary switches for L, R, C

R(low)	= 10Ω - 8.2kΩ	(10Ω - 1kΩ E6-stepping; else: E12-stepping)
R(high)	= 10kΩ - 820kΩ	(E12-stepping)
C(low)	= 10pF - 68nF	(E6-stepping)
C(high)	= 100nF - 1000μF	(E6-stepping)
L(low)	= 10nH - 68μH	(E6-stepping)
L(high)	= 100μH - 150mH	(E6-stepping)



RLC-Box Deluxe-Version

- (1) Toggle-Switch (DPDT On-None-On) for R+C in parallel, R+C in series or mutually isolated
- (2) Toggle-Switch (DPDT On-None-On) for L+C in parallel, L+C in series or mutually isolated
- (3) Toggle-Switch (SPDT) for upper and lower range of the 24-position rotary switches for L, C. (Ranges as in Standard-Version)
- (4) Toggle-Switch (SPDT) for fixed (24-position rotary switch) and variable range (2x10-turn pots) for R: 120kΩ-10MΩ in E12-Stepping
- (5) 1kΩ 10-turn potentiometer with analog turning knob with dial for 10 revolutions and 50 divisions per revolution
- (6) 100kΩ 10-turn potentiometer with analog turning knob with dial for 10 revolutions and 50 divisions per revolution
- (7) Toggle-Switch (SPDT) for selecting 1kΩ or 100kΩ potentiometer

**The turning knobs for the potentiometers have a locking-lever.
Do not to try to turn the knob while it is locked!**

Technical data:

- Fixed Resistors:
 - SMD12
 - 1% tolerance
 - ≤ 100 ppm temperature coefficient
 - 0,25W power-rating
 - ≥ 50 VDC voltage rating
- 10-turn potentiometers:
 - 5% tolerance of nominal value
 - 0,25% linearity
 - ≤ 100 ppm temperature coefficient
 - 2W power-rating
 - ≥ 50 VDC voltage rating
- Capacitors:
 - ≥ 50 VDC/30VAC voltage rating
 - 10pF...68nF: SMD1206 COG/NP0 ceramic capacitors 5% tolerance
 - 100nF...1 μ F: Polypropylene plastic film capacitors 5%/10% tolerance
 - 1.5 μ F...10 μ F: PET plastic film capacitors 5%/10% tolerance
 - 15 μ F...1000 μ F: Aluminum electrolytic capacitors; 10%/20% tolerance
 - parasitic parallel capacitance: ca. 10...20 pF
- Inductors:
 - 10nH-680nH: SMD1210; Fastron AS1210
 - 1 μ H...150mH: (mostly) cylindrical Fastron inductors
 - parasitic series inductance: 100...250 nH
 - tolerance 5%/10%/20%
 - current rating: see table
- Size: 215x110x130 mm
- Weight: 680g (Standard) / 730g (Deluxe)

#	Typ	RC-Schalter	LC-Schalter	Eingang	Common GND	Ausgang	Eckfrequenz/Resonanzfrequ.	Güte
1.	R (isoliert)	Independent	Independent	R1+R2				
2.	L (isoliert)	Independent	Independent	L1+L2				
3.	C (isoliert)	Independent	Independent	C1+C2				
4.	RC-Parallelschaltung	Parallel	Independent	R2/C2	R1/C1			
5.	RC-Reihenschaltung	Series	Independent	R1		C1		
6.	LC Parallel-Schwingkreis	Independent	Parallel	C2/L1	C1/L2		$1/(2*\pi*SQRT(L*C))$	
7.	LC Reihen-Schwingkreis	Independent	Series	C2		L1	$1/(2*\pi*SQRT(L*C))$	
8.	RC Tiefpass (6dB/Oct.)	Series	Independent	R1	C1	R2/C2	$1/(2*\pi*R*C)$	
9.	RC Hochpass (6dB/Oct.)	Series	Independent	C1	R2/C2	C2	$1/(2*\pi*R*C)$	
10.	RLC Low-pass (12dB/Oct.)	Series	Independent	R1	C1	R2/C2	$1/(2*\pi*R*C)$	
11.	RLC High-pass (12dB/Oct.)	Series	Independent	C1	R2/C2	C2	$1/(2*\pi*R*C)$	
12.	RLC Series Band-pass	Series	Series	L1	R1	R2/C2	$1/(2*\pi*SQRT(L*C))$	$1/R*SQRT(L/C)$
13.	RLC Series Band-stop	Series	Series	R1	L1	R2/C2	$1/(2*\pi*SQRT(L*C))$	$1/R*SQRT(L/C)$
14.	RLC Parallel Band-pass	Series	Series	R1	C1/L2	C2/R2/L1		
15.	RLC Parallel Band-stop	Series	Series	C1/L2	R1	C2/R2/L1		
16.	RLC Series Tank-Circuit	Series	Series	R1		L1	$1/(2*\pi*SQRT(L*C))$	$1/R*SQRT(L/C)$
17.	RLC Parallel Tank-Circuit	Parallel	Parallel	R2/C2/L1		R1/C1/L2	$1/(2*\pi*SQRT(L*C))$	

Funktionen, Schalterstellung, Klemmenbelegung, Eck-/Resonanzfrequenz, Güte

In obiger Tabelle sind die Schalterstellungen und die Anschlussklemmen-Belegung für die verschiedenen Funktionen zusammen mit einigen Kenndaten aufgelistet.

Die ersten 3 Einträge sind für die isolierte Verwendung der Bauteile:

1. Einstellung für isolierte Verwendung von R
2. Einstellung für isolierte Verwendung von L
3. Einstellung für isolierte Verwendung von C

Es folgen die Zusammenschaltung von Widerstand und Kondensator zu einer Reihen- oder Parallel-Schaltung. Die Reihenschaltung wird z.B. als sog. "Snubber" (auch "Boucherot-" bzw. "Zobel-Glied") eingesetzt:

4. RC-Parallelschaltung
5. RC-Serienschaltung

Das gleiche für die Zusammenschaltung von Kondensator und Induktivität zu einem Reihen- oder Parallel-Schwingkreis.

Die Dämpfung wird hier im Wesentlichen durch den internen Serienwiderstand der Induktivität begrenzt:

6. LC-Parallelschaltung
7. LC-Serienschaltung

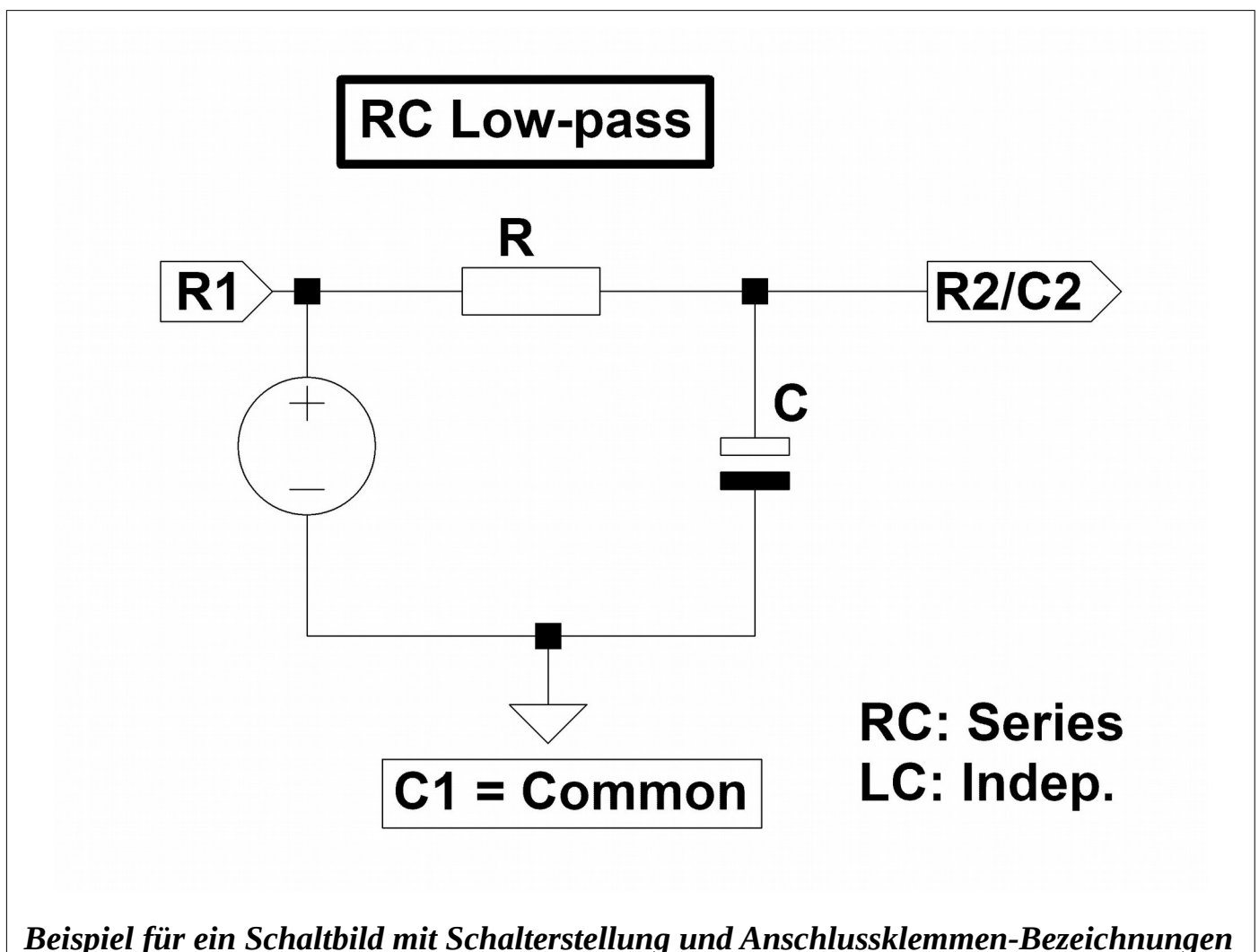
Auf den nächsten Seiten folgen die Filterschaltungen und Schwingkreise, die auch auf den Aufklebern der RLC-Box dargestellt sind.

Ein Kondensator ist immer als Elko dargestellt, um die Lage der Anode bei Kapazitäten über $10\mu\text{F}$ (=rote Polklemme) in der Schaltung anzuzeigen. Für die Spule wurde das alte/amerikanische Symbol verwendet, um die "Lesbarkeit" für den englischsprachigen Raum zu verbessern bzw. um Verwechslungen zu vermeiden.

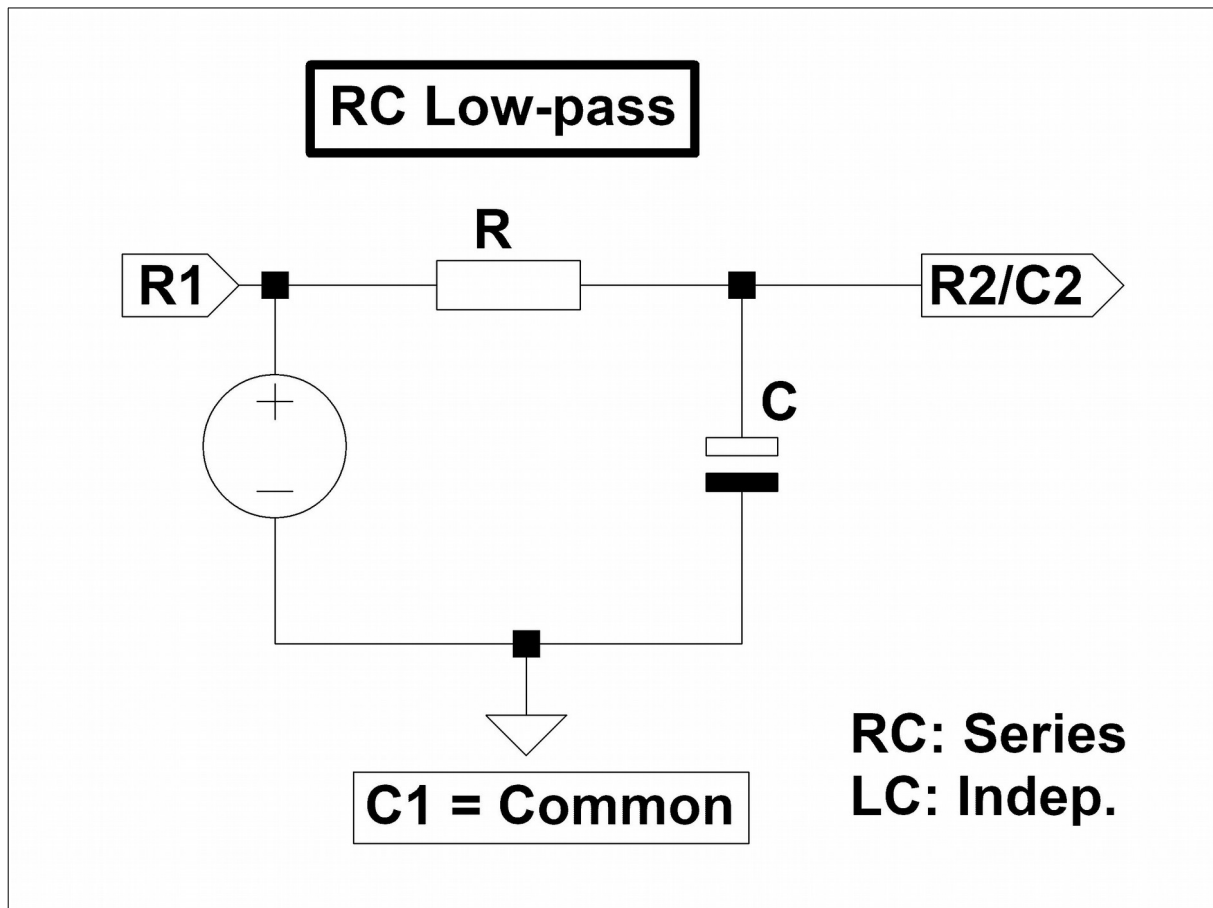
Die Schalterstellung der beiden Kippschalter ist auf dem Bild jeweils rechts unten dargestellt.

Die Anschlussbuchsen (z.B. "R1") für Ein-/Ausgang und der gemeinsame Anschluss der Schaltung (=Common/Ground/Masse) sind an den entsprechenden Anschlüssen eingezeichnet.

Wenn ein Anschluss parallel an mehreren Buchsen gleichzeitig anliegt, sind diese durch einen Schrägstrich getrennt (z.B. "R2/C2")



8. RC-Tiefpass 1.Ordnung (6dB/Oktave = 20dB/Dekade)



Das Bild zeigt den klassischen RC-Tiefpass 1. Ordnung mit 6dB/Oktave Steilheit.

3dB-Grenzfrequenz: $f_g = \frac{1}{2\pi RC}$

Amplitude linear: $A = \frac{1}{\sqrt{1+(2\pi f RC)^2}}$

Amplitude in dB: $A = 20 * \log\left(\frac{1}{\sqrt{1+(2\pi f RC)^2}}\right)$

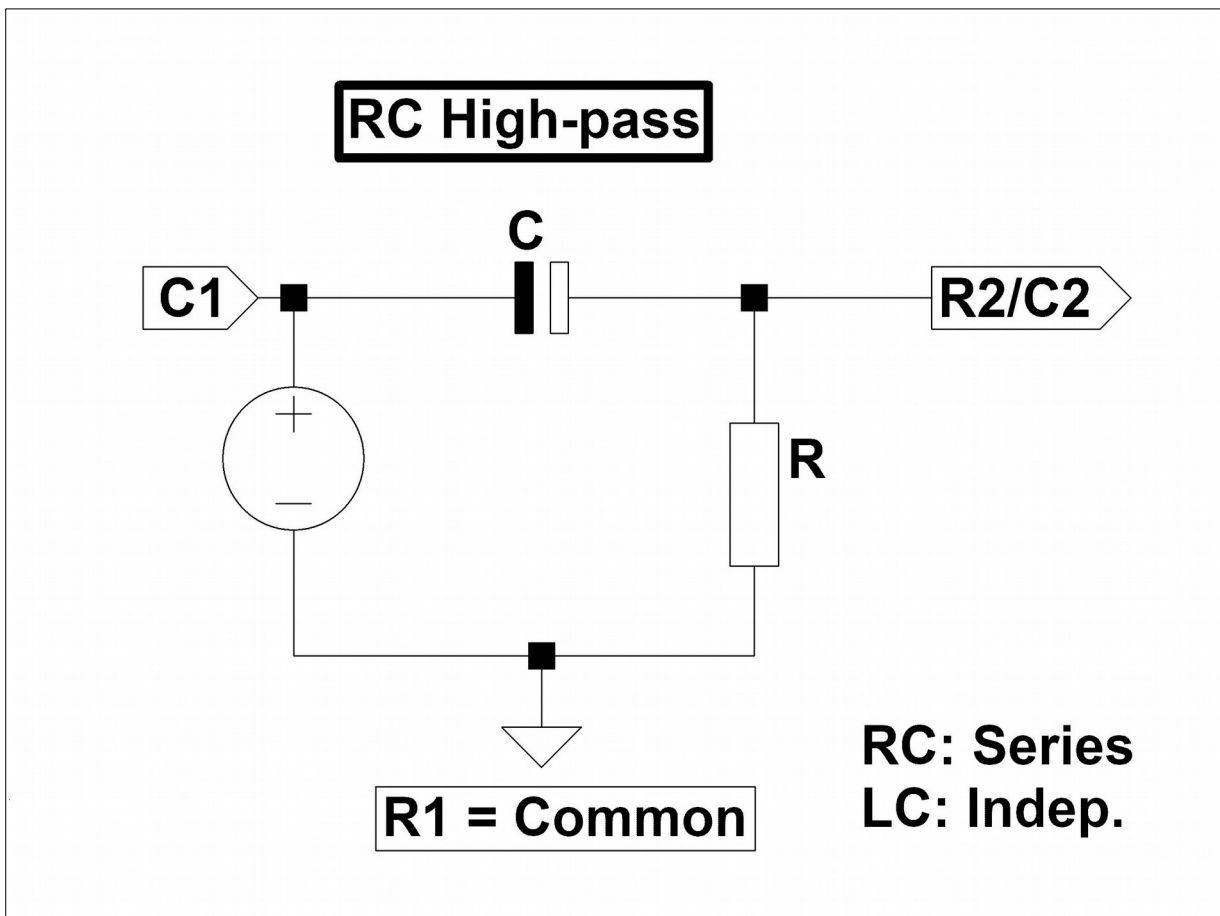
Phasenverschiebung: $\phi = -\arctan(2\pi f RC)$

Zeitkonstante (bei Verwendung als RC-Zeitglied): $\tau = RC$

Die Einstellzeit bei Verwendung als RC-Zeitglied:

τ	$2,3\tau$	$4,6\tau$	$6,9\tau$
37%	10%	1%	0,1%

9. RC-Hochpass 1.Ordnung (6dB/Oktave = 20dB/Dekade)



Das Bild zeigt den klassischen RC-Hochpass 1. Ordnung mit 6dB/Oktave Steilheit.

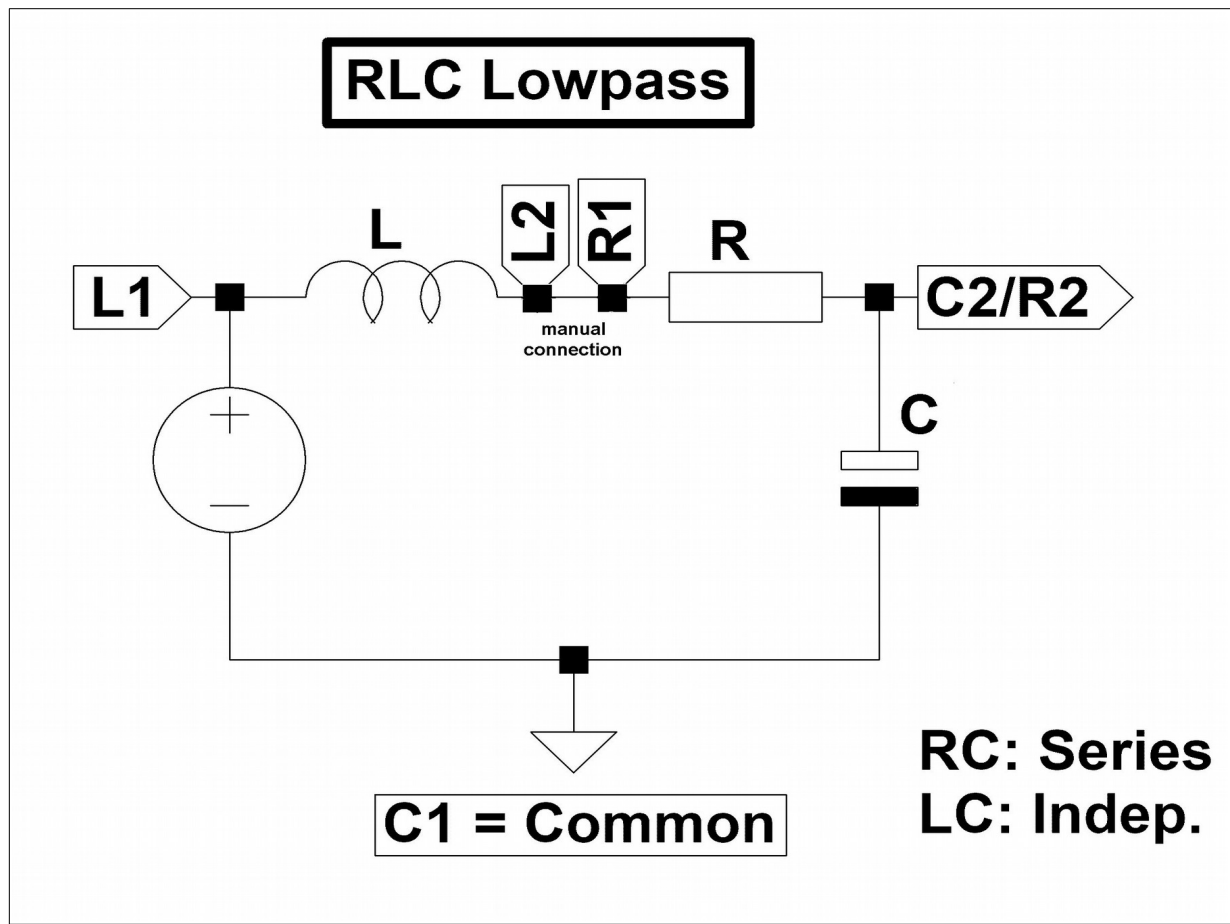
3dB-Grenzfrequenz: $f_g = \frac{1}{2\pi RC}$

Amplitude linear: $A = \frac{1}{\sqrt{1 + (1/(2\pi f RC))^2}}$

Amplitude in dB: $A = 20 * \log\left(\frac{1}{\sqrt{1 + (1/(2\pi f RC))^2}}\right)$

Phasenverschiebung: $\phi = \arctan(1/(2\pi f RC))$

10. RLC-Tiefpass 2.Ordnung (12dB/Oktave = 40dB/Dekade)



Das Bild zeigt eine Möglichkeit einen RLC-Tiefpass 2. Ordnung mit 12dB/Oktave Steilheit zu realisieren.

Hier muss ausnahmsweise eine zusätzliche Verbindung zwischen den Klemmen L2 und R1 hergestellt werden!

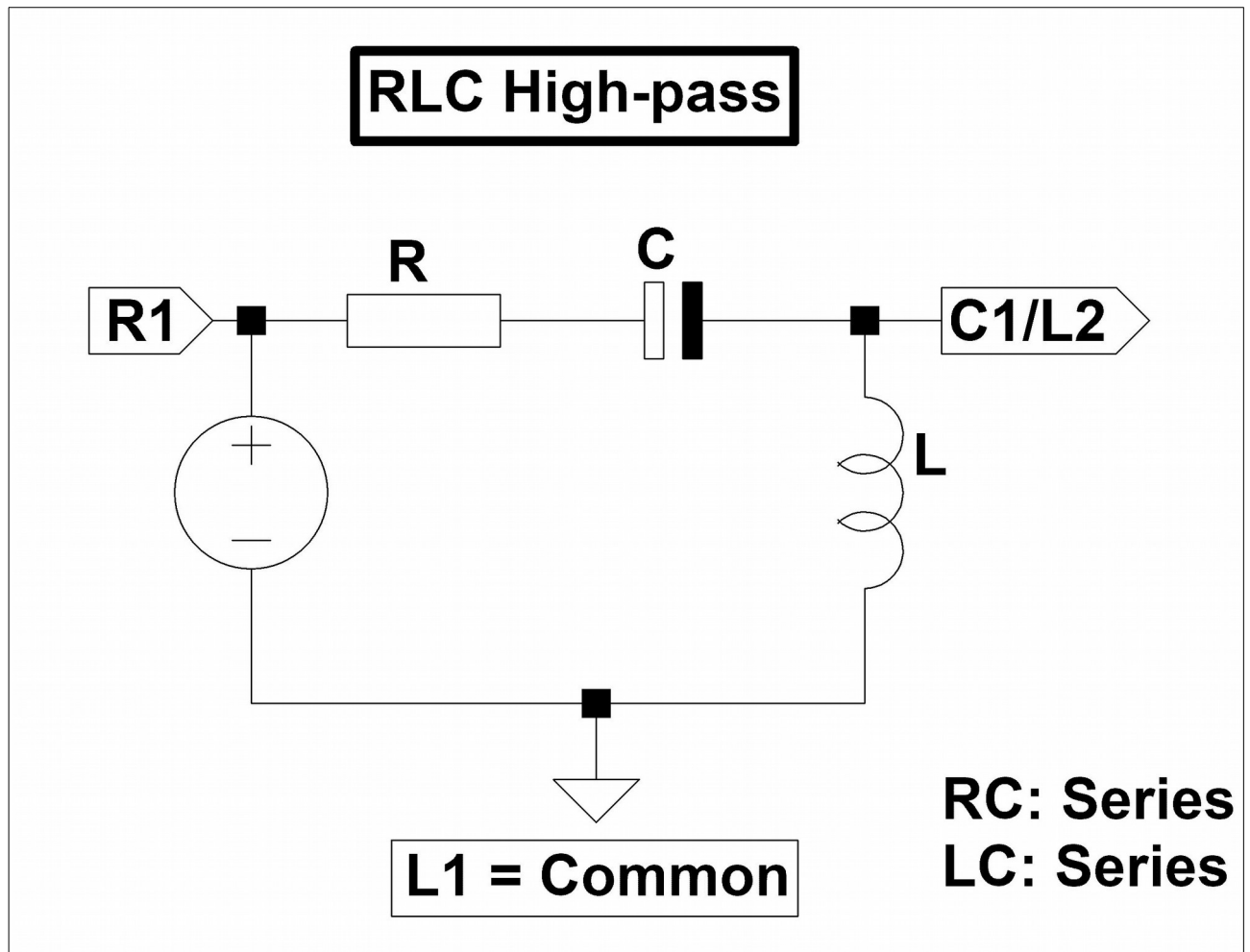
3dB-Grenzfrequenz:

Amplitude linear:

Amplitude in dB:

Phasenverschiebung:

11. RLC-Hochpass 2.Ordnung (12dB/Oktave = 40dB/Dekade)



Das Bild zeigt eine Möglichkeit einen RLC-Hochpass 2. Ordnung mit 12dB/Oktave Steilheit zu realisieren.

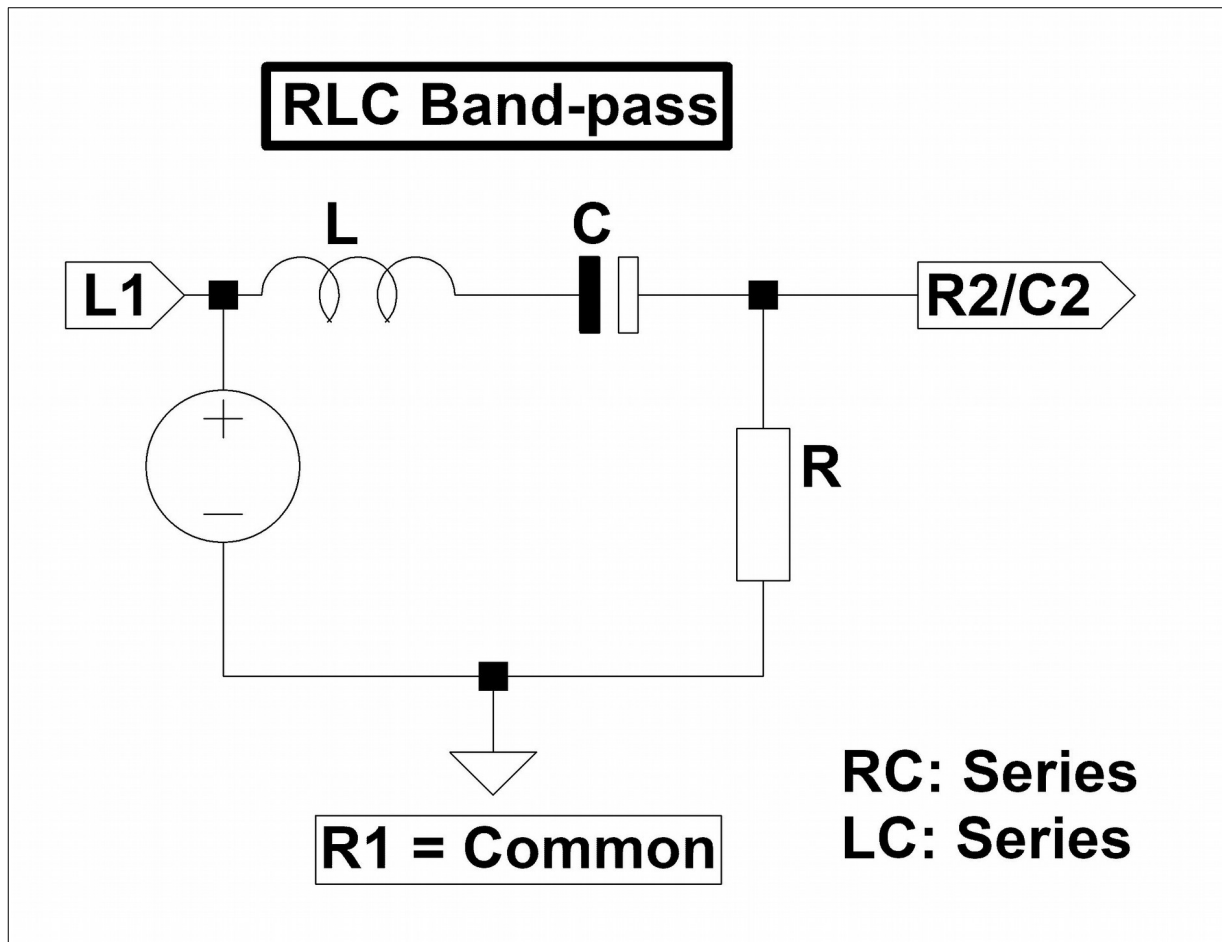
3dB-Grenzfrequenz:

Amplitude linear:

Amplitude in dB:

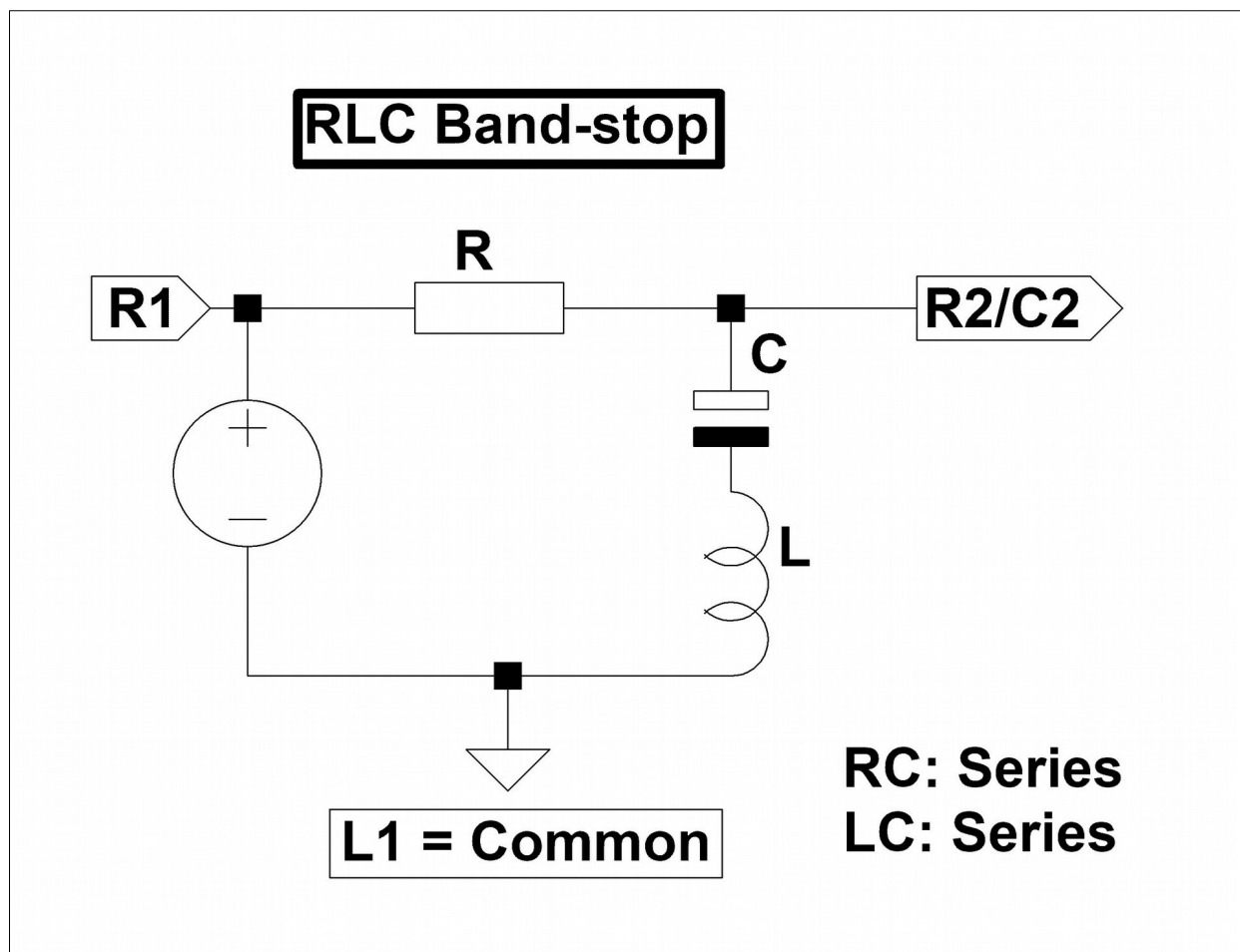
Phasenverschiebung:

12. RLC-Bandpass (Variante 1)



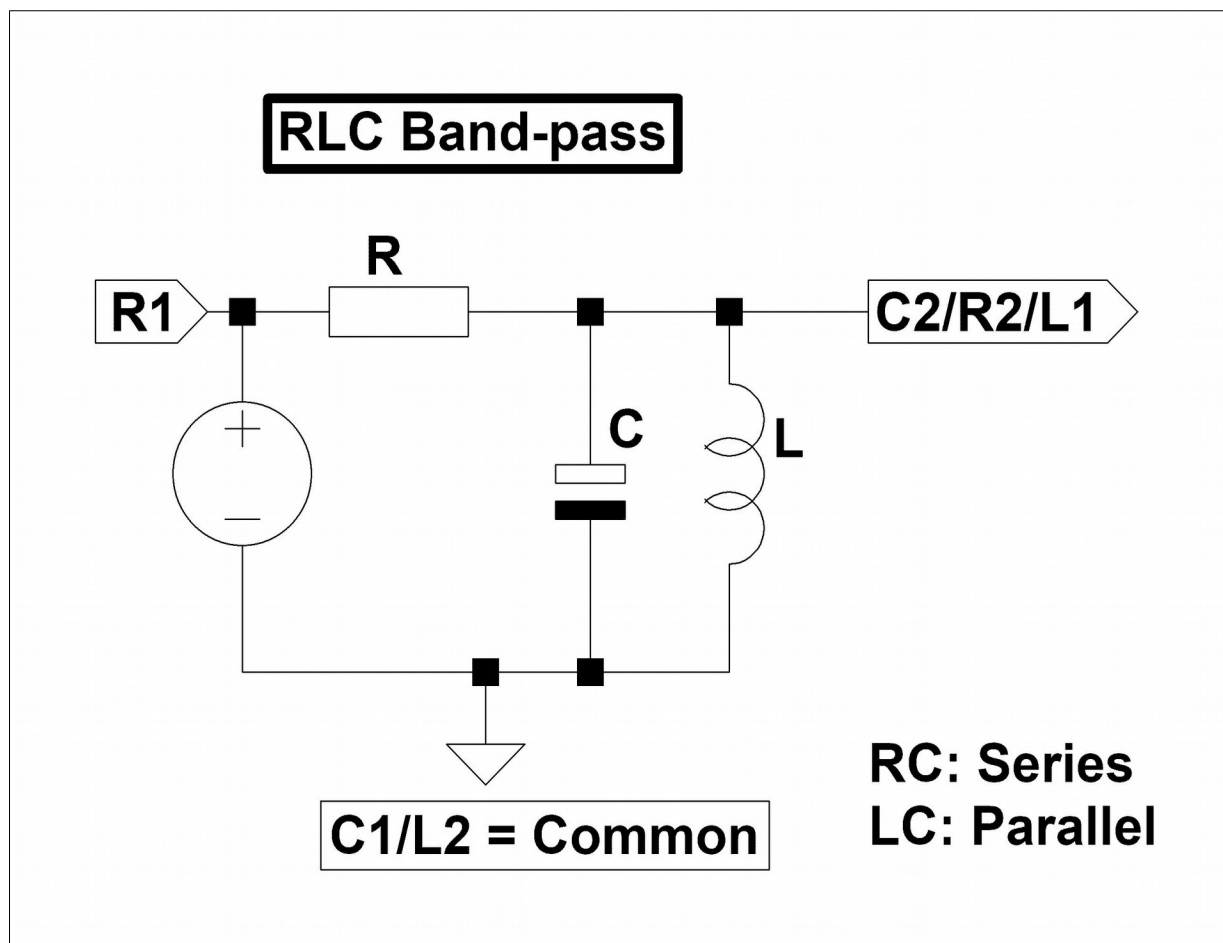
Das Bild zeigt eine Möglichkeit für einen RLC-Bandpass

13. RLC-Bandsperre (Variante 1)



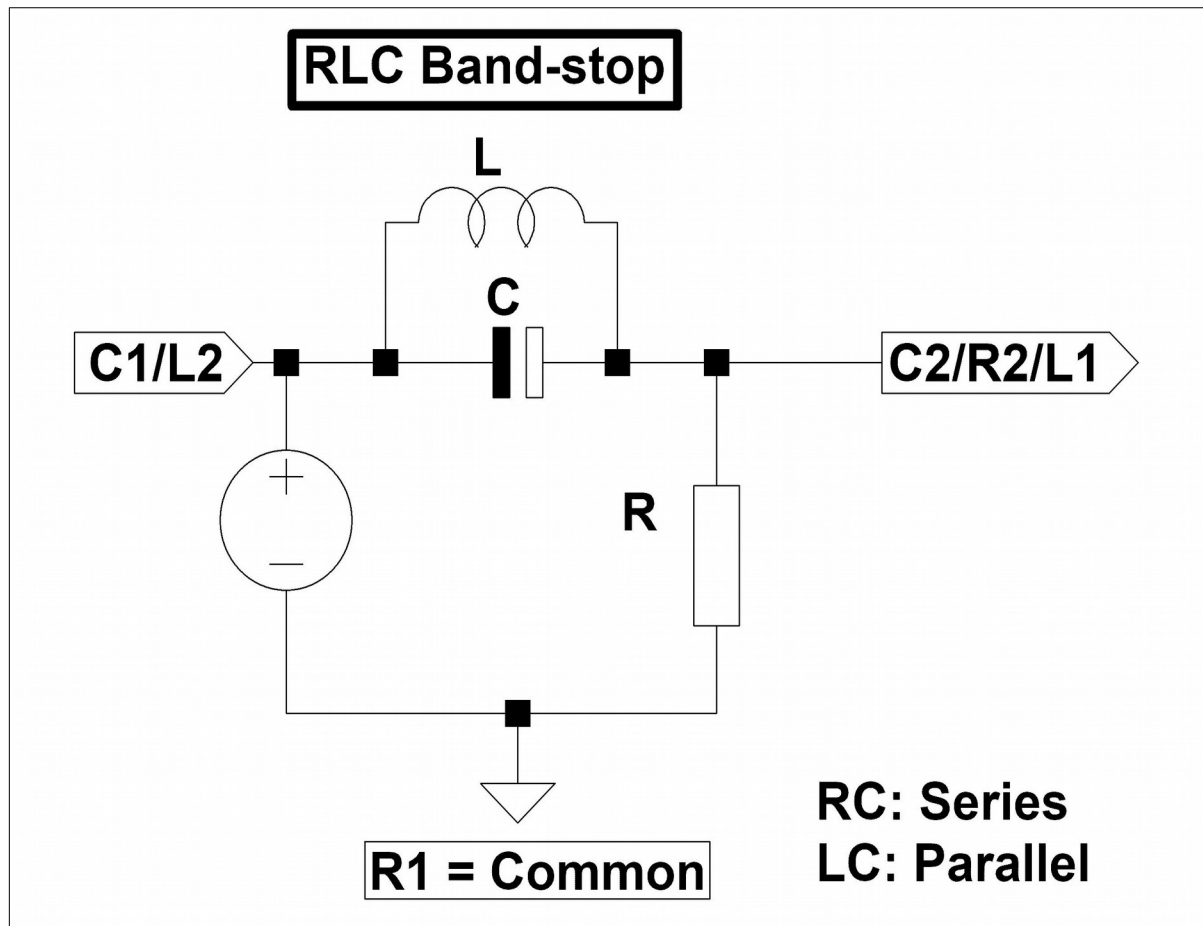
Das Bild zeigt eine Möglichkeit für eine RLC-Bandsperre

14. RLC-Bandpass (Variante 2)



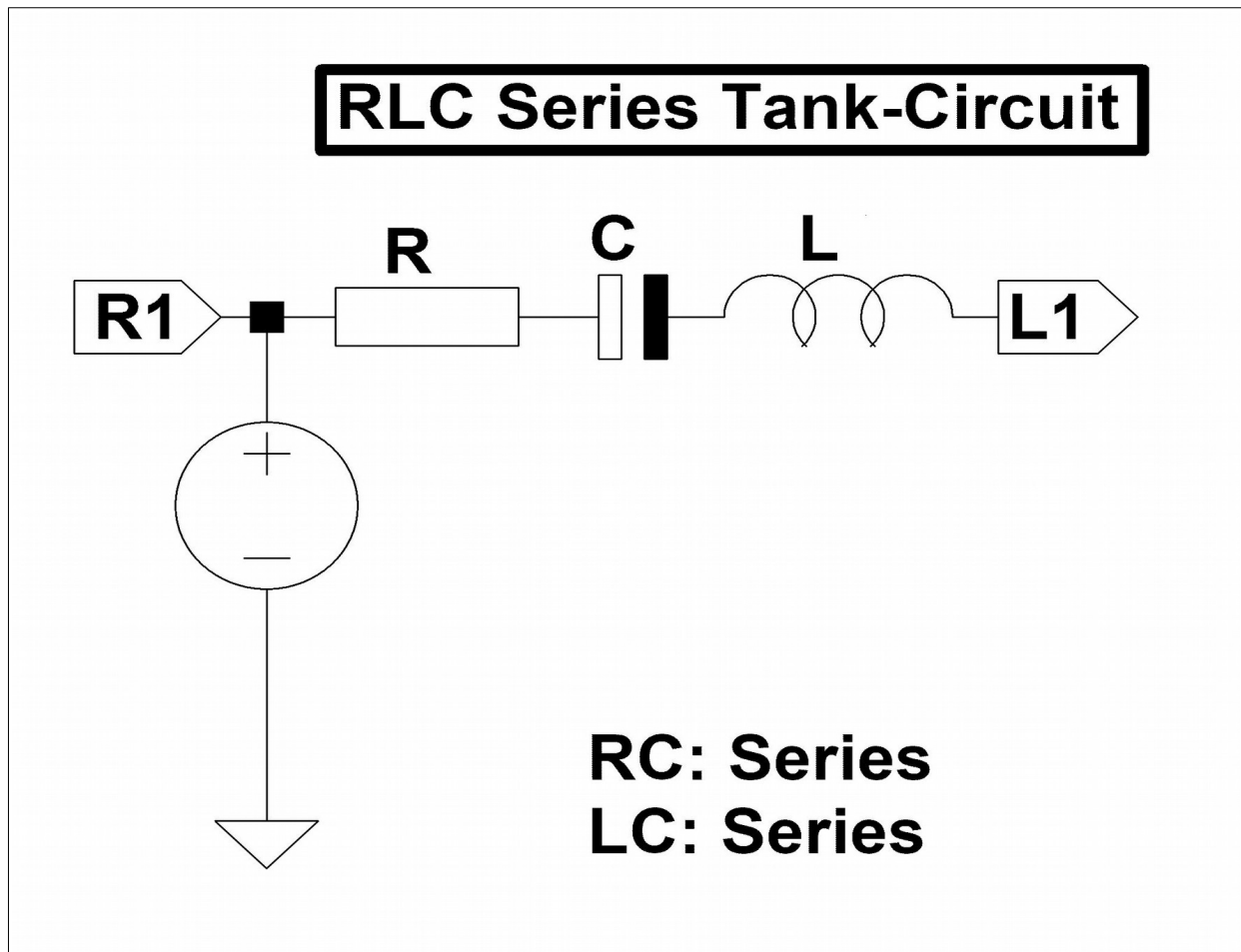
Das Bild zeigt eine Möglichkeit für einen RLC-Bandpass

15. RLC-Bandsperre (Variante 2)



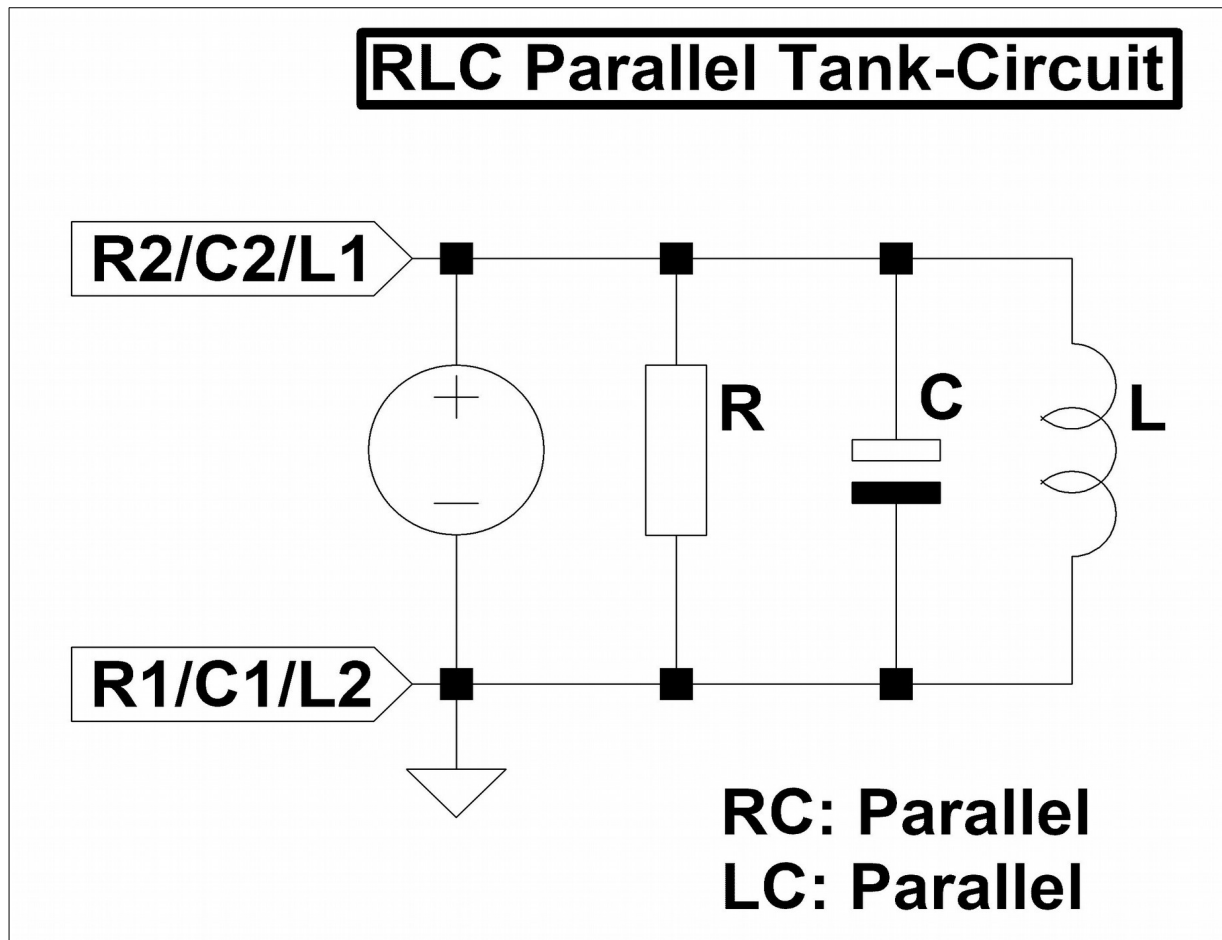
Das Bild zeigt eine Möglichkeit für eine RLC-Bandsperre

16. RLC-Serienschwingkreis



Das Bild zeigt einen (durch R1) gedämpften Serienschwingkreis.

17. RLC-Parallelschwingkreis



Das Bild zeigt einen (durch R1) gedämpften Parallelschwingkreis.

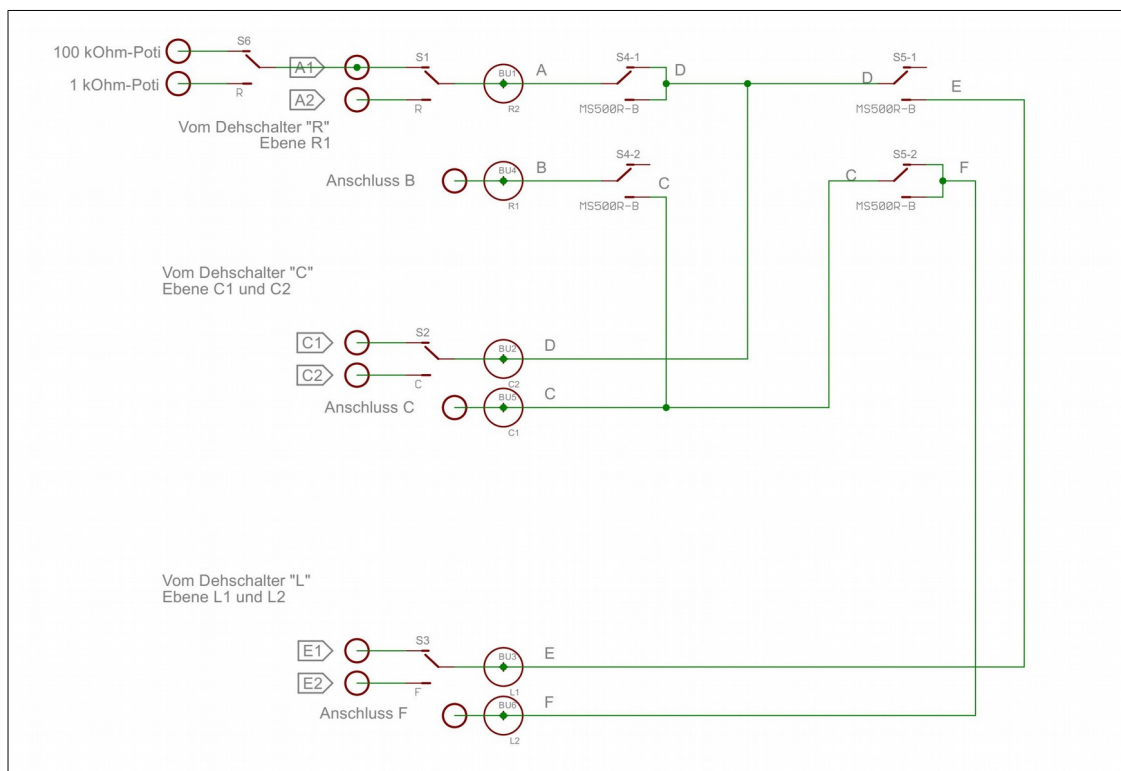
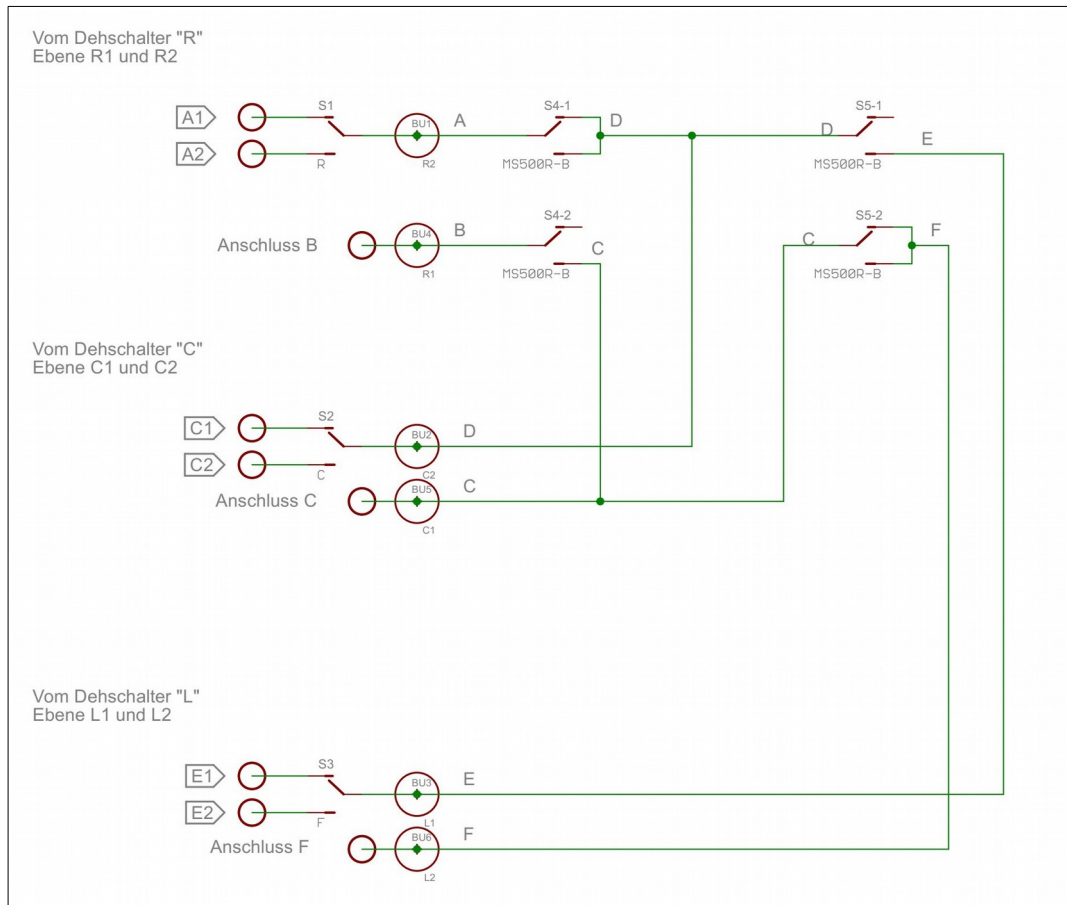
Technical Data of the used components

RESISTORS/ CAPACITORS		Tolerance:	Power- Rating:	Voltage- Rating:	Temperature -Coefficient:	tan δ:	Dielectric Absorbtion:
Fixed Resistors	SMD 1206	1%	250mW	200VDC	<=100ppm/K		
10-Turn Potentiometers		2%	2W / 50mA	>240VAC	50ppm/K		
Capacitors 10p...68n	SMD 1206	5%		>=50VDC	C0G/NPO		
Capacitors 100...1.0μ	WIMA MKP2	5% or 10%		>=63VDC	<=400ppm/K	<0.08% @ 10kHz	<0.05%
Capacitors 1.5μ...10μ	WIMA MKS2	5% or 10%		>=50VDC	<=400ppm/K	<1.5% @ 10kHz	<0.25%
Capacitors 15μ...1.000μ	Al-Electrolytic	10% or 20%		>=50VDC			

INDUCTORS (low):				INDUCTORS (high):					
Type:	SRF (MHz):	R-DC (Ω):	I (mA)	Nom.:	Type:	SRF (MHz):	R-DC (Ω):	I (mA)	Nom.:
Fastron 1210AS	4000	0.08	1000	10 nH	Fastron 09P/HCP				100 μH
Fastron 1210AS	3200	0.1	1000	15 nH	CTC CH8010	3.2	0.29	1000	150 μH
Fastron 1210AS	2200	0.1	1000	22 nH	Fastron 07HCP		0.38	640	220 μH
Fastron 1210AS	1800	0.11	1000	33 nH	Fastron 11PHC		0.53	970	330 μH
Fastron 1210AS	1500	0.13	1000	47 nH	Fastron 11PHC		0.83	1170	470 μH
Fastron 1210AS	1200	0.26	900	68 nH	Fastron 11PHC		1.35	960	680 μH
Fastron 1210AS	1100	0.26	850	100 nH	Fastron 09P/	1.6	2.6	280	1.0 mH
Fastron 1210AS	950	0.31	750	150 nH	Fastron 09P/	1.2	5.1	220	1.5 mH
Fastron 1210AS	760	0.5	670	220 nH	Fastron 11PHC		3.7	500	2.2 mH
Fastron 1210AS	650	0.62	590	330 nH	Fastron 11PH	0.6	3.7	190	3.3 mH
Fastron 1210AS	550	1.3	490	470 nH	Fastron 09P	0.65	11.5	130	4.7 mH
Fastron 1210AS	450	1.58	430	680 nH	Fastron 09P	0.57	17	110	6.8 mH
Fastron 07HCP		7	7500	1.0 μH	Fastron 11P	0.35	23	110	10 mH
Fastron HBCC	170	0.1	2100	1.5 μH	Fastron 11P	0.29	28	90	15 mH
Fastron 07HCP		0.01	6000	2.2 μH	Fastron 11P	0.25	39	80	22 mH
Fastron 07HCP		0.013	5000	3.3 μH	Fastron 11P	0.20	56	65	33 mH
Fastron 07HCP		0.018	4000	4.7 μH	Fastron 11P	0.18	73	55	47 mH
Fastron 07HCP		0.025	3800	6.8 μH	Fastron 11P	0.13	120	50	68 mH
Fastron 07HCP		0.04	2600	10 μH	Fastron 11P	0.11	155	40	100 mH
CTC CH6080	11	0.052	2100	15 μH	Fastron 11P	0.08	205	35	150 mH
Fastron 07HCP		0.055	2300	22 μH					
Fastron 07HCP		0.1	1500	33 μH					
Fastron 07HCP		0.1	1300	47 μH					
Fastron 07HCP		0.14	1100	68 μH					

Actual types & specifications may vary due to availability!

Circuit-Diagrams of the "Standard" and "Deluxe" Model

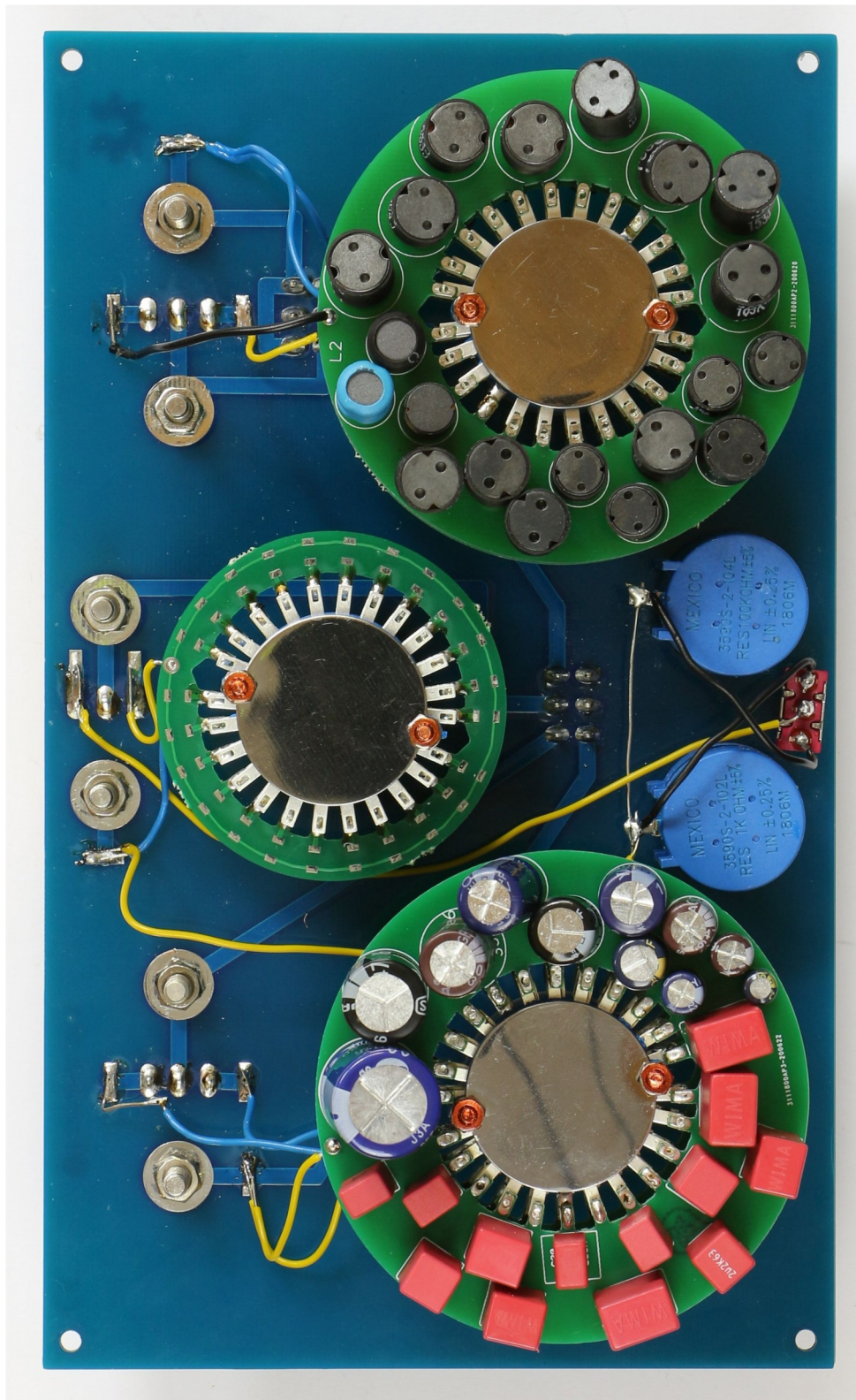


Inside the prototype of the "Deluxe" Version

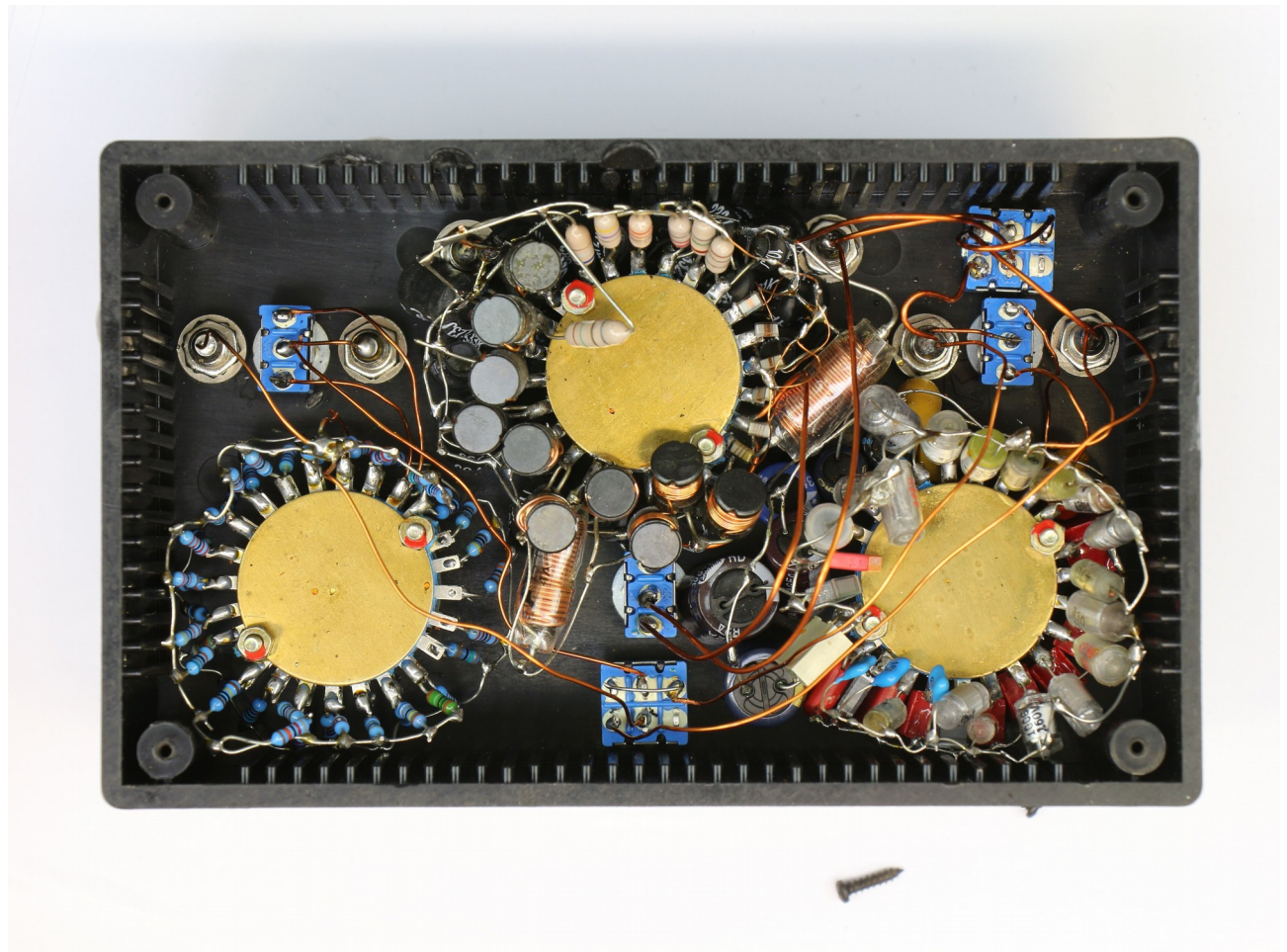
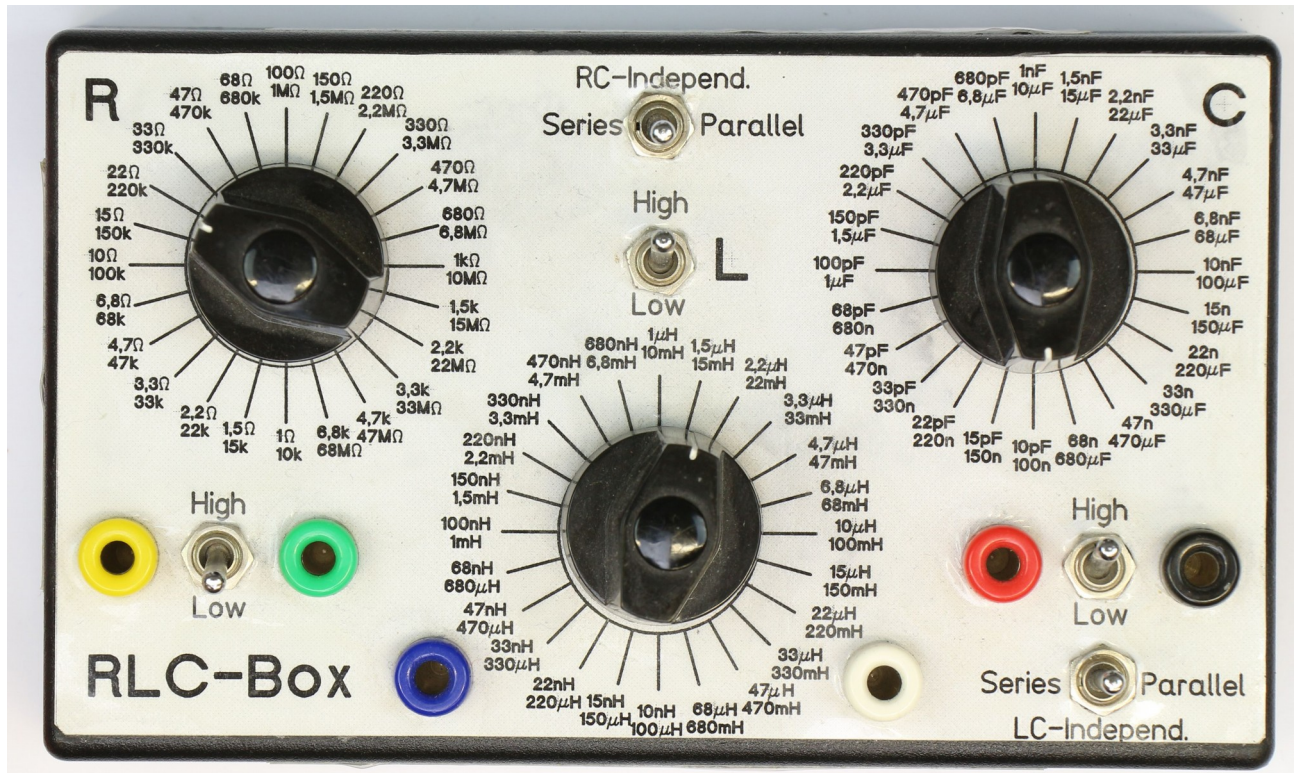
The PCBs for the inductors and capacitors are "double-stacked" and soldered directly to the rotary switch contacts.

You also can see the two blue 10-turn precision potentiometers.

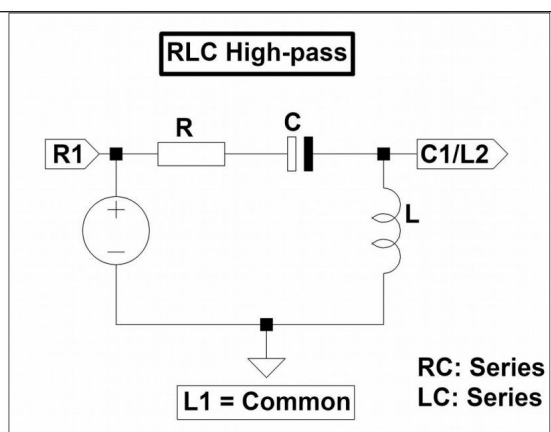
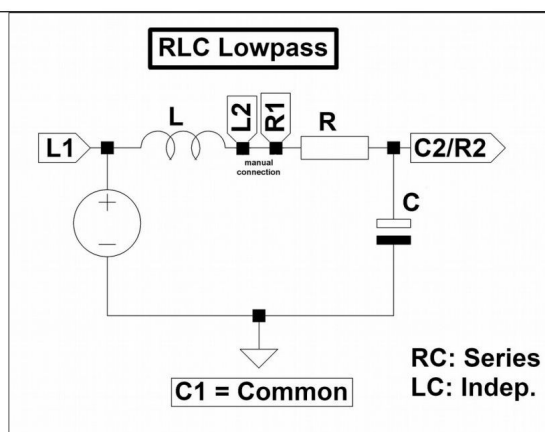
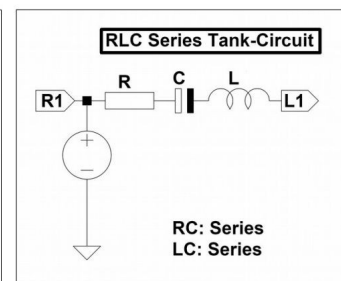
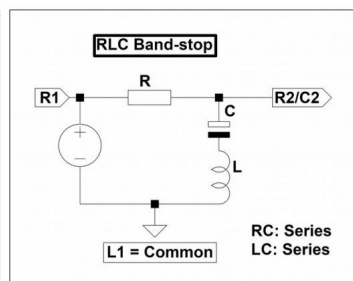
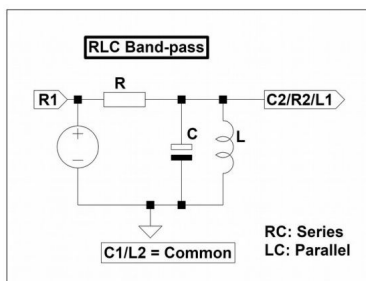
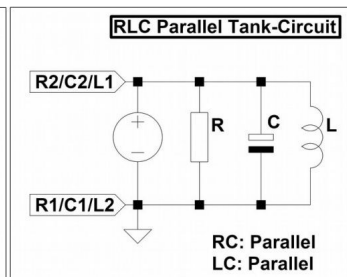
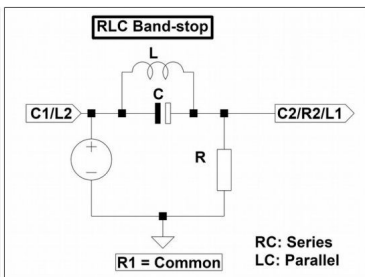
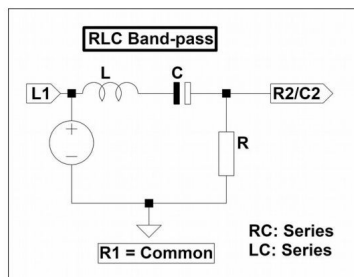
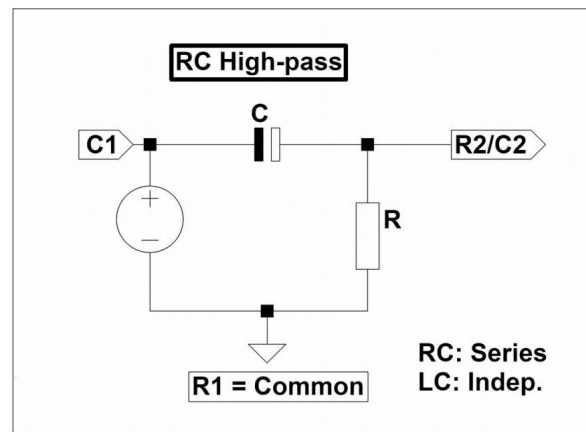
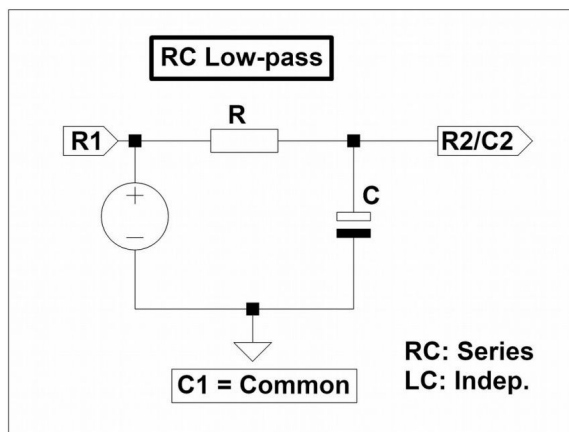
(In the standard version the rotary switch for the resistors also has double-stacked PCBs)



The "original" RLC-Box build around 2005 for personal use



Adhesive labels for the sides of the RLC-box (for custom cutout)



Protocol of the measured L- and C-values of the first prototype

You can see from the data that the parasitic parallel capacitance is around 15 pF and the paratic series inductance is around 100...150 nH.

The first decade of the inductances is therefore of no good use und will be left out in later version. Nevertheless the relatively low parasitic capacitance and inductance makes the RLC-Box also useable for RF up to perhaps 30 MHz (depending on the actual application)

Serial-No.: 2020007

Date: 11.08.20

LCR-Meter: Mastech MS5308

CAPACITORS (low):			
Type:	Nom.:	Measured:	Freq:
NP0/COG	10 pF	26 p	10kHz
NP0/COG	15 pF	31 p	10kHz
NP0/COG	22 pF	38 p	10kHz
NP0/COG	33 pF	48 p	10kHz
NP0/COG	47 pF	64 p	10kHz
NP0/COG	68 pF	82 p	10kHz
NP0/COG	100 pF	118 p	10kHz
NP0/COG	150 pF	164 p	10kHz
NP0/COG	220 pF	233 p	10kHz
NP0/COG	330 pF	351 p	10kHz
NP0/COG	470 pF	490 p	10kHz
NP0/COG	680 pF	690 p	10kHz
NP0/COG	1.0 nF	1.02 n	10kHz
NP0/COG	1.5 nF	1.56 n	10kHz
NP0/COG	2.2 nF	2.17 n	10kHz
NP0/COG	3.3 nF	3.30 n	10kHz
NP0/COG	4.7 nF	4.74 n	10kHz
NP0/COG	6.8 nF	6.90 n	10kHz
NP0/COG	10 nF	10.7 n	10kHz
NP0/COG	15 nF	15.0 n	10kHz
NP0/COG	22 nF	22.2 n	10kHz
NP0/COG	33 nF	33.7 n	10kHz
NP0/COG	47 nF	47.6 n	10kHz
NP0/COG	68 nF	69.9 n	10kHz

CAPACITORS (high):			
Type:	Nom.:	Measured:	Freq:
PP-Film	100 nF	96.4 n	10kHz
PP-Film	150 nF	146 n	10kHz
PP-Film	220 nF	214 n	10kHz
PP-Film	330 nF	324 n	10kHz
PP-Film	470 nF	506 n	10kHz
PP-Film	680 nF	644 n	10kHz
PP-Film	1.0 µF	947 n	10kHz
PET-Film	1.5 µF	1.44 µ	10kHz
PET-Film	2.2 µF	2.07 µ	10kHz
PET-Film	3.3 µF	3.13 µ	10kHz
PET-Film	4.7 µF	4.51 µ	10kHz
PET-Film	6.8 µF	6.60 µ	10kHz
PET-Film	10 µF	9.60 µ	10kHz
Al-Electrolytic	15 µF	14.6 µ	100 Hz
Al-Electrolytic	22 µF	20.6 µ	100 Hz
Al-Electrolytic	33 µF	27.8 µ	100 Hz
Al-Electrolytic	47 µF	39.7 µ	100 Hz
Al-Electrolytic	68 µF	68.4 µ	100 Hz
Al-Electrolytic	100 µF	85.7 µ	100 Hz
Al-Electrolytic	150 µF	147 µ	100 Hz
Al-Electrolytic	220 µF	189 µ	100 Hz
Al-Electrolytic	330 µF	277 µ	100 Hz
Al-Electrolytic	470 µF	441 µ	100 Hz
Al-Electrolytic	1.000 µF	900 µ	100 Hz

INDUCTORS (low):			
Type:	Nom.:	Measured:	Freq:
Fastron 1206AS	10 nH	110 n	100 kHz
Fastron 1206AS	15 nH	118 n	100 kHz
Fastron 1206AS	22 nH	132 n	100 kHz
Fastron 1206AS	33 nH	157 n	100 kHz
Fastron 1206AS	47 nH	173 n	100 kHz
Fastron 1206AS	68 nH	200 n	100 kHz
Fastron 1206AS	100 nH	240 n	100 kHz
Fastron 1206AS	150 nH	297 n	100 kHz
Fastron 1206AS	220 nH	380 n	100 kHz
Fastron 1206AS	330 nH	490 n	100 kHz
Fastron 1206AS	470 nH	640 n	100 kHz
Fastron 1206AS	680 nH	860 n	100 kHz
Fastron 07HCP	1.0 µH	1.38 µ	10kHz
Fastron HBCC	1.5 µH	1.91 µ	10kHz
Fastron 07HCP	2.2 µH	2.83 µ	10kHz
Fastron 07HCP	3.3 µH	3.64 µ	10kHz
Fastron 07HCP	4.7 µH	5.01 µ	10kHz
Fastron 07HCP	6.8 µH	-	10kHz
Fastron 07HCP	10 µH	10.6 µ	10kHz
CTC CH6080	15 µH	15.7 µ	10kHz
Fastron 07HCP	22 µH	23.9 µ	10kHz
Fastron 07HCP	33 µH	37.1 µ	10kHz
Fastron 07HCP	47 µH	51.0 µ	10kHz
Fastron 07HCP	68 µH	71.3 µ	10kHz

INDUCTORS (low):			
Type:	Nom.:	Measured:	Freq:
	100 µH	108 µ	10kHz
CTC CH8010	150 µH	153 µ	10kHz
Fastron 07HCP	220 µH	228 µ	10kHz
Fastron 11PHC	330 µH	378 µ	10kHz
Fastron 11PHC	470 µH	590 µ	10kHz
Fastron 11PHC	680 µH	848 µ	10kHz
Fastron 09P/HCP	1.0 mH	1.1 m	10kHz
Fastron 09P/HCP	1.5 mH	1.59 m	10kHz
Fastron 11PHC	2.2 mH	2.60 m	10kHz
Fastron 11PHC	3.3 mH	3.93 m	10kHz
Fastron 09P	4.7 mH	5.14 m	10kHz
Fastron 09P	6.8 mH	7.05 m	10kHz
Fastron 11P	10 mH	10.5 m	10kHz
Fastron 11P	15 mH	15.5 m	10kHz
Fastron 11P	22 mH	23.9 m	10kHz
Fastron 11P	33 mH	36.6 m	10kHz
Fastron 11P	47 mH	49.8 m	10kHz
Fastron 11P	68 mH	77 m	10kHz
Fastron 11P	100 mH	105 m	10kHz
Fastron 11P	150 mH	159 m	10kHz
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