Improved Version of

„A Simple S-Parameter Test Set for the VNWA2 Vector Network Analyzer"

Quad-Relay-Test-Set

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In May/June 2009 the article „A simple S-Parameter Test Set for the VNWA2 Vector Network Analyzer“ by Prof. Dr. Thomas C. Baier, DG8SAQ was published in the QEX. This article described a simple test set for the VNWA2 by using two low cost Omron RF relays from the type G6Y.
The motivation for such a unit was to turn the VNWA2 into a full-featured two port network analyzer by maximum simplicity of such a test set by using only two of those relays [1].
To understand the results it is nessecary to take a look at the most important characteristics of the relay.

Table 1: High-Frequency Characterisic G6Y

Item	250 MHz	900 MHz	2.5 GHz
Isolation	80 dB min.	65 dB min.	30 dB min.
Insertion loss	0.5 dB max.	0.5 dB max.	-
V.SWR	1.5 max.	1.5 max.	-
Max. carry power	10 W		-
Max. switching power	10 W		-

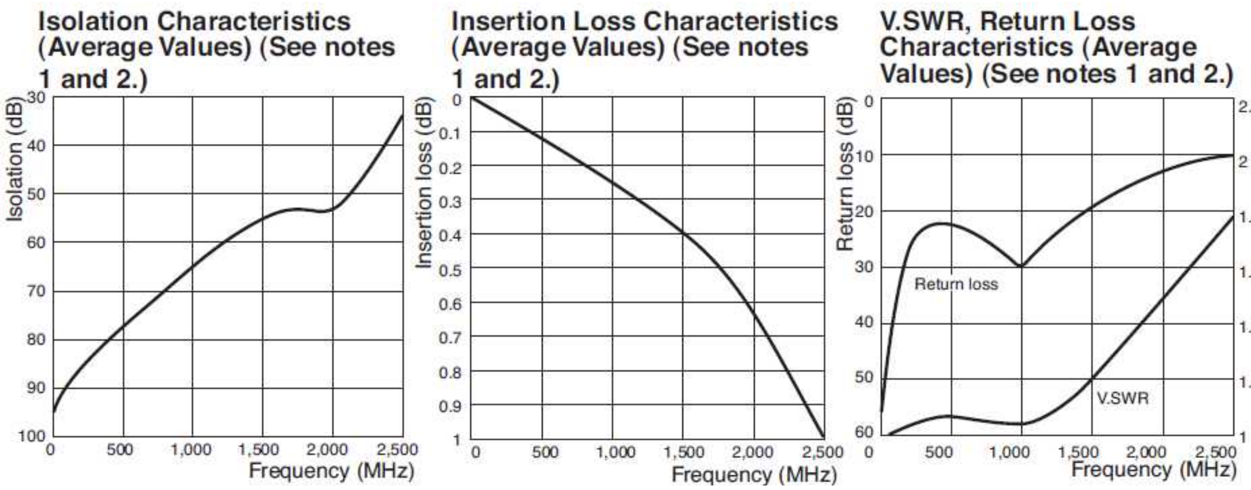


Figure 1: High-Frequency Characterisic G6Y.

The datasheet of the relay shows about 55 dB isolation and an insertion loss of about 0.4 dB at 1.5 GHz [2]. Two of those relays where used in the “Simple S-Parameter Test Set for the VNWA2 Vector Network Analyzer”.

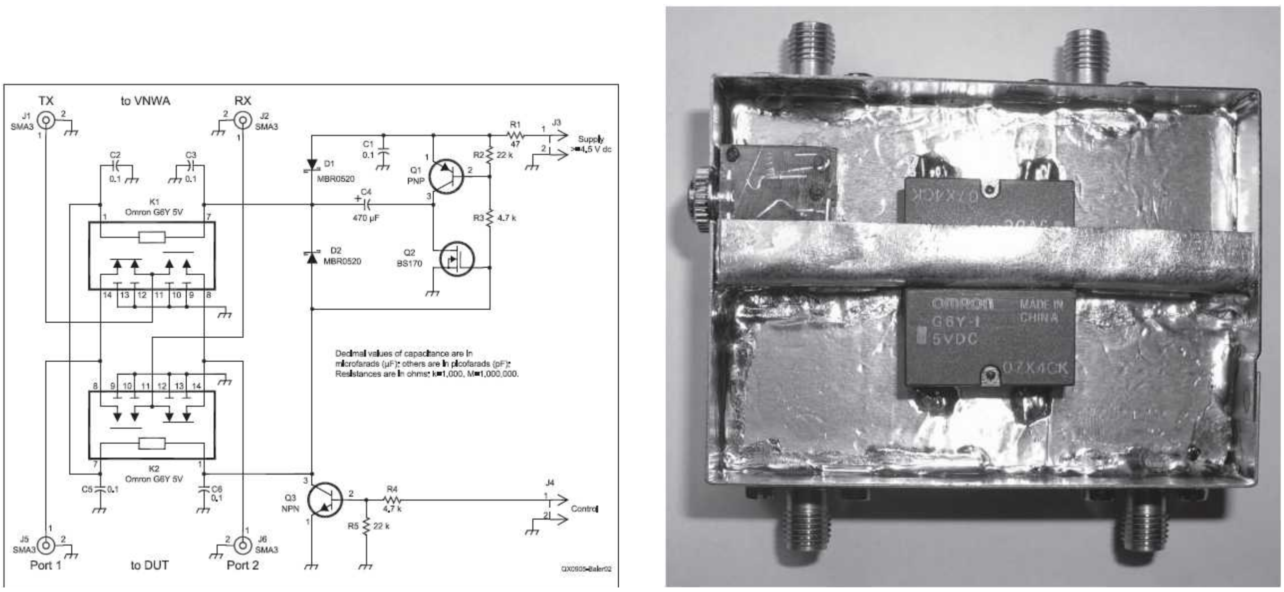


Figure 2: Schematic (left) and photo of the test set by Thomas C. Baier (right).

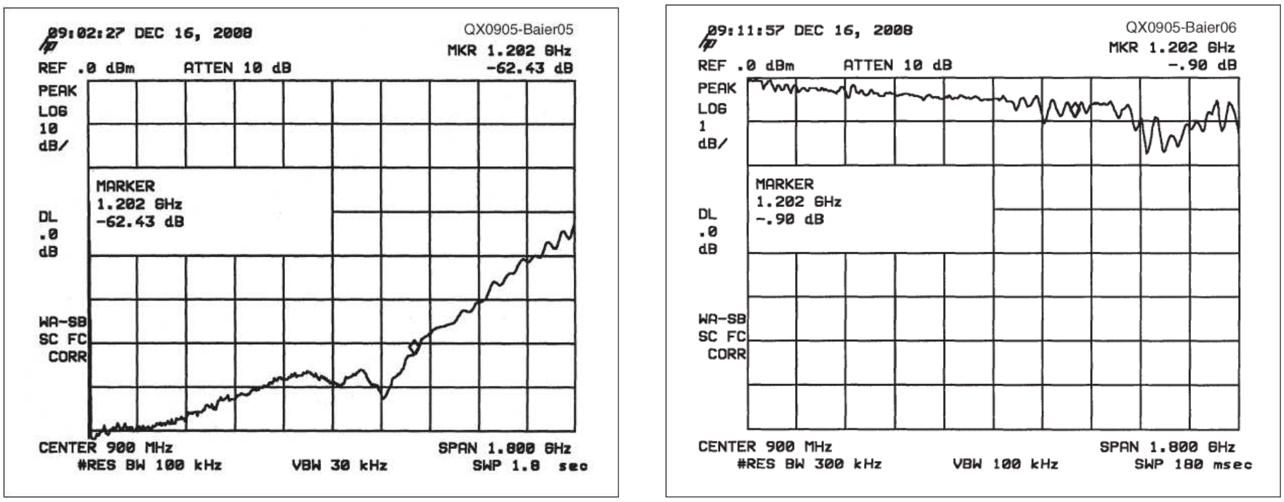


Figure 3: Isolation (left) and transmission measurement from TX to RX of the test set by Thomas C. Baier.

Obviously the isolation characteristic of the test set is essentially dominated by the isolation characteristic of the relay itself. This can be traced back to the fact, that both rf signals from TX and RX of the network analyzer passes the same relay in the same time. Furthermore, the open contacts of the relays generate stubs in the signal path.
To counter that facts it is nessecary to use four instead of only two relays with the effect that stubs are minimized and isolation characterisic is basically dominated by the assembly of the test set. Moreover, further improved behavior can be expected using the relay type G6Z in the Y-shape version. With two relays in series and an insertion loss of max. 0.1 dB @ 900 MHz (max. 0.3 dB @ 2.6 GHz) per relay of the type G6Z a whole insertion loss of typ. ≤0.5 dB can be expected in the frequency range of the VNWA2.

To prove the above mentioned a printed boad was designed using four relays of the type G6Y. The dual layer, 1.6 mm FR4 printed circuit board with 1 oz copper plating (35 µm) uses four SMA end launch connectors directly printed to the board. The signal paths were formed as coplanare waveguides with 1.5 mm line width and 0.35 mm clearance to ground on the top layer.
The relays were arranged on top and bottom side to improve the relay to relay isolation. The relay control signals are placed in the center of the circular pcb. The recovery diodes for each relay are placed on the opposite side of the pcb.

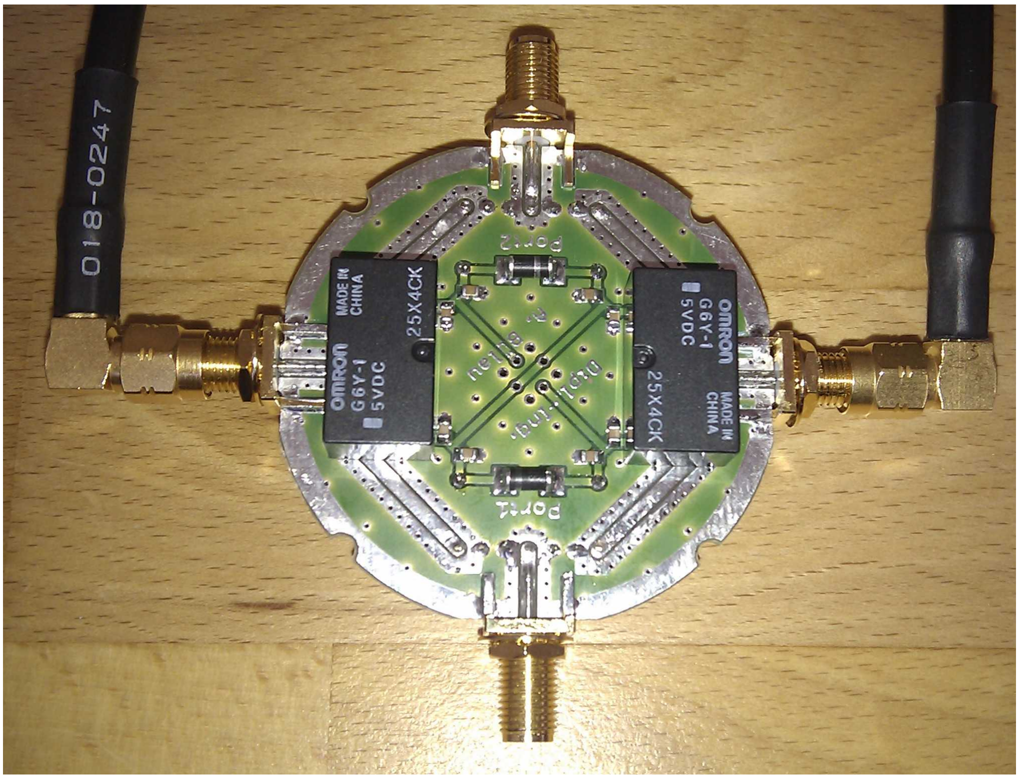


Figure 4: Assembled Quad-Relay-Test Set.

First measurements on the assembled but open pcb showed the following results.

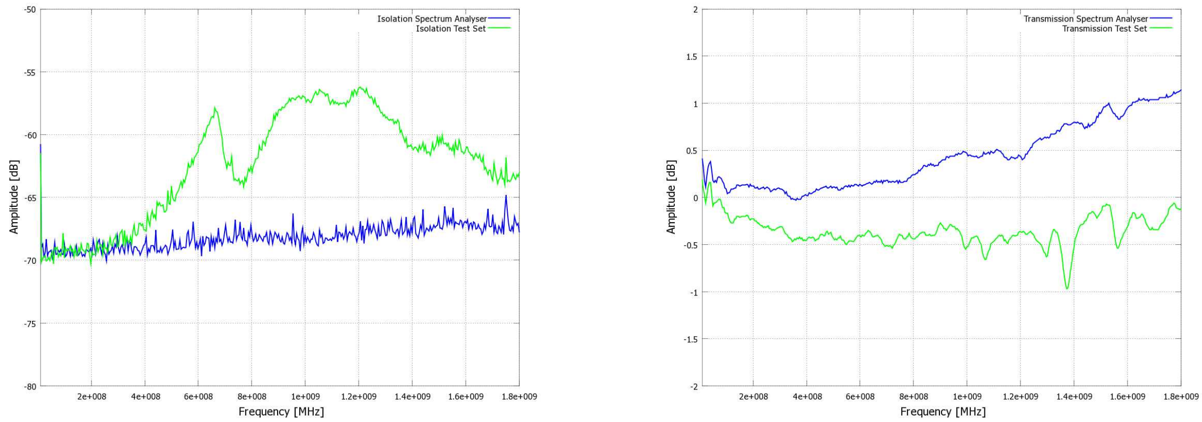
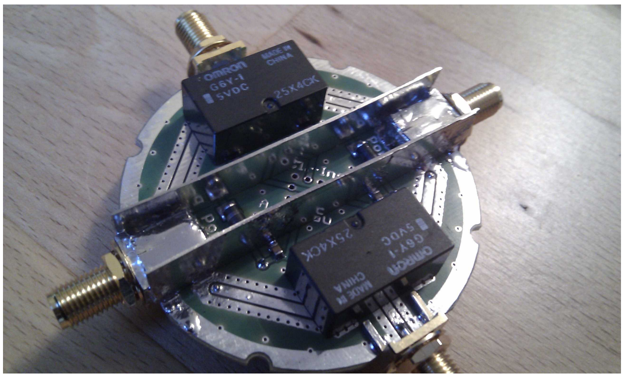
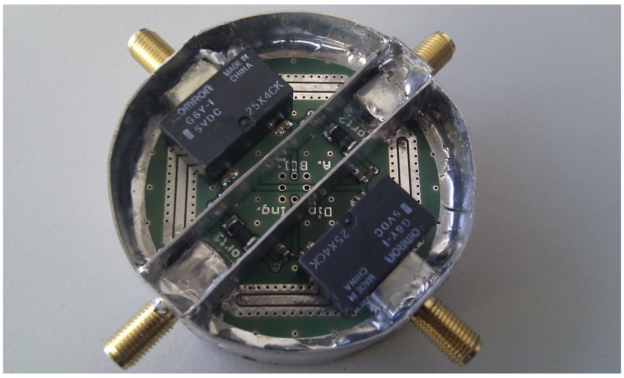
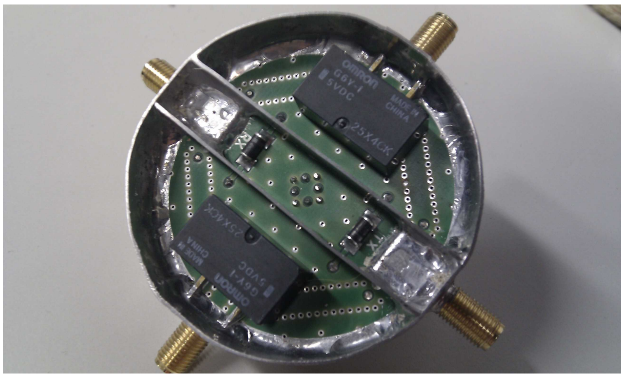
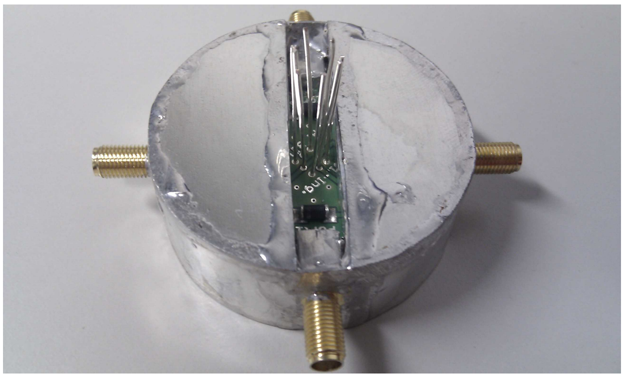
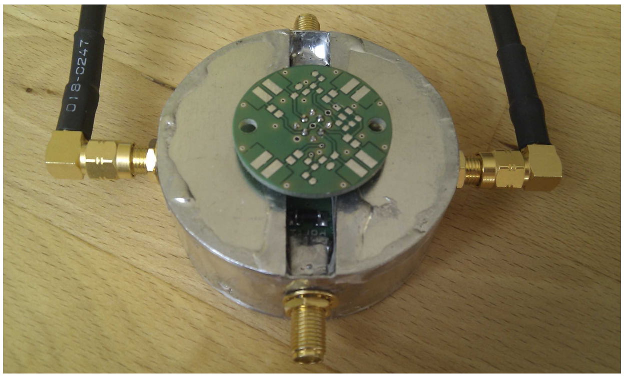


Figure 5: Isolation (left) and transmission measurement from TX to RX of the Quad-Relay-Test Set.

In further steps isolation characteristic were gradual improved by encapsulating the SMA connectors on the pcb with galvanic tin-coated sheet metal, placing shieldings between the relays on both sides of the pcb and housing the whole circuit.
The following picture sequence shows the single steps of shielding.



This actions resulted in the following isolation characteristic. To better value the results a measurement of a Rohde&Schwarz RUF-Relay with N-connectors and N-SMA adapter is also shown (see datasheet at the end of this article).

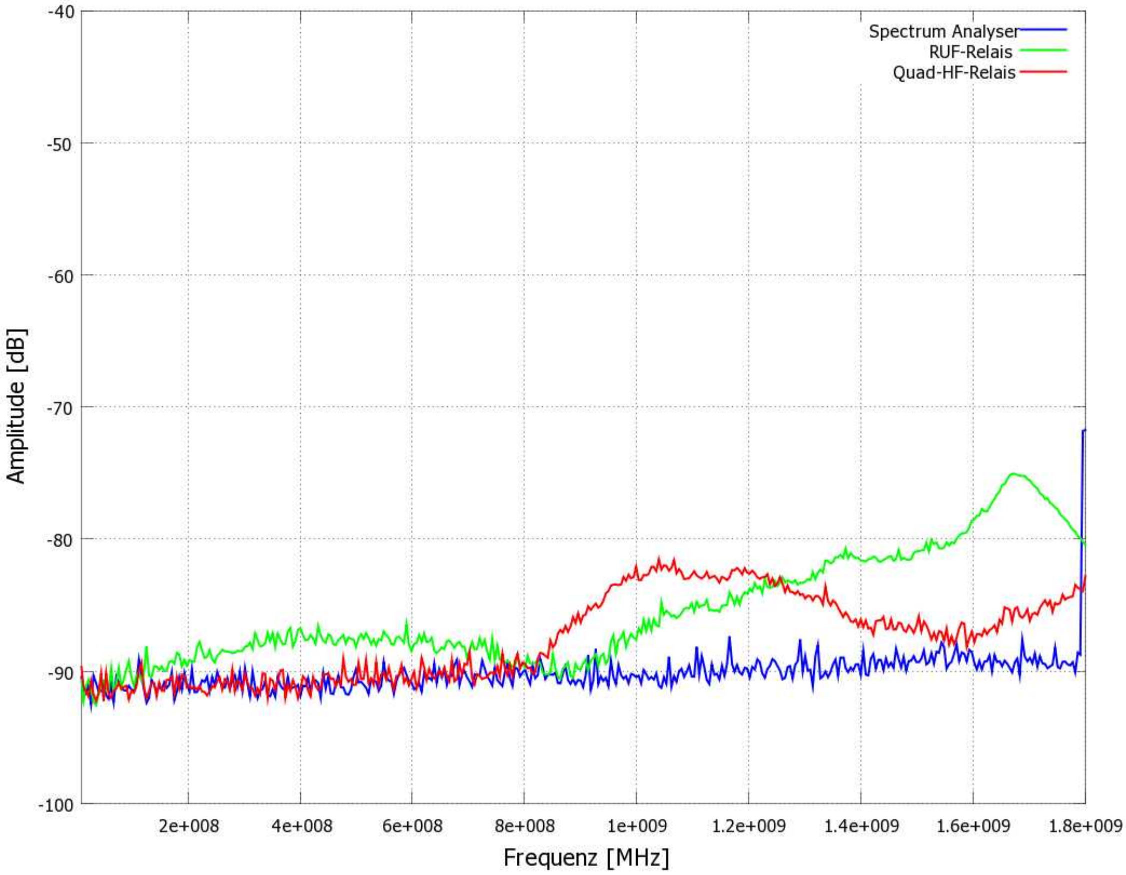


Figure 6: Isolation measurement of the Quad-Relay-Test Set after shielding (red) and a referenz RF Precision Relay RUF – 2039.8357.04 by Rhode&Schwarz (green) [4].

The results show good values in respect to moderate time and effort that have been invested. Anymore the inferior relays G6Y were used in this test. The main reasons for crosstalk are identified and their influences reduced. The achieved results can be introduced into a redesign of the pcb with the better relay G6Z.

As mentioned the insertion loss of that relay arrangement is about twice the insertion loss of a single relay. So it's recommendable to use the G6Z series in through hole technics and Y-shape with considerable lower value [3].

Table 2: High-Frequency G6Z.

Item		**900 MHz**				**2.6 GHz**			
		TH		**SMD**		**TH**		**SMD**	
		E-shape	**Y-shape**	**E-shape**	**Y-shape**	**E-shape**	**Y-shape**	**E-shape**	**Y-shape**
Isolation	50 Ω	60 dB min.		60 dB min.		35 dB	45 dB	30 dB	40 dB
Insertion loss	50 Ω	0.1 dB max.				0.3 dB min.			
V.SWR	50 Ω	1.1 max.				1.3 max.			
Return loss	50 Ω	26.4 dB max.				17.7 dB max.			

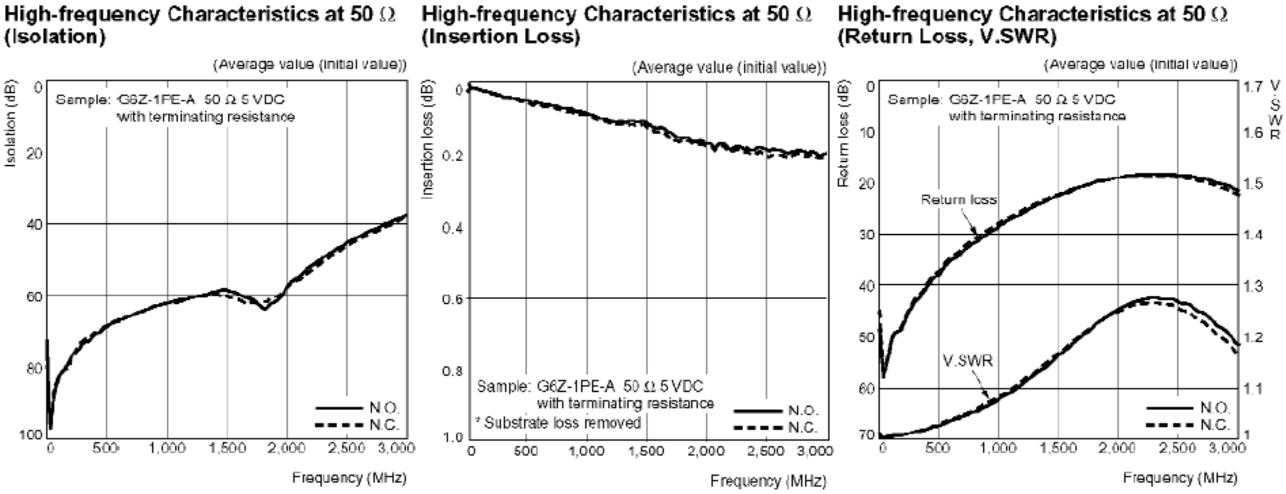


Figure 7: High-Frequency Characterisic G6Z.

NOTES

All measurements are made using a HP8594E spectrum analyzer with tracking generator and were exported via Agilent 82357A GPIB-USB adapter and plotted with Octave.

[1] Professor Dr. Thomas C. Baier, DG8SAQ, “A Simple S-Parameter Test Set for the VNWA2 Vector Network Analyzer”, QEX, Mai/June 2009

[2] Omron G6Y Relay, see:
http://downloads.components.omron.eu/OCB/Products/Relays/High%20Frequency%20Relays/G6Y/K104/K104-E2-02A-X.pdf

[3] Omron G6Z Relay, see:
http://downloads.components.omron.eu/OCB/Products/Relays/High%20Frequency%20Relays/G6Z/K124/K124-E2-02A-X.pdf

[4] Datasheet of RF Precision Relay

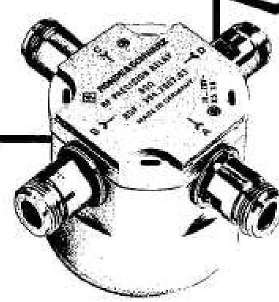
RF-Präzisionsrelais RUF

RUF

neu

♦ DC ... 2 GHz

- Selbstjustierende Schaltscheibe
- LED-Schaltzustandsanzeige
- Übersprechdämpfung bis 1 GHz ≥86 dB
- Rückflußdämpfung bis 1 GHz ≥40 dB



Das **RF-Präzisionsrelais RUF** ist ein motorbetriebener **Zweiwegschalter** in 50-Ω-Technik. Vier LEDs zeigen die Schaltstellungen an.

Anwendung Das RUF wird in der Senderkontrolltechnik zur Meßstellenwahl sowie überall dort eingesetzt, wo Signale bis 2 GHz mit kleinen oder mittleren Leistungen umzuschalten oder in Zweiwegtechnik zu führen sind (z. B. Meß- und Überwachungsanlagen für Umsetzer und Breitbandkommunikation, Betriebs- und Meßtechnik von Satellitensignal-Empfangsanlagen).

Aufbau Die HF-Anschlüsse sind als umrüstbare N-Präzisionsbuchsen ausgeführt. Ein besonderes Merkmal ist die selbstjustierende, vergoldete Schaltscheibe mit Rhodiumkontakten.

Technische Daten

		bis 1 GHz	>1 ... 2 GHz
Rückflußdämpfung	für RUF mit 4 N-Buchsen bestückt	≥40 dB	≥28 dB
Reflexion		≤1%	≤4%
VSWR		≤1,02	≤1,08
Übersprechdämpfung		≥86 dB	≥70 dB
Durchgangsdämpfung		≤0,1 dB	≤0,2 dB
Übertragbare Leistung (nicht unter Last geschaltet)		max. 100 W	max. 35 W
Betriebsspannung		+18 ... +26 V/−18 ... −26 V	
Schaltstrom/Haltestrom (24 V)		<500 mA/50 ... 100 mA	
Umschaltzeit (bei 24 V)		<30 ms	
Lebensdauer in Schaltvorgängen		$\geq 0{,}5 \cdot 10^6$	
Schaltzustandsanzeige		4 LEDs	
Anschlüsse		N-Buchsen (umrüstbar)	
für Schaltspannung		Lötstützpunkte	
Nenntemperaturbereich		+5 ... +45 °C	
Abmessungen (D×H), Gewicht		100 mm×53 mm, 0,4 kg	
Bestellbezeichnung		▶ RF-Präzisionsrelais RUF 394.7007.03	

Empfohlene Ergänzungen

Abschlußwiderstand RNB, 50 Ω, 1 W, N-Stecker	272.4910.50
Präzisions-Einbau-Abschlußwiderstand, 50 Ω	124.1143.00
4,1/9,5-Einbaubuchse, 50 Ω	076.6780.00