

E Connector – A new 1.35 mm Precision Coaxial Interface for DC to 90 GHz

Hans-Ulrich Nickel

SPINNER GmbH

Aiblinger Str. 30, 83620 Feldkirchen-Westerham, Germany

Email: uli.nickel@spinner-group.com

E Connector – A new 1.35 mm precision coaxial interface

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E Connector Working Group



Physikalisch-Technische Bundesanstalt Braunschweig and Berlin

Bundesallee 100, 38116 Braunschweig, Germany

- Rolf Judaschke (rolf.judaschke@ptb.de)
- Karsten Kuhlmann (karsten.kuhlmann@ptb.de)



Rohde & Schwarz GmbH & Co. KG

Muehldorfstrasse 15, 81671 Munich, Germany

- Martin Leibfritz (martin.leibfritz@rohde-schwarz.com)



Rosenberger Hochfrequenztechnik GmbH & Co. KG

Hauptstrasse 1, 83413 Fridolfing, Germany

- Herbert Babinger (herbert.babinger@rosenberger.de)
- Thomas Schmid (thomas.schmid@rosenberger.de)



SPINNER GmbH

Erzgiesserei strasse 33, 80335 Munich, Germany

- Richard Coppola (richard.coppola@spinner-group.com)
- Martin Grassl (martin.grassl@spinner-group.com)
- Hans-Ulrich Nickel (uli.nickel@spinner-group.com)
- Wolfgang Zissler (wolfgang.zissler@spinner-group.com)

Motivation

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"V Connector" (1.85 mm connector)

- single-mode operation to 65 GHz (70 GHz); 76 to 81 GHz uncovered
- design is robust and reliable

"E Connector" (1.35 mm connector)

- this presentation

"W Connector" (1.00 mm connector)

- single-mode operation to 110 GHz (120 GHz)
- drawbacks
 - unintended unlocking due to coarse coupling thread (M4x0.7)
 - possible connector damage due to largely tolerated eccentricities
 - unnecessarily small / fragile for "low-frequency" applications (70 to 90 GHz)
 - pin dia. different from inner conductor dia. of any standard semi-rigid cable

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Target specification

- characteristic impedance 50 Ω
- operating frequency range DC to 90 GHz (92 GHz), E band
- highly robust mechanics
 - accurate alignment by outer conductor
 - minimum life 3000 cycles
 - locking by threaded coupling nut that sufficiently secures against unintended opening
- precision interface with
 - well-defined reference plane
 - maximized return loss
 - high connector repeatability (min. 45 dB)
 - suitable for precision S-parameter measurement
 - design similar to 1.85 mm connector
- push-pull coupling as an option
- "thru male" capability, i.e. pin diameter must coincide with inner conductor of UT47, the standard 0.047 inch semi-rigid cable (biggest cable covering the E band; H_{11} -cutoff at 109 GHz)

Why 90 GHz as the upper frequency limit?

Applications / Frequency allocations

"77 GHz community"	76 to 81 GHz (automotive and industrial radar sensors)
E band satcom	71 to 76 GHz and 81 to 86 GHz
5G mm wave bands	81 to 86 GHz (highest band proposed at WRC-15, to be decided at WRC-19)
WLAN IEEE 802.11ax	up to 86 GHz
WLAN IEEE 802.11ay	up to 90 GHz

Harmonization with E band waveguide

WR 12	60 to 90 GHz	(EIA-RS-261-B)
R 740	60.5 to 91.9 GHz	(IEC 60153-2:2016-05)

Frequencies not covered

"94 GHz atmosph. window" 92 to 95 GHz (many applications in astronomy, defense, security)

- At 90 GHz the thickness of the contact fingers is only 0.15 mm since the pin diameter is determined by the semi-rigid cable.
- Above 90 GHz --> contact fingers even thinner --> disproportionate reduction of spring forces and thus mechanical robustness -->

90 GHz is a well-balanced compromise between bandwidth and mechanical robustness.

Interface Development

Choice of outer conductor diameter → connector designation

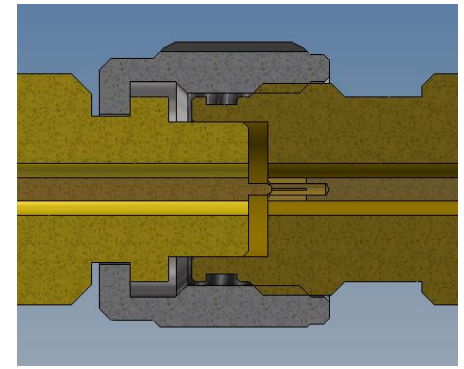
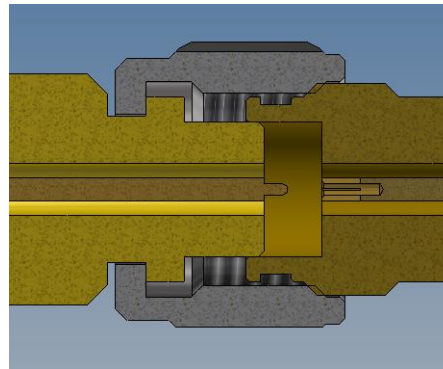
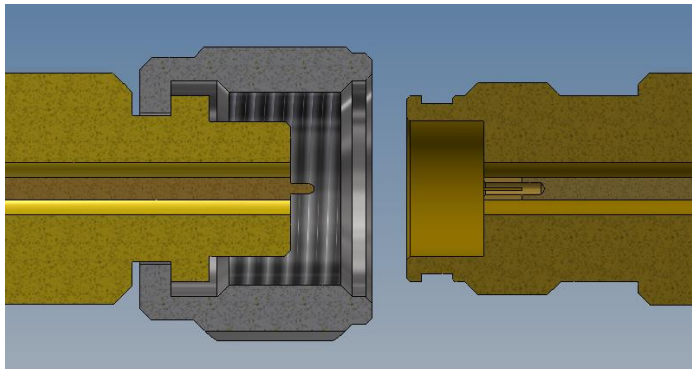
PC	$f_{\text{IEEE287}} / \text{GHz}$	$f_{\text{cutoff}} / \text{GHz}$	Usage / %
N-50	18	19.00	94.7
3.50 mm	33	38.01	86.8
2.92 mm	40	45.54	87.8
2.40 mm	50	55.43	90.2
1.85 mm	65	71.90	90.4
1.00 mm	110	133.05	82.7
0.80 mm	140	166.34	84.2
1.40 mm	≥ 90	95.02	94.7
1.35 mm	≥ 90	98.55	91.3
1.30 mm	≥ 90	102.36	87.9

$$f_c(H_{11}) \approx \frac{2c_0}{\pi(d_{\text{out}} + d_{\text{in}})}$$

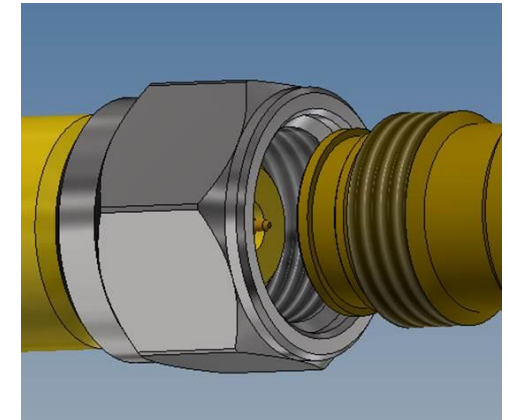
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↑
three significant digits

Solution



- centering diameter 3.5 mm
- outer conductor internal diameter 1.35 mm
- inner conductor external diameter 0.586 mm
- pin diameter (= i. c. dia. of UT47) 0.29 mm
- cutoff frequency H_{11} 98.6 GHz
- operating frequency range DC to 90 GHz (92 GHz)
- thread M5.5x0.5 (well-proven thread; used also in fiber-optic DIN-LSA connectors)
- coupling torque 0.9 N·m (secure locking with contact pressure similar to 3.5 mm connector)
- wrench flat size 8 mm (6.35 mm and 7 mm possible)
- groove for optional push-pull locking



Special design features

- Sole precision connector which **ensures a pin gap in mated condition** to avoid near field effects that would corrupt the connector repeatability.
- Sole precision connector which uses a **common reference for all eccentricity tolerances** (rf-functional tolerancing scheme which avoids tolerance chains).
- Sole precision connector for higher frequencies with a provision for **push-pull locking**.
- Chosen pin diameter enables **high-quality low-budget jumper cables** in conjunction with UT47 ("thru male" design).
- Can be used with **same wrench as most precision connectors** (3.5 mm, 2.92 mm, 2.4 mm, 1.85 mm).

Standardization status

- IEEE Std 287: Precision Coaxial Connectors
 - Submitted and accepted for publication
 - next revision 2019

- IEC standards
 - Submission completed

First 1.35 mm Products from SPINNER

Calibration standards and adapters

- 1.35 mm OSLT calibration kit BN 534936:

- Adapters 1.00 mm <-> 1.35 mm:

- BN 534917 (m-m)
- BN 534718 (f-m)
- BN 534919 (m-f)
- BN 534920 (f-f)



- Adapters 1.35 mm <-> 1.85 mm:

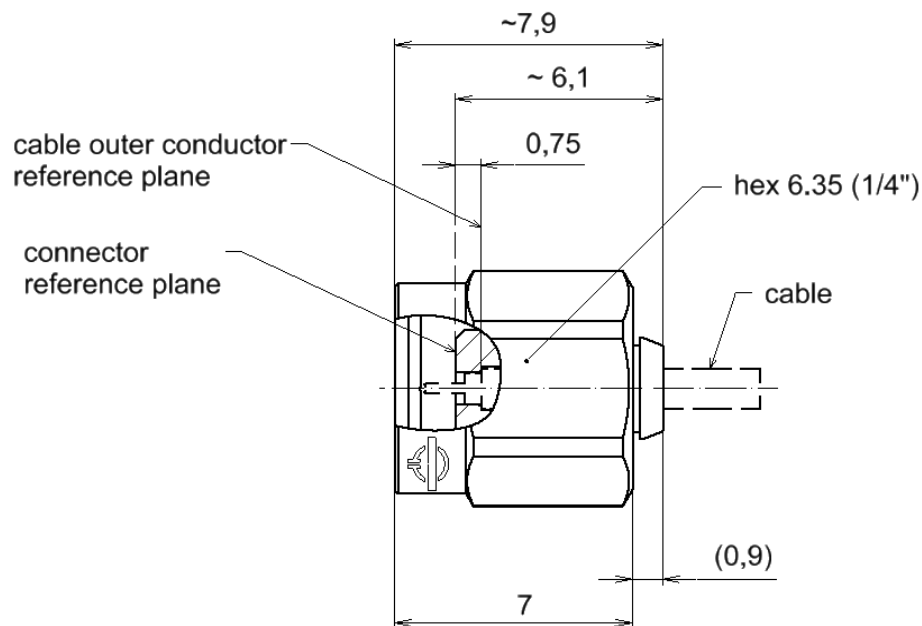
- BN 534921 (m-m)
- BN 534722 (f-m)
- BN 534923 (m-f)
- BN 534924 (f-f)



First 1.35 mm Products from SPINNER

Cable plugs

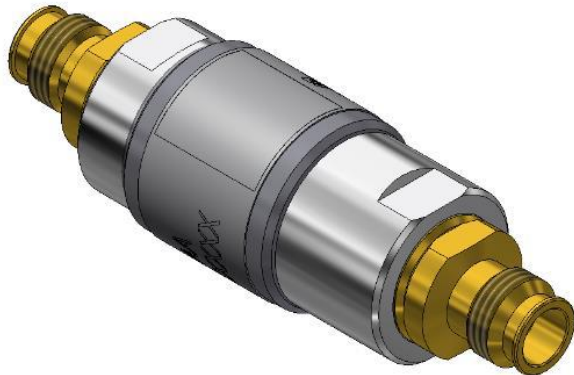
- 1.35 mm plug for cable UT47 BN 534942
"thru male" design:



- Further 1.35 mm plugs for special cables.

Rotary Joint

- 1.35 mm contacting rotary joint
BN 835082:



835082-BEA 1.35
mm Rojo

Coaxial interface connector	1.35-f (50 Ω)
Frequency range	DC to 92 GHz
Peak power rating	800 W @ 2.000 m
Average power rating	4 W @ DC to 26.5 GHz 0.8 W @ 26.5 to 70 GHz 0.7 W @ 70 to 90 GHz
VSWR, max.	1.20 @ DC to 26.5 GHz 1.40 @ 26.5 to 70 GHz 1.60 @ 70 to 90 GHz
VSWR variation with rotation, max	0.04 @ DC to 26.5 GHz 0.10 @ 26.5 to 70 GHz 0.15 @ 70 to 90 GHz
Insertion loss, max.	0.5 dB @ DC to 26.5 GHz 0.8 dB @ 26.5 to 70 GHz 1.0 dB @ 70 to 90 GHz
Insertion loss variation with rotation, max.	0.05 dB @ DC to 26.5 GHz 0.15 dB @ 26.5 to 70 GHz 0.3 dB @ 70 to 90 GHz
Phase variation with rotation, max.	2 deg. @ DC to 26.5 GHz 5 deg. @ 26.5 to 70 GHz 7 deg. @ 70 to 90 GHz
DC carrying capability	0.1 A

New 1.35 mm coaxial connector

- **robust and precise interface**
- **covers frequencies up to 90 GHz (92 GHz)**
- **target applications:**
 - **automotive and industrial radar sensors** (76 to 81 GHz),
 - **E band satcom** (71 to 76 GHz and 81 to 86 GHz),
 - **proposed 5G mm-wave bands** (81 to 86 GHz),
 - **proposed WLAN IEEE 802.11ax+ay** (up to 86 GHz).
- **enables high-quality low-budget jumper cables (UT47)**
- **no special torque wrench required**
- **push-pull locked connector variants** in progress
- **first products available at SPINNER**

Thank you!

Questions?