Analysis of Quick Lock N Type Connectors

The N series of coaxial connector is the most widely used series for low to medium power applications in the DC to 11 GHz frequency range. The N connector is particularly well suited for applications in harsh environments or those where there is a high number of mating cycles. A relatively recent improvement has been the introduction of the Precision N connector, which operates up to 18 GHz. A major inconvenience of the traditional N connector is the threaded coupling mechanism. This has led to the invention of the Quick Lock N (QL-N) type connector, which showcases a quick disconnect feature

- **Design Principles**

Since its invention in the 1940's by Paul Neill of Bell Labs, the N connector has undergone continuous improvement. Many in the engineering community are of the opinion that the present day version of the N connector is at or near optimum performance. In light of this perception, we were guided by the following design criteria when developing a Quick Lock N connector.

1) To maintain the electrical performance of the present day N connector.

2) Simplify the design and make it smaller in order to promote its use in miniaturized applications

3) Make it waterproof

- **History of Quick Lock N connector development**

Keeping in mind the above design criteria for the QL-N, we will discuss the development history of the three typical design variations of the QL-N; QN, SnapN and HPQN. We will compare their performance with a standard N type connector, and their suitability for substituting their use in varied applications.

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The QN was designed by H+S and RADIALL，and evolved through three design stages from 2002 to 2004. Following are the designs of these three versions :(IEEE, Feature Article in Microwave Magazine February, 2008 Volume: 9 Issue: 1)

1) 2002 version

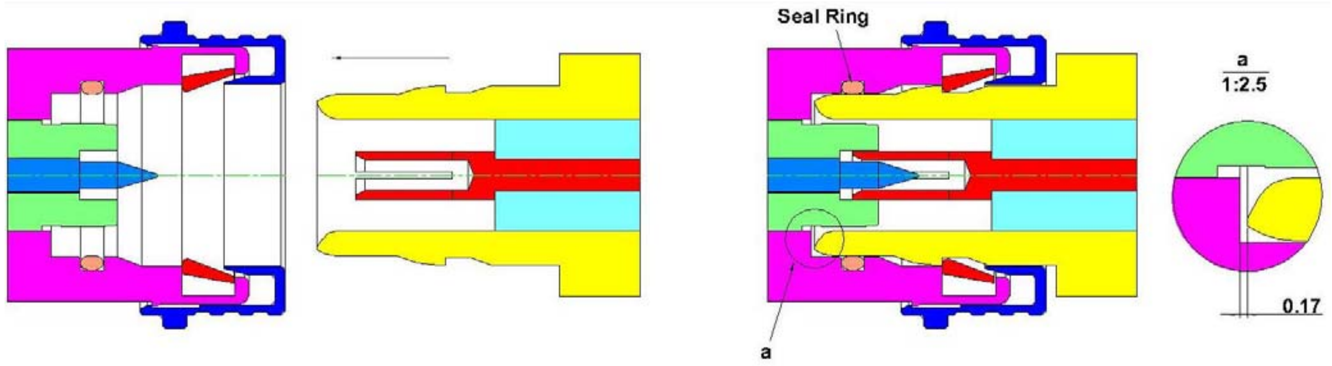

Fig.1 QLF'S QN(2002)

Advantage: elimination of threaded coupling with a snap-in retention mechanism, and an integrated sealing ring (Figure 1).

Disadvantage: there is clearance between the contact surfaces of the outer conductors (Figure 1, partial enlarged view a), leading to instability resulting, in a potential discontinuity of the characteristic impedance.

2) 2003 version

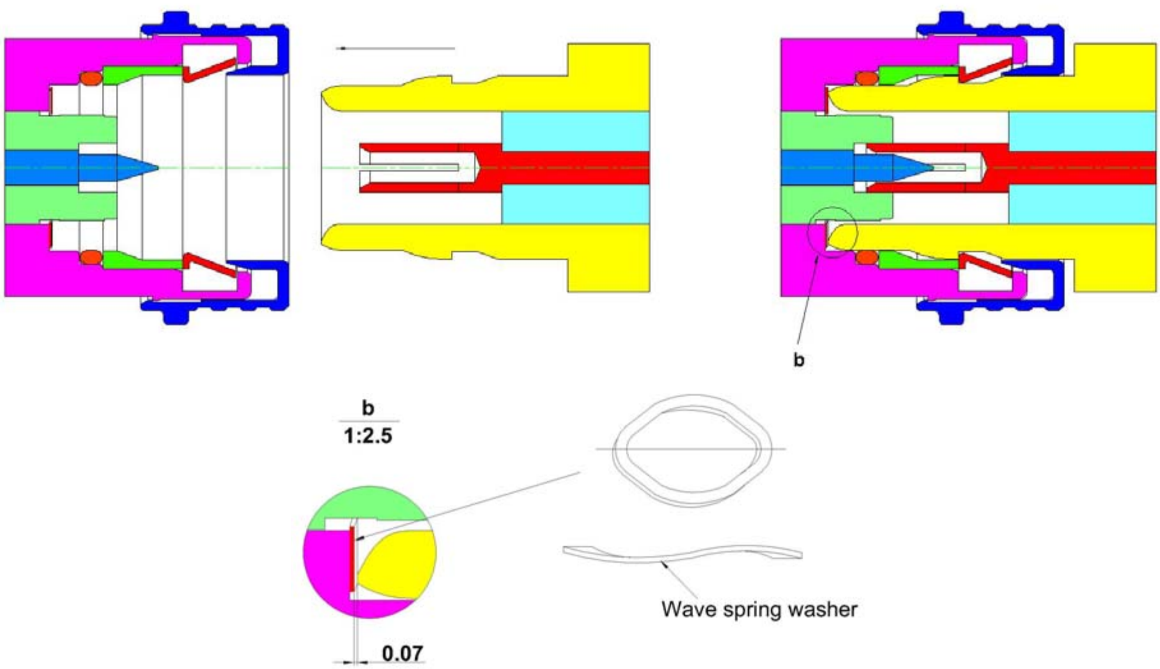

Fig.2 QLF'S QN (2003) with wave spring washer

Advantage: by eliminating the clearance between the contact surfaces with the elasticity of a wave spring washer (Figure 2), the contact between the outer conductors is improved when compared with 2002 version.

Disadvantage: there is contact at only a few points between the outer conductors (Figure 2, partial enlarged view b), which, while an improvement over the earlier design, again leads to a potential discontinuity of the characteristic impedance and poor performance at high frequency.

3) 2004 version

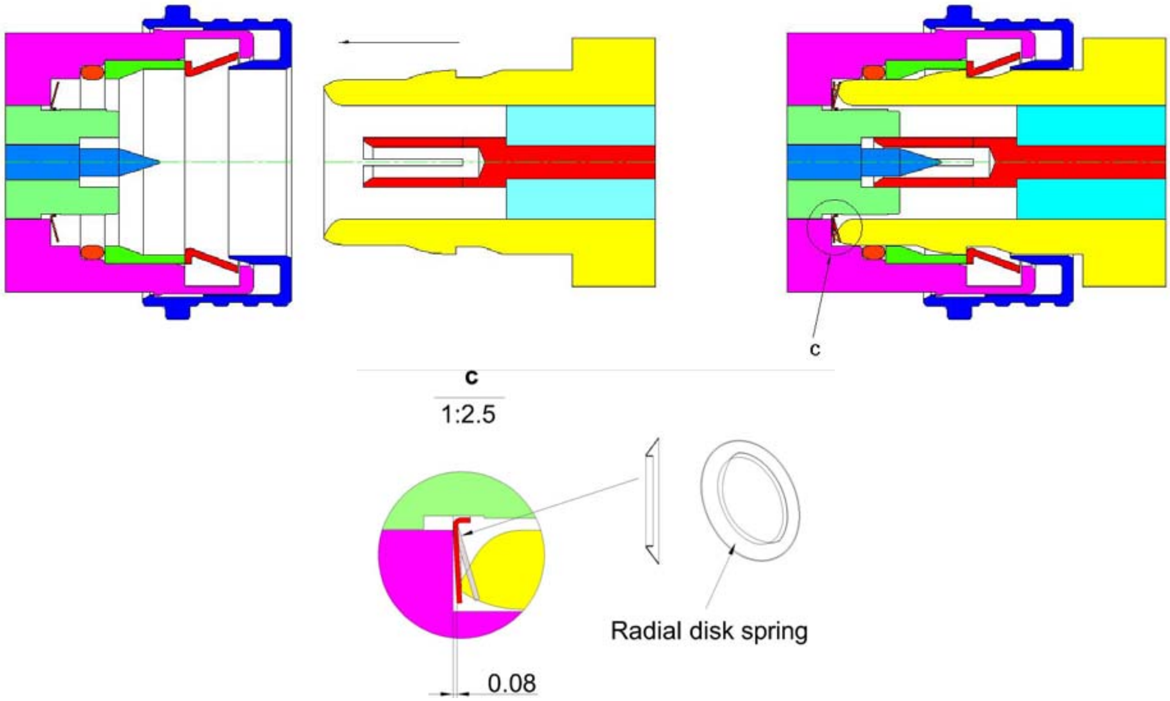

Fig.3 QLF'S QN (2004) with radial disk spring

Advantage: the wave spring washer is replaced by a radial disk spring (Figure 3), and the contact between the outer conductors is extended from several points to a complete circle, thus improving the contact pressure.

Disadvantage: the characteristic impedance at the contact points (Figure 3, partial enlarged view c) is still potentially discontinuous; and the performance at high frequency is poor (above 6 GHz).

The most recent 2004 version of the QN have been used in some wireless basestations. Taking into account the previously described discontinuity design issue, applications are limited to those below 6 GHz.

On the whole, the three versions of the QN's designs achieved snap-fastening and self-locking, which were major developments. However, owing to a design flaw, their usage is limited to at or below 6 GHz, which limits their application as compared with a standard, threaded N connector.

- **SnapN**

  Rosenberger, perhaps because they were aware of this design limitation, designed a new type Snap N as soon as they joined the QLF. The characteristics of this design are:

1) The design of the SnapN is an improvement over that of the QN. Where the QN has the spring placed between the contact surfaces of the outer conductors, the SnapN places the spring at the rear of the outer conductor of the plug. This allows for a rigid, continuous contact and zero clearance between the contact surfaces of the outer conductors of the plug and jack, resulting in improved performance.
2) The Jack maintains 5/8" of external thread, which permits mating with a standard plug type N.

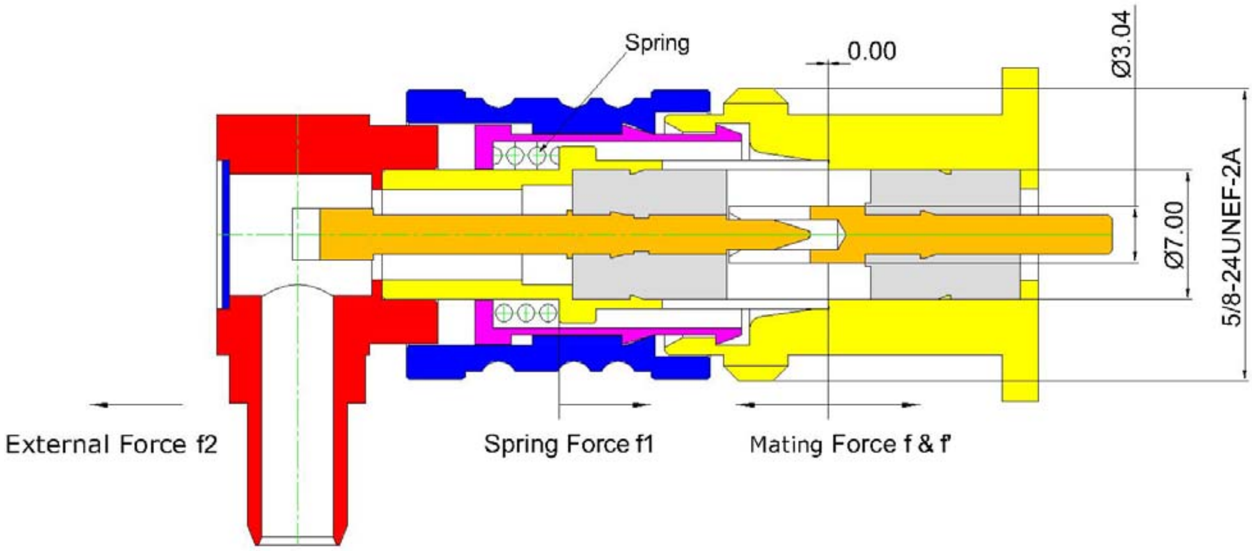

Fig.4 SnapN

As can be seen from the Figure 4, this design is consistent with the basic principles of RF connector's design: when the plug and jack connectors are mated, the spring maintains constant interface pressure, which allows for continuous impendence between their outer conductors. Therefore, the SnapN can be used in a wider range of applications than the QN and at higher frequencies.

However, the SnapN still has some disadvantages when it is compared with the traditional threaded N connector. We have described that the contact pressure between the outer conductors is provided by the spring's elasticity, the data provided by ROSERBERGER states it is 30N. According to the action/reaction principle we know the spring force f1 equals to the mating force f&f' (see Figure 4), so the mating force of the connector(B) is also 30N. In some dynamic applications, due to a heavy cable's swing or other external forces, the force conducted to the connectors(f2) may easily exceed 30N. Once this critical force is exceeded, separation of the contact surfaces of the outer conductors may occur, which adversely effects the signal transmission. The problem with increasing this force, let's say to 100N, would result in a mating/demating force which is unacceptably high.

Another problem with this design is that SnapN's outer conductor is exposed to the external environment, putting the four milled groves at risk of being damaged. Lastly, owing to its higher complexity, the cost to manufacture the SnapN is slightly higher than that of the QN.

With its design change and resulting enhanced performance, the SnapN is an improvement over the QN and can replace the QN in many applications. But there is still that critical design flaw which could result in the potential for a discontinuous signal under certain stress conditions.

HPQN (High Performance Quick-Lock N)

Improving upon the SnapN, Anoison designed the HPQN in 2007(Figure 5). This design incorporates a ring-like locking washer(Figure 6) inserted into the plug. Thus, when mated, this ring-like locking washer is fixed in the plug and locks on the mating slope of the jack. The external faces of the inner teeth thrust down the slope in its original direction, creating close contact between the surfaces with zero clearance. Different lengths of the adjacent inner teeth enable them to stop on different circumferences of the jack down slope when locking. This design creates a very good retention force with excellent anti-shock performance.

As we all know, the traditional N-type connector is able to operate excellent performance at DC to 11GHz, even 18 GHz, because it completely meet high frequency coaxial connector design principle----- zero clearance between contact interfaces and continuous impedance between the plug and jack contact surfaces (like a coaxial line). The newly designed HPQN adheres to this same design principle; rigid contact between the plug and jack contact surfaces which ensures continuous impedance.

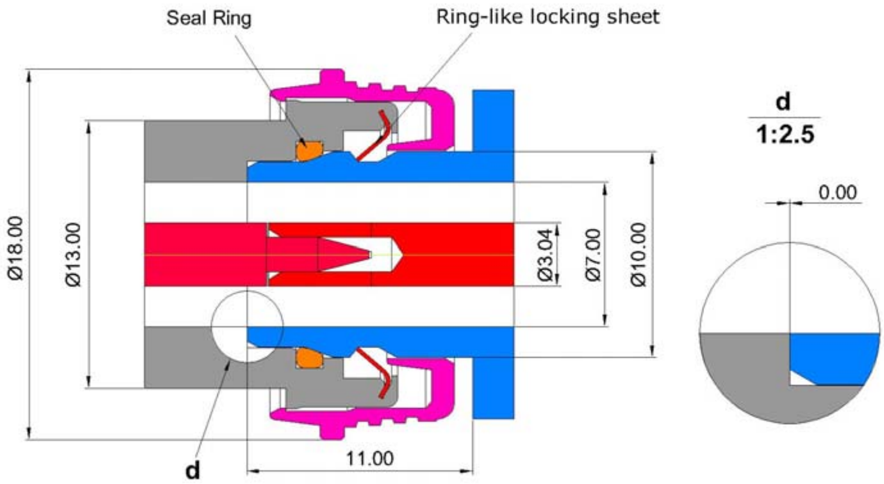

Fig.5 HPQN

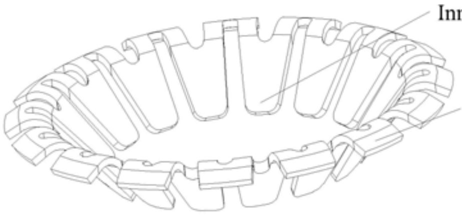

Fig.6 Ring-like locking sheet

In conclusion, the HPQN is the latest generation of QL-N's design following the QN and SnapN. The HPQN has eliminated the QN and SnapN's performance deficiencies, while maintaining all the electrical performances of a standard N connector. Added benefits are a smaller package and lower cost than the QN and SnapN.

.The HPQN can replace the traditional N connector in a wide variety of applications without sacrificing performance. This is not to say that the HPQN is the final stage in the evolution of the QL-N. Market competition must continue to drive design improvements. Only time will tell if there are still improvements which can be made to the design of the HPQN.