Times SilverLine-QMA Improves Yield of Portable Radio Production at Motorola

Motorola is a major supplier of portable, hand held radios sold into many markets. The product is manufactured globally including in Schaumberg, IL. In 2004 Motorola adopted Times SilverLine test cables in its high volume production test department in an attempt to improve test cable usable life and thus improve product yields.

SilverLine test cables are very consistent for loss and VSWR both with frequency & flexure and from cable to cable. The product features a triple shielded, 26.5 Ghz, custom-built coax, high performance connectors and a unique attachment system that provides over 175lbs of pull force before separation. The cable is also available in an armored configuration.

Studies revealed the test cable replacement cycle improved from an average of 30 days to up to 17 months with acceptable RF repeatability and durability versus products previously used. The associated improvement in product yield was equally dramatic and appeared to have met the customer's goals.

Following their continuing process improvement process, two years later Motorola began taking a second look at test costs. It was determined that recalibrating the loss path over various frequency bands and on numerous pieces of equipment was a time consuming and expensive exercise. It was repeated each time test components or radio models were changed, at employee shift changes, or when operators noticed a difference in results between test stations when testing the same radio.

Motorola employs a two-tiered approach to radio testing. Radios are first RF tested on semi-automatic equipment and subsequently on manual equipment where the RF test is repeated as a double check and then further tests such as audio are performed.

(Semi-automated radio test stations)

On the semi-automatic test equipment Motorola custom designed a spring-loaded, "pogo-stick" test adaptor that mated directly to the radio. However it was time consuming and costly to produce or repair. Worse, it was discovered the adaptor lacked the necessary repeatability to assure high yields. A method needed to be found to A) mate to the custom antenna interface of various radios, B) provide excellent RF repeatability, C) provide fast mating & un-mating, and D) achieve long life (goal of 2500 mates).

(Radio during test. Semi-automatic test station)

On manual test equipment Motorola employed BNC adaptors to the radio antenna interface instead of the "pogo-pin" approach. The current

radio antenna interface in production is an SMA male but several radio antenna interface designs exist that are unique to older Motorola radios, some of which are shown below.

General purpose, nickel plated brass BNC adaptors have very loose electrical and mechanical manufacturing specifications. They are not consistent from supplier to supplier and are not designed to withstand high volume mating applications where 1mw of power output makes the difference between product acceptance and failure.

Another issue with BNC's is that they are inherently prone to changes in RF performance that can be dependent on the pressure or "side loading" between two mating halves. While inexpensive, poor adaptor performance, a short useful life, and lower product yield increases the effective cost.

In practice Motorola found the better performing BNC adaptors were hoarded by a few test technicians causing a change in product yield statistics between production shifts that alluded root cause analysis for almost two years.

(Legacy radio BNC test adaptors)

Any new adaptor(s) needed to accommodate not only the individual needs of both the semi-automatic test and manual test equipment but legacy radios as well. Multiple, unique adaptors that had to accommodate older products was an unforeseen complication. Lastly, Motorola wanted the adaptors to be available to its dealers. The solution needed to be a straightforward, robust, easy to use and cost effective.

(Portion of manual test station)

Since the SilverLine test cables worked out so well Motorola approached Times for an additional solution. Times' response was to re-engineer the QMA interface developed for the telecom market several years ago to meet the customer's goals.

The QMA is an SMA-sized interface but replaces a threaded coupling mechanism with what can generally be described as an "air-hose" coupling action. Simply push on to "snap" mate. Pulling back on the coupling nut releases the mated pair. The QMA series was chosen because it A) is a robust interface, B) meets present and future frequency needs, D) has a compact size, and E) is cost effective to produce volume.

("Air-hose" fast mate action is easy to operate)

The first challenge was to make an adaptor that fit both types of test stations. Since a Type N jack interface was common to both stations the first requirement was to design a “between series” adaptor from Type N plug to QMA plug as seen in the picture below. The Type N plug mates to a Type N jack equipped attenuator in the semi-automatic station. In a manual station the Type N plug mates to a Type N jack-equipped, SilverLine test cable and/or Type N jack-equipped attenuator depending on the radio model being tested.

(QMA plug-Type N plug between series)

Stainless steel was chosen for the body versus industry standard nickel-plated brass because it wears well and eliminates plating that flakes and chips easily on brass bodies, possibly causing shorts. The internal metal components including the all-important sliding tines are heat-treated beryllium copper. A highly polished nickel plate is used on the tines to extend mating life.

The next step was to design adaptors that mate with the between series adaptor and to the various radio antenna interfaces. This was a serious challenge because drawings no longer existed for some of the items. The picture below shows a few of the new Times steel adaptors alternating with their older, brass BNC counterparts.

(QMA jack versus older, BNC radio adaptors)

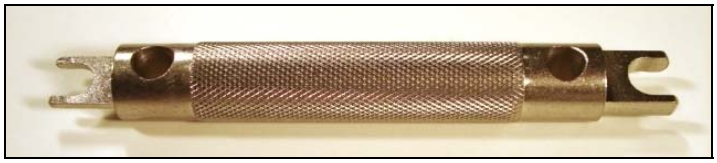
In all cases (except the SMA plug-equipped adaptor) the QMA’s have large knurled surfaces to ease handling and installation. During trials it was found that the semi-automatic station required a higher retentive force (i.e. a more secure “snap”) to assure sliding brackets with a very large mass would not inadvertently decouple. The original internal, eight-tine design of the QMA male was replaced with a stiffer, four-tine design. This worked nicely but made it too difficult to retract the QMA coupling nut hand. The coupling nut was therefore redesigned.

(8 & 4-tine designs compensate for side load)

Times’ Suregrip™ coupling nut features a sharp knurl instead of smooth ridges and a much larger shoulder against which an ergonomic, soft, inert plastic ring resides. The plastic ring greatly aids hand manipulation and reduces operator fatigue.

(QMA Suregrip™ vs. standard QMA)

Because of the repetitive nature of work in a high volume environment a fast release tool was designed and made available at all test stations. The release tool simply slides between mating halves and with a quick levering action causes the coupling nut to push back and release the radio. The tool and almost all the adaptors are designed not to roll, reducing the probability of misplacing or losing them.



(QMA fast release tool)

It should be noted that the high retention system is not required for manual testing similar to that which is found in radio repair shops. Therefore, the same Type N plug to QMA plug between series adaptor with the original, eight-tine design is available for sale that does not require the release tool (Times pn 3191-190EA). All QMA plug-equipped adaptors feature the Suregrip™ design and soft, ergonomic plastic ring.

Using hardware that was unique to each test system made it difficult for Motorola to resolve RF results discrepancies between them. Times' QMA solution solved this problem too since the same hardware is now used on both test systems.

Improving the quality of the materials, designing for high frequency operation (in some cases 18 ghz) and tightening the manufacturing tolerances improved adaptor VSWR to under 1.02:1 at 1 ghz (3191-136EA) on average. The loss consistency between copies of the same adaptor improved to the extent that adaptors can now readily be changed out on a test system without recalibration. Power output readings now routinely fall well within +/-1mw from station to station.

(SilverLine-QMA adaptors. Precision, all steel)

The QMA interface inherently resists changes in RF performance due to side load because the heat-treated tines conform to the mating half regardless of external pressure. The symmetrical, "air-hose" mating inter-face allows the two halves to fully rotate 360° relative to each other.

Thus there is no need to disconnect a radio or otherwise manipulate the coax test cable to reach the front controls or view the display and internal components from the rear for repair and tuning. The swivel joint maintains performance and also eliminates all torque or twist from being introduced into the test cable (the primary source of test cable failure) thus greatly extending the cable's usable life.

The “snap-on, pull-off” mating action also eliminates the need for torque wrenches of different sizes and values and the cost associated with their purchase and maintenance and recalibration. Further, the secure “snap” means the proper mating force is applied at all times, unlike threaded joints that are not properly torqued.

Today 23 adaptors exist including those that mate with most popular radio brands including Motorola, ICOM, Kenwood, Johnson, M/A-COM, Vertex Standard and others. The list includes adaptors to mate with most popular coax series as well including PL259, TNC, SMB, mini-UHF in both male and female and many others. An SMA between series is available as is reverse polarity SMA and TNC for wireless Internet operators.

Times continues to add to the list of available adaptors and is currently working with several additional radio makers. In addition, All SMA, N and TNC adaptors in both male and female will be rated to 18 Ghz and made available in late 2007 along with a life cycle guarantee approaching 5000 mates*.

(Adaptors exist for most hand & mobile radios)

Adaptors are available for purchase separately or as kits. A shop kit includes two copies of adaptors for most popular hand held and mobile radios (20 count). The kit box is made of a high impact plastic and is airline approved. Dense foam inserts keep the adaptors securely in place during rough handling. Cutouts in the lid hold additional adaptors purchased separately.


(QMA shop kit (left) and Field kit (right))

A field kit includes two copies of all popular adaptors to mate with virtually all coax connector series encountered in radio base stations (30 count). This eliminates the need for multiple test cables. Field kit adaptors ship in a heavy-duty, cut resistant yet lockable suede pouch that is easily stowed with other test gear.

Test cables are purchased separately and are available in any length and connector configurations to fit all test equipment. Standard lengths are in stock with Times Authorized distributors.

SilverLine test cables equipped with QMA plugs on both ends along with a full compliment of QMA adaptors make a high performance, rugged, yet universal and cost effective test system that meets almost all shop and field needs.

*Assumes proper use and periodic cleaning.