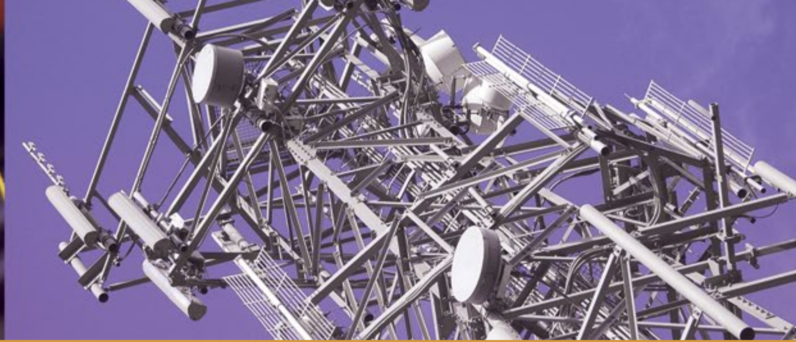

Fast Surge Protection for RF Ports in Handheld Instrumentation

APPLICATION NOTE

TBU-CX065-VTC-WH

CDSOT23-SM712

2031-23T-SM

INTRODUCTION

Capital expenditures in wireless communications continue to increase with operators investing in faster wireless broadband services for their customers. In a study by Infonetics Research, the analyst firm found that overall expenditures worldwide for telecom infrastructure in 2011 was $311 billion USD, which was up six percent over the previous year. As base station towers increasingly dot the landscape over the coming decades, there will also be a growing need for portable equipment to monitor the health of coaxial feeder cables on-site as well as the quality of transmission signals. The transmit and receive functions of a base station antenna system are quite vulnerable to extreme weather conditions. Any damage to the sheath of a cable, for example, or potential leak points within a tower-mounted amplifier can affect the VSWR (Voltage Standing Wave Ratio) of the cable, reducing the overall transmit capabilities of the base station. Handheld spectrum analyzers are used by technicians in remote field locations for monitoring the general health of base station antenna systems.

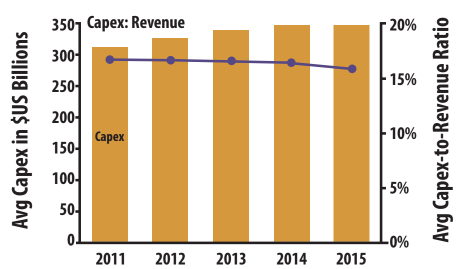

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Figure 1. *Global Telecom Carrier Capex*

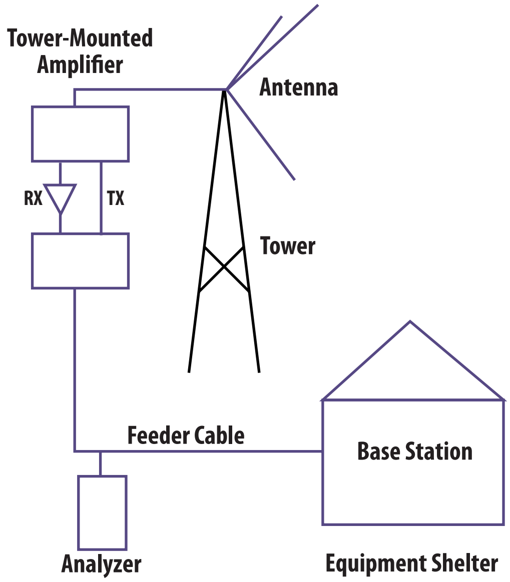

Figure 2. *Block Diagram of Telecommunications Cellular Base Station*

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TYPICAL BASE STATION MEASUREMENTS

The most common frequency bands used by cellular base stations are summarized in the table below:

Table 1. *Common Frequency Bands in Modern Wireless Communications*

Standard	Bands
WiMAX	2.6 GHz, 5.6 GHz
WCDMA	0.88 GHz, 1.96 GHz, 2.68 GHz
GSM	0.85 GHz, 1.8 GHz

Field technicians typically make the following cellular base station measurements with a handheld analyzer:

- **Return loss measurement:** This matching measurement for an antenna system provides information about the basic condition of the system. If problems are shown during this test, it can be assumed with a high degree of certainty that the antenna system contains faults that will affect the customer.
- **Discontinuity measurement:** The measurement of discontinuities in the antenna system shows abnormal changes in the characteristic impedance. It also indicates the location of the discontinuities in the connection and feeder cables as well as in the cable connectors (plugs and sockets). This measurement makes it possible to determine the effect of these discontinuities on the operating frequency range of the antenna system, and to determine the radiation characteristics of the antenna itself.
- **Decoupling measurement:** The decoupling measurement determines the electrical decoupling of two antenna systems in the coverage area. This type of measurement is both necessary and useful for cross-polarized antennas.

Cellular base stations are usually equipped with circuit protection to protect against lightning surges in several locations such as the top of the tower where a gas tube normally is grounded to the tower structure or to a lightning down conductor. The base of the antenna tower is also a common location for circuit protection where the feeder cable bends, which increases the cable inductance and puts more stress on the cable insulation at that point. Another common location for surge arrestors is at the entrance to the equipment shelter providing primary protection to the networking and RF equipment inside.

The RF analyzer used to monitor the health of the antenna system will also have circuit protection built-in. According to the EMC directive 89/336/EEC, all electronic equipment must comply with the protective aims of the EMC directive. The CE mark of conformity on the product indicates that the equipment meets these requirements. Because handheld analyzers can potentially be exposed to lightning induced transients, the relevant test surge standard is IEC 61000-4-5.

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THE NEED FOR ADEQUATE SURGE PROTECTION IN RF ANALYZERS

A basic problem for handheld RF analyzers is how to protect the device's internal 50 ohm load from lightning induced surges. Using 50 ohm terminated ports in RF test equipment and common oscilloscopes is a well understood practice. Among the benefits of using 50 ohms is the superior voltage sensitivity resolution provided especially at low signal levels compared to analyzers that do not have a terminated input port. Furthermore, 50 ohms is the industry standard impedance for RF transmission lines and portable analyzers also use 50 ohm terminations. Lab equipment test engineers also use external 50 ohm loads, commonly employed in coaxial BNC connectors. For handheld test equipment designed for rugged conditions such as base stations, it is more convenient to have the RF termination inside the device.

It is important to note that handheld analyzers are more susceptible to induced surges from events such as lightning or power cross when checking 30-40 meters of feeder cable. This would require the device to be tested according to IEC 61000-4-5 in order to conform to international standards. The internal 50 ohm termination would need to be a planar thick film load resistor with a VSWR of less than 1.2. This allows the 50 ohm load to perform effectively in absorbing the RF waves while reflecting as little energy back as possible. A VSWR of 1.2 corresponds to a return loss of 20 dB.

$$\text{Return Loss} = 10 \text{ times log base } 10 \left(\frac{\textit{Reflected Power}}{\textit{Input Power}} \right)$$

Planar resistor technology is very good at withstanding RF energy, which is the result of the skin effect where RF energy migrates away from the center of a conductor to the surface. Hence, a planar surface conducts RF energy with fewer losses than a cylindrical conductor. However, the thin layer of resistor material of 50 ohms cannot cope with high voltages. For example, a 5 W, 50 ohm load could handle a maximum of 80 V for a maximum 5 seconds, and there is a large gap between being able to handle 80 V for 5 seconds and a high-voltage surge of 2 KV with a duration of 50 microseconds.


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FAST BLOCKING, HIGH CURRENT SOLUTION

The recommended solution involves using circuit protection components to form a circuit that will pass RF waves through the cable to the analyzer, yet will block any surge energy from reaching the 50 ohm load inside the analyzer. The key component in this solution is a Bourns® TBU® High-Speed Protector (HSP) which when placed in series with the RF analyzer and in parallel with a surge arrestor provides a complete and effective solution within rated limits. The Bourns® TBU® HSP will trigger immediately to a high impedance state once the current going into the 50 ohm termination rises above 500 mA. The Bourns® TBU® HSP is used in conjunction with a Bourns® Gas Discharge Tube (GDT) to break down at a voltage (630 V for a surge of 5 KV) below the maximum voltage rating of the TBU® HSP (650 V for Model TBU-CX065-VTC-WH). The GDT also protects the Bourns® TBU® HSP from the high-voltage levels of the surge, and will not break down during a 300 V_{rms} power cross test. In that type of event, the current going into the termination will crowbar the Bourns® TBU® HSP, causing it to trigger into a high impedance state. The 50 ohm termination is therefore protected from the lightning surge and the Bourns® TBU® HSP will reset once the surge event passes. During normal conditions, the Bourns® TBU® HSP has a DC resistance that varies depending on the model chosen. It delivers a consistent insertion loss level over 1 GHz as shown in figure 3 (7 ohms for Model TBU-CX065-VTC-WH).

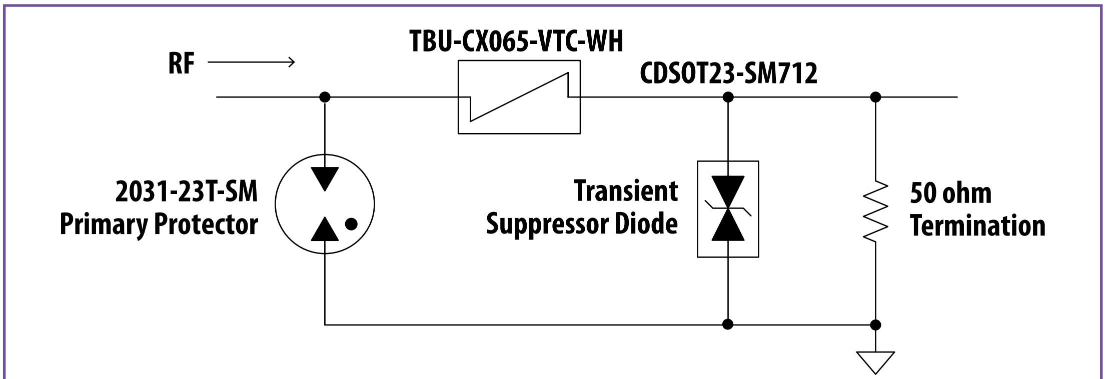

Figure 3. *Overview of Solution for Protecting A 50 ohm Internal Load in an Rf Analyzer*

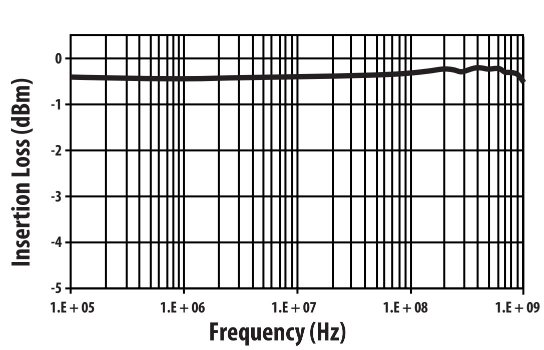

Figure 4. *Typical Insertion Loss of a Bourns® TBU® HSP Over 1 GHz*

The key advantages of placing a TBU® HSP in series with the RF signal compared with other solutions such as surge resistors is its speed of response to transient events and its high bandwidth. The TBU® HSP will change state in less than a microsecond. The key benefit of this termination is a vast reduction in the amount of energy it will receive from the surge than with a conventional surge resistor. Furthermore, the TBU® HSP has been characterized to RF frequencies and shows a very stable impedance to resistance ratio. The same ratio for surge resistors often will either taper off or increase depending on the resistance value at frequencies above 100 MHz.

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EFFECTIVE PROTECTION OF RF INSTRUMENTATION

There is a growing need for test and measurement equipment in the expanding wireless communications market to monitor cables and antennae as well as RF signals of cellular base stations. To maintain performance of this crucial equipment, adequate protection for RF ports is an essential design requirement. Of particular importance is ensuring that the internal 50 ohm termination is spared severe lightning surges, which could destroy the termination. Through its decades of providing proven circuit protection solutions, Bourns has developed a comprehensive portfolio of component solutions. Developers of handheld analyzers for cellular base stations can find viable and effective primary protection solutions for RF ports with Bourns® surface mount GDTs and TVS diodes. In addition, Bourns® TBU® High-Speed Protectors are an optimal solution for blocking damaging high-voltage energy from reaching the termination.

ADDITIONAL RESOURCES

For more information on Bourns® circuit protection products, visit Bourns online at:

www.bourns.com

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