# Selecting the Right Probe For Probe Card Test Applications

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The testing of small geometry devices requiring probe cards or other custom fixturing can be very frustrating to even the most experienced test engineer. Originally developed for DC parametric testing of wafers, probe cards are now commonly being used for functional or AC parametric testing of wafers and hybrids and are even starting to be used to probe printed circuit boards (PCBs), particularly those with surface mounted devices (SMDs).

Unfortunately, until now the probes that have been available for probe card mounting, while well suited to DC testing, have had limitations when used in high speed functional or wide-bandwidth AC testing. Other custom fixturing for testing these devices also has had some of the same limitations, including narrow bandwidth, high loading, low dynamic range, poor linearity, and high cross talk.

To overcome many of these testing problems, low-cost field-effect transistor (FET) probes recently have been introduced offering wide bandwidths, low input capacitance and high input and impedance, wide dynamic range, and good linearity. Not only has this provided the test engineer with a better method of making many of the previously difficult measurements, but it also has opened up a range of applications never possible using past techniques.

## The Traditional Approach

In probing a microcircuit or device, the probe is mounted onto probe cards positioned directly over the hybrid, IC, circuit board, or SMD to be tested, as seen in figure 1. Actual probing occurs through an opening in the center of the probe card, often aided by a high power microscope and three-axis probe station.

Traditionally, choices for probe card applications have been metal blade probes, ceramic blade probes, buffer amplifiers, and oscilloscope probes.

*Metal blade probes:* These probes are the most common in probe card applications. Metal blade probes are available from a number of manufacturers in a variety of different sizes and dimensions to suit different applications. They also are available with a wide variety of different tip materials to suit the application. For example, tungsten tips may be used for probing aluminum, and palladium tips for probing gold. Metal blade probes also are inexpensive. However, their use in other than DC or very low speed applications will result in a number of problems, the worst of which is usually high loading of the device under test. The probe itself is an uncontrolled impedance but the bulk of the loading is the result of the capacitance of the cable or wire between the probe and test

*Figure 1, (on next page), active FET probes (lower right) can be mounted on a probe card directly alongside passive 50 Ω (upper right) and standard blade probes (upper left).*

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equipment. This capacitance is often 100 pF or more (100 pF at 10 MHz = 159 Ω; 100 pF at 100 MHz = 15.9 Ω). Impedance this low results in loading that makes functional or AC parametric testing of most devices impossible.

*Ceramic blade probes:* These probes, also available in a variety of configurations and with a variety of probe tip materials, have an advantage over metal blade probes. The ceramic (alumina) is a reasonably good dielectric, therefore the probe can have stripline conductors with controlled impedance. If these probes are connected to the instrumentation through coaxial cable of the same impedance and are terminated at the test equipment in this characteristic impedance, a transmission line is created and the lumped inductance and capacitance disappears. This transmission line with its controlled impedance can have a very wide bandwidth, and makes functional and AC parametric testing possible. However, this characteristic impedance must necessarily be low, usually 50 Ω. Testing of devices not capable of driving 50 Ω, therefore, still is not possible.

*Buffer amplifiers:* Traditionally, the approach taken to testing devices that cannot tolerate much loading has been to put a buffer amplifier between the device under test (DUT) and the test equipment. In effect, this results in a high input impedance, low output impedance amplifier immediately behind a blade probe to drive the low impedance of the transmission line. The buffer amplifier usually is mounted directly on the probe card as close to the DUT as possible to minimize the reactance.

Buffer amplifiers have two major problems. First, they are normally left to the test engineer to design, which consumes a lot of time and, as a result, are expensive. Unfortunately, the accounting practices of most companies do not reveal these hidden costs. Second, because they usually are designed by someone for whom this is a part-time job, such test setups tend to be "kluged," unreliable, and require frequent calibration and/or repair. For the same reason, there tends to be many different versions. For example, one buffer amplifier may be designed for an application requiring it to have a wide dynamic range, but the next device may require a buffer amplifier with good linearity over a more narrow range.

*Oscilloscope probes:* There are a wide variety of different probes available primarily intended for use with oscilloscopes, but also are used with other types of instrumentation. Included are a number of differential and single-ended voltage probes, both passive and active, DC and AC coupled current probes, logic probes, very high voltage probes, and now even optical probes.

These oscilloscope probes are designed primarily to be hand held, however they sometimes are used in probe card applications, where they are often well-suited from an electrical point of view, but rarely well-suited from a mechanical point of view.

*Figure 2, the Tektronix P6501 card mountable active probe uses a FET amplifier to minimize loading.*

### A Better Way

Two probes* have been introduced recently that have been both mechanically and electrically optimized for probe card mounting. As a result, many of the difficult problems previously faced when using probe cards have been eliminated, reducing much of the cost and time spent in test setup development.

The 1 MΩ card mountable probe shown in figure 2 is an active FET input probe that has high input impedance, wide bandwidth, and wide dynamic range shown in figure 3. It also has lower aberrations, and better linearity than expected from an active probe with this wide bandwidth. This was done because it was anticipated that measurements, when using probe cards or fixturing, tend to be more quantitative. To avoid interference with the objective lenses of microscopes and laser trimming systems, the 1 MΩ probe has a low profile of approximately 0.5 inch. In addition, its narrow body of about 0.2 inch enables multiple probe configurations to be built, making it well-

**Tektronix P6501 and P6507.*

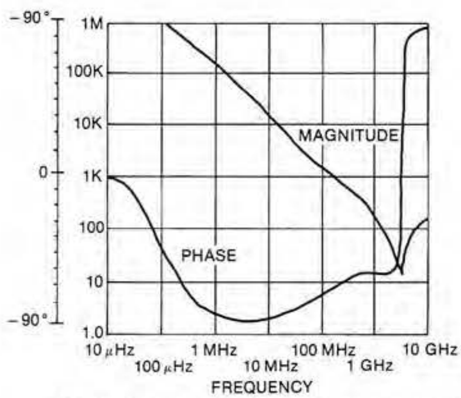


*Figure 3a, typical input impedance of the P6501 FET probe.*

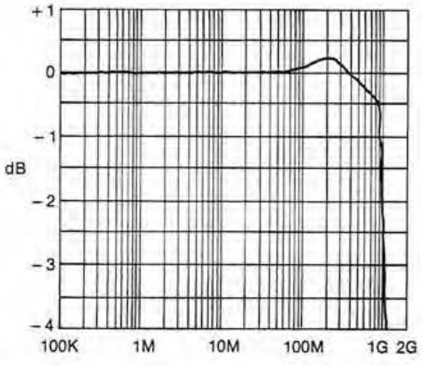


*Figure 3b, typical normalized frequency response of the P6501.*

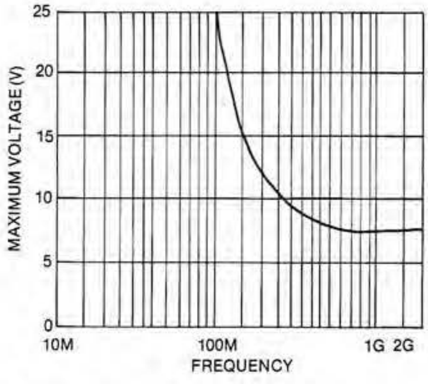


*Figure 3c, typical voltage derating vs. frequency of the P6501 FET probe.*

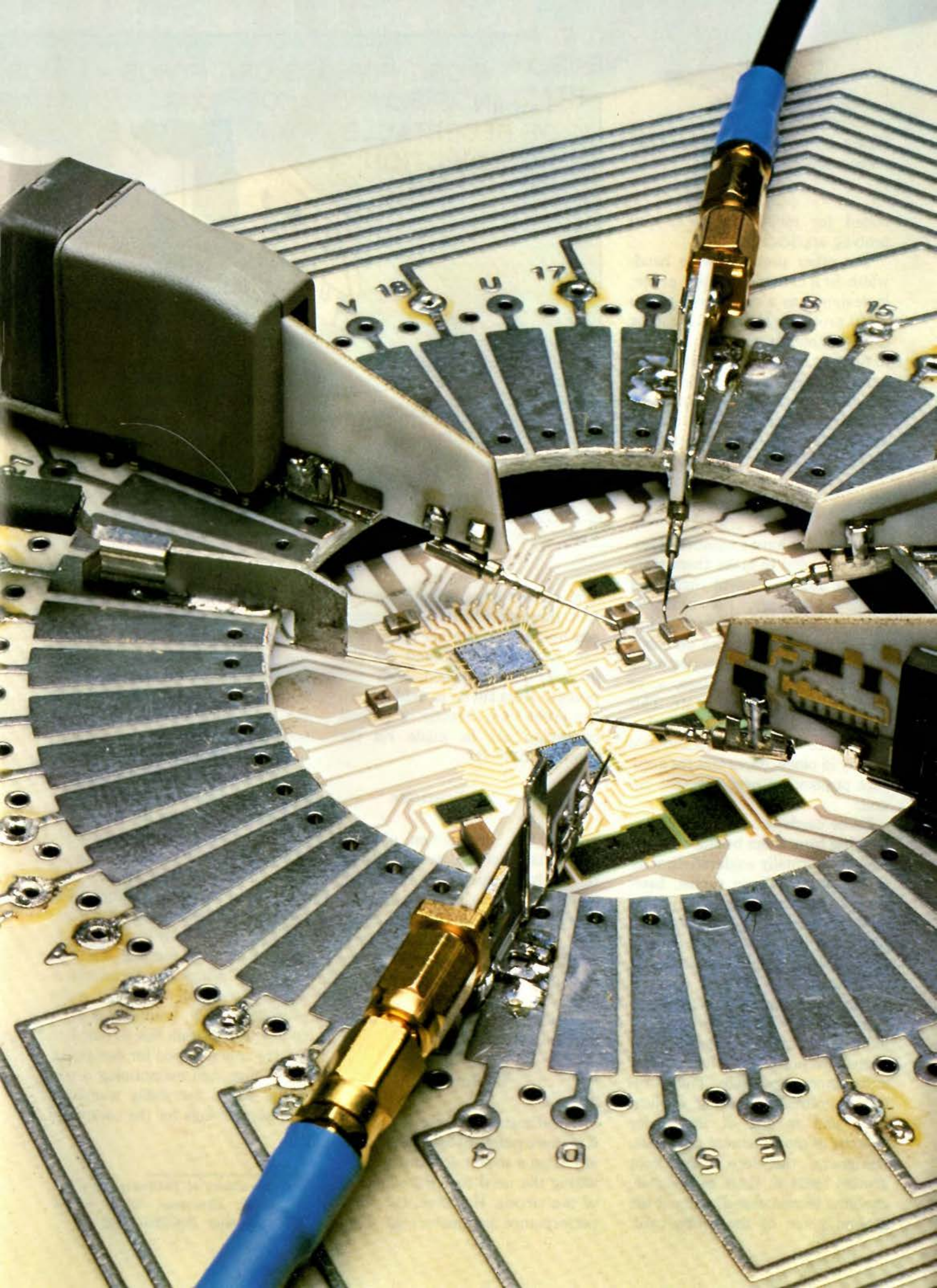
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*Figure 4, the P6507 probe has a frequency response to 16 MHz.*

suited for medium high density probing applications.

The other probe, a wide bandwidth 50 Ω ceramic stripline probe, is designed as a companion to the 1 MΩ probe for injecting signals or as a 50 Ω output probe. It is shown in figure 4. It also can be used for a variety of applications; for example, as a power supply input probe with decoupling capacitors mounted on the probe or in time-domain reflectory (TDR) applications.

### Advantages

The probes have a number of features intended to make them more flexible and convenient than older probe technology. For example, both probes have replaceable tips and receptacles that can be easily replaced for applications requiring different materials or sizes, or as wear or contaminants dictate. This can be seen in figure 5. Both probes also can be soldered down and held rigidly in place, important for accurate positioning over the test circuit.

Probe cards usually have cables hanging from them because the cables are normally soldered directly to the probe. These cables, however, are a constant source of reliability problems. To eliminate such problems, the new probes employ connectors so that all cables can be disconnected.

The input capacitance of a probe is essentially charged through the inductance of the ground lead. Hence, grounds should have as low inductance as possible. This is often forgotten in probing applications and is one of the major sources of measurement problems. Designers, therefore, have kept ground leads as short as possible, enabling termination directly at the ground plane of the probe card.

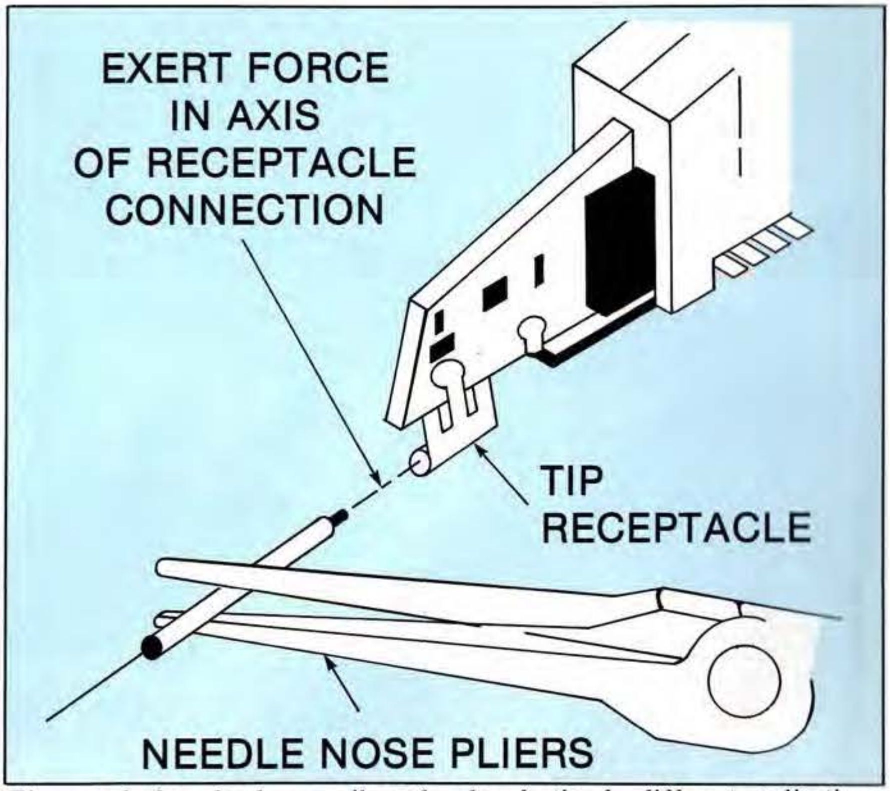


*Figure 5, both probes have easily replaced probe tips for different applications.*

The probes have ground connectors through which a connection can be made to another probe that can be used for ground via the ground wire supplied with the probes. Because it is soldered to the probe card directly, a ground connecton can be made via the probe card itself.

### New Applications

With the introduction of high performance probes designed to be relatively transparent to the circuit under test, some new applications areas may have high growth rates. For example, functional hybrid laser trimming may replace some of today's passive trimming. Probe cards for circuit board probing, particularly when SMDs are used, may find wide use.

### Buffering

Sometimes with hybrid circuits, it is more practical to conduct testing using a socket or fixture, eliminating the need for direct probing of the circuit. However, the same performance parameters as when probe cards are used must be measured, and the same problems exist. To achieve wide bandwidth and low loading, therefore, the 1 MΩ FET probe can be used to condition test signals simply by mounting the probe on the fixture or socket, removing the tip, and wiring a lead directly from the probe tip to the hybrid socket.

The development of high performance active probes for probe card mounting has made it possible for test engineers to make more accurate measurements easier than ever before. Even more important, measurements now can be made that were previously impractical or perhaps not even feasible. And, because test setups can be standardized, procedures become more practical and convenient. Of course, the bottom line is that less time is now required for designing, initializing, and maintaining a test setup, which inevitably translates into cost savings for the company.

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