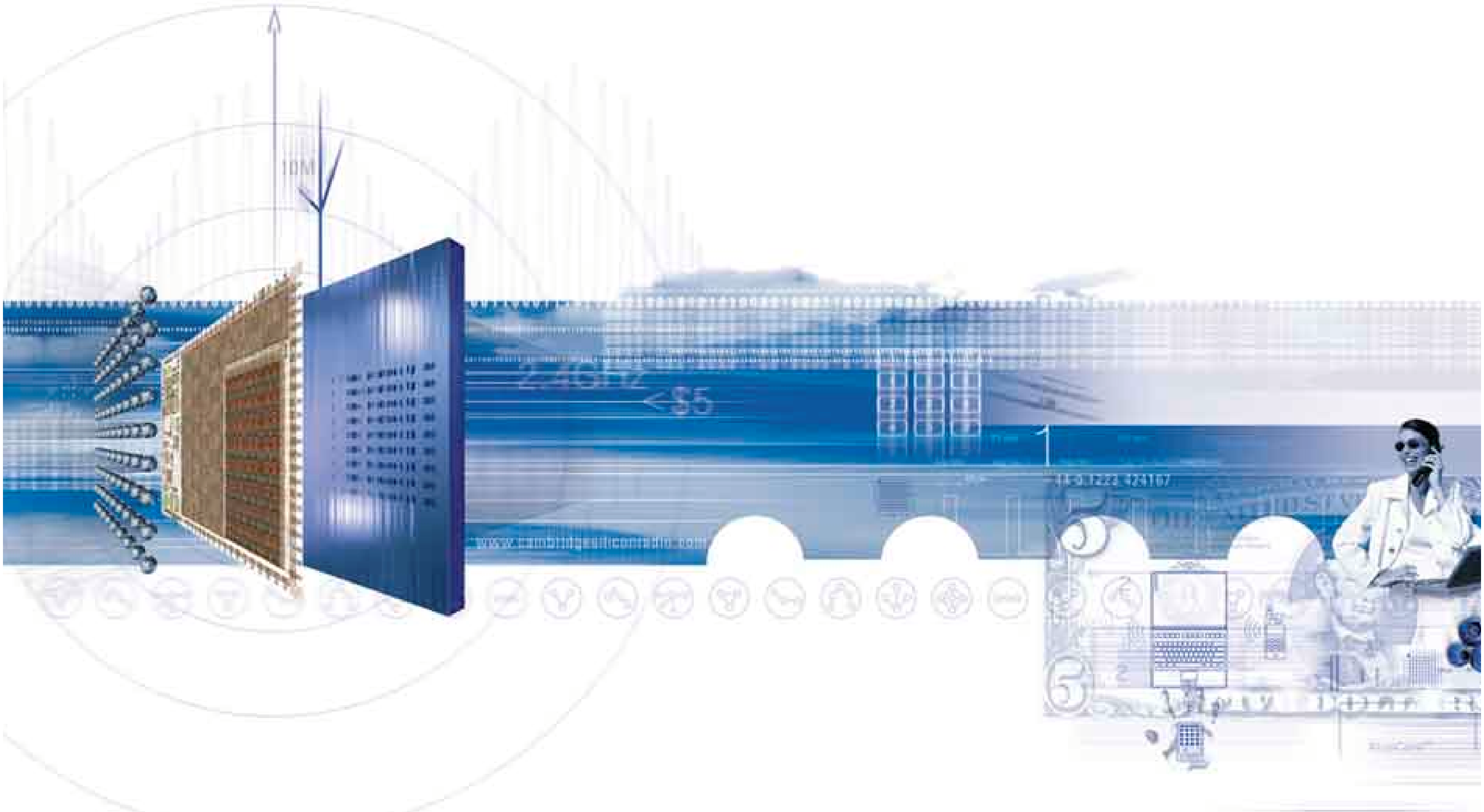
BlueCore™

Inverted-F and Meander Line Antennas

Application Note

January 2003



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Contents

List of Figures

1 Introduction

This document outlines two types of Printed Circuit Board (PCB) antennas used by CSR.

- Inverted-F
- Meander Line

Also discussed in this document is the effect of placing metallic or dielectric materials near an antenna.

2 Inverted-F Antenna

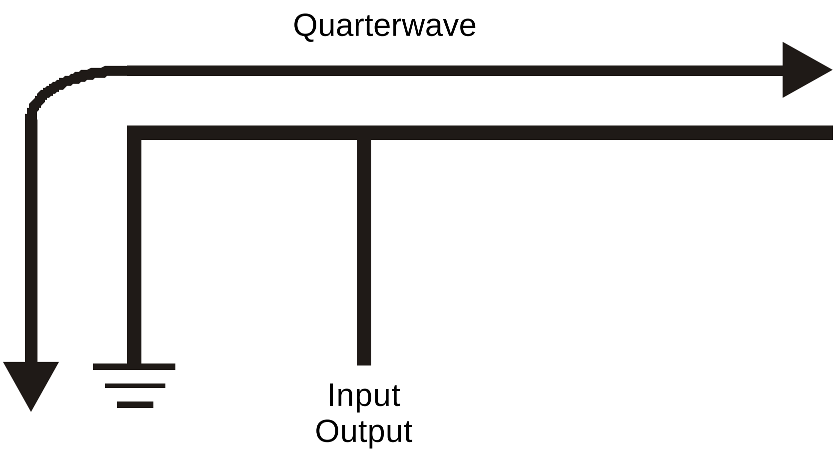


Figure 2.1: Inverted-F Antenna

The inverted-F is a quarterwave antenna. It is bent into an L-shape. The shorter side is connected to earth. The longer side is left open circuit at the end. The feed point is located somewhere between the earth end and the open end. The resulting structure resembles the letter F and possesses the properties of both a loop antenna due to the circulating current from the feed point to ground and a whip antenna due to the open circuited straight section.

In the PCB version the antenna is printed on the top layer and a ground plane is placed near the antenna on the top layer. There must not be a ground plane underneath the antenna.

The aim is to make the quarterwave section resonate at midband frequency (which is 2441MHz for Bluetooth™). The feed point (which is the input/output connection) is connected to the L-Shape at the point corresponding to 50Ω. Experiment with measurement to determine correct location for the feed point and length of this antenna.

3 Meander Line Antenna

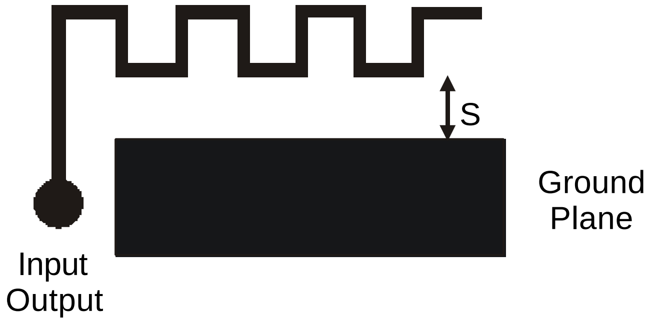


Figure 3.1: Meander Line Antenna

The length of the meander line antenna is difficult to predict. It is usually a bit longer than a quarterwave but dependent on its exact geometry and proximity to the ground plane.

Note:

In Figure 3.1 the ground plane is shown in black. S is the distance from the ground plane. See Figure 4.2 for approximate dimensions.

This type of antenna is always a PCB version. The antenna is printed on the top layer and a ground plane is placed near the antenna on the top layer. There must be no ground plane underneath the radiating section of the antenna.

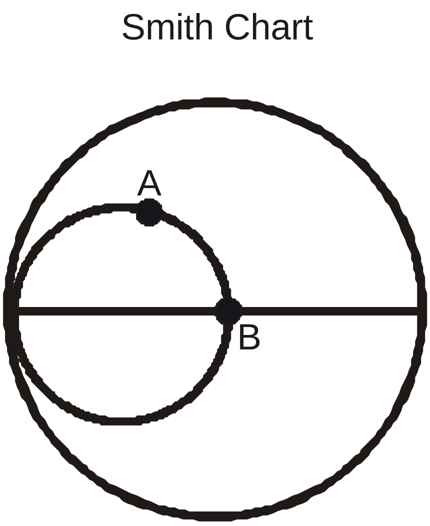
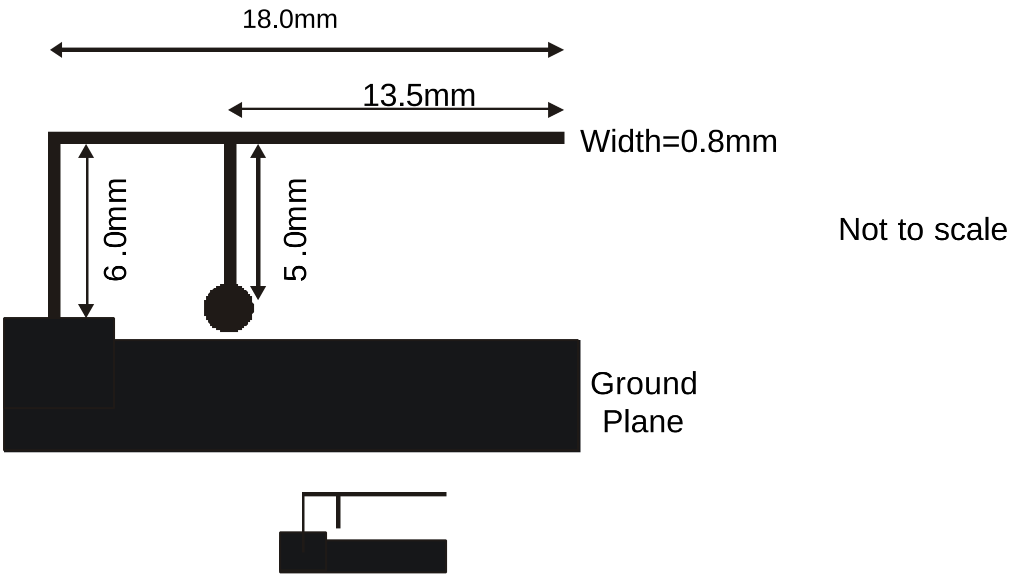


Figure 3.2: Input Impedance of Two Meander Line Antennas

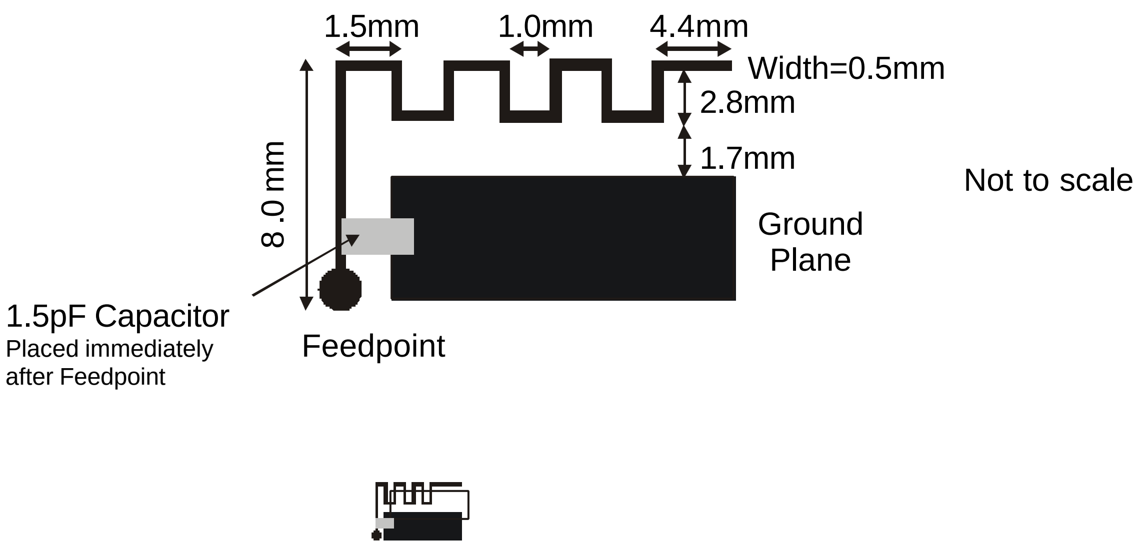
The real part of the impedance of this antenna is about 15-25Ω, depending on geometry and proximity to the ground plane. The impedance matching is done by adjusting the length of the antenna until the input impedance is at the unity conductance circle (when normalised to 50Ω), in the top half of the Smith chart (Point A). A shunt capacitor is then connected between the antenna input and ground to match to 50Ω (Point B). Experimental measurement is used to determine the correct design.

4 Real Designs



Actual Size

Figure 4.1: Approximate Dimensions of Inverted-F Antenna



Actual Size

Figure 4.2: Approximate Dimensions of Meander Line Antenna

BlueCore™ Inverted-F and Meander Line Antennas

5 Proximity to Metal Objects

CSR recommends keeping metal objects as far away from the antenna as possible. Keeping metallic objects out of the near field is usually adequate.

Near Field = $2D^2 / \lambda$

D is the largest dimension of the antenna. In the case of these antennas, this is approximately a quarterwave ($\lambda/4$).

Notes:

λ is the wavelength of the signal in freespace.

At Bluetooth frequencies, λ=122mm in freespace.

Substituting D=$\lambda/4$ into the Near Field equation gives Near Field = $\lambda/8$.

Near Field = 122/8 mm = 15.25mm.

6 Proximity to Dielectric Materials

Dielectric materials (like plastic or FR-4) detune an antenna by lowering its resonant frequency. The effect is not as serious as placing an antenna next to metal objects and can be corrected by reducing the length of the antenna. Therefore it is important for the antenna to be tuned when it is in the product. This is done during the development of the product.

7 Network Analyser

A Vector Network Analyser (VNA) is used to perform the initial tuning of the antenna:

1. The PCB track (trace), just before the antenna matching network is cut to isolate the filter and previous stages from the measurement.
2. A coaxial cable is connected between the VNA and the PCB of the product. The outer conductor of the coaxial cable is soldered to the ground plane of the PCB as close as possible to the input of the antenna matching network. The inner conductor of the coaxial cable is left floating. The coaxial cable must have ferrite beads over the outer sleeve of the coaxial cable. The ferrite beads help to prevent RF currents from flowing on the outside of the coaxial cable (which would disturb the measurement).
3. A One-Port calibration is performed on the VNA with Open, Short, Loads connected at the end of the coaxial cable inside the product.
4. The inner conductor of the coaxial cable is soldered to the input of the antenna matching network.
5. The antenna is tuned by adjusting the values of any “matching network” components, the feed point of the antenna or the length of the antenna until the S11 trace (displayed on the VNA) is at the centre of the Smith chart at the midband frequency 2441MHz.
6. The antenna is now roughly tuned and the cut track can be repaired by putting a small amount of solder over the cut.

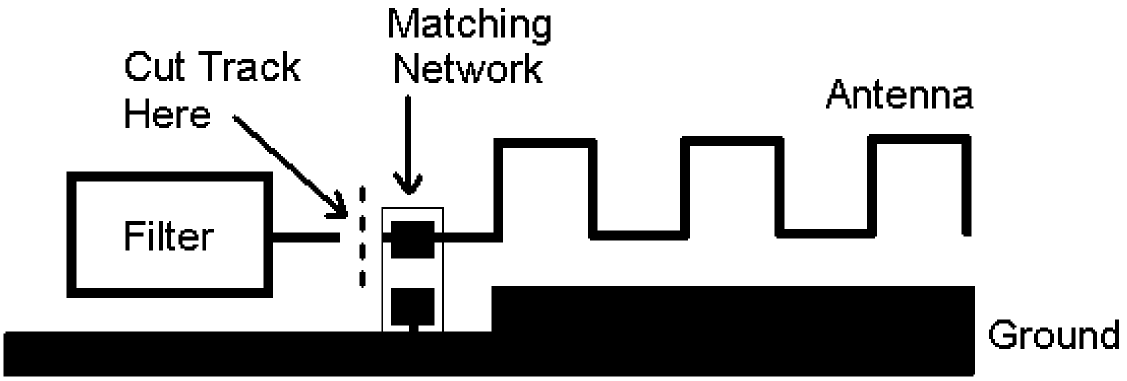


Figure 7.1: Preparation Before Measurement

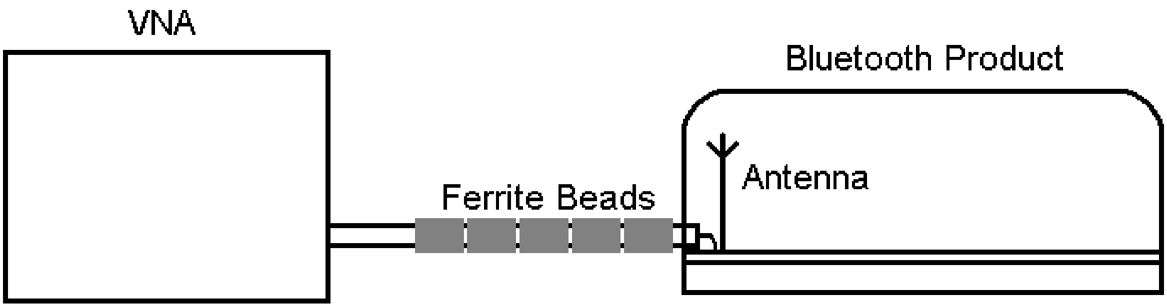


Figure 7.2: Assembled System Ready to Measure

8 Final Tuning

After tuning the antenna using the VNA procedure, it is necessary to perform fine tuning. This will yield a small improvement and will be the final optimisation of the antenna. It is best to perform this procedure in an anechoic chamber, but when this is not possible an indoor or outdoor test range can be used. It is important to minimise radio signal reflections. Avoid metallic objects such as lab-benches, filing cabinets, lampposts and cars.

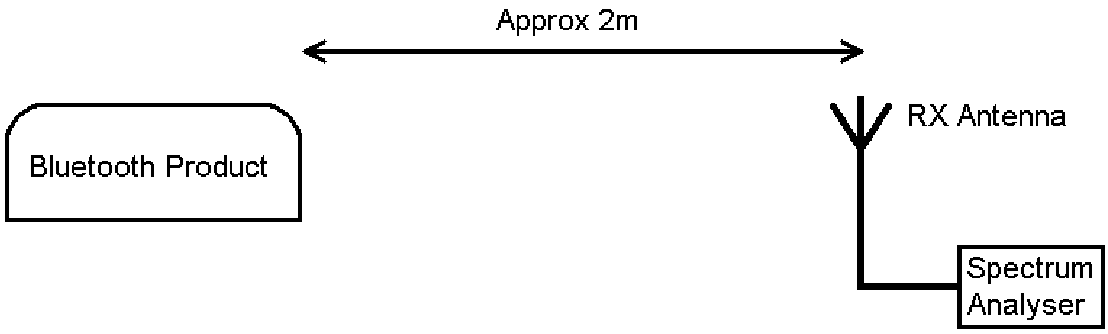


Figure 8.1: Locating Product in Far Field of Antenna

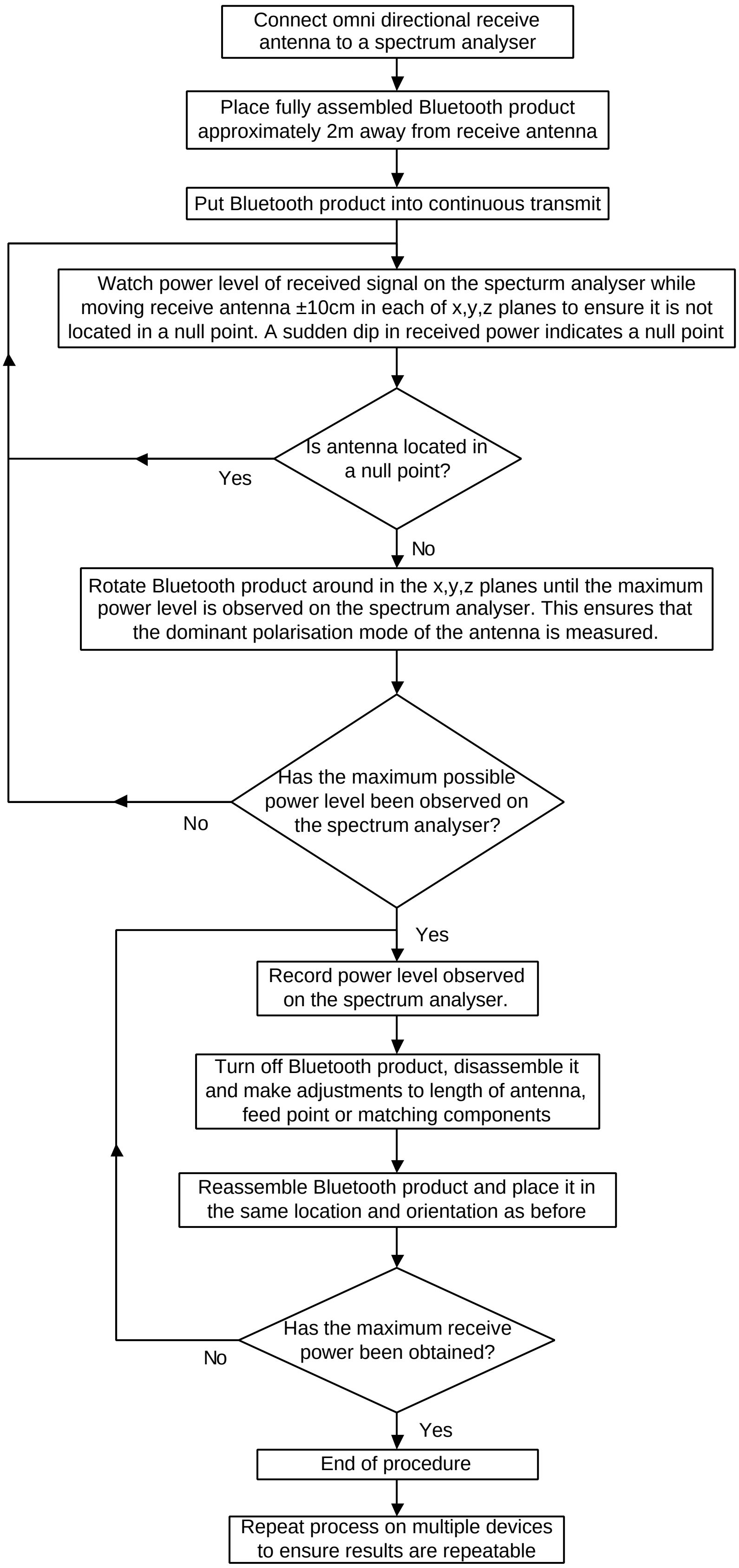


Figure 8.2: Final Tuning Procedure

9 Conclusion

Metal objects should be kept at least 15.25mm away from the Inverted-F and Meander Line types of antennas in the Bluetooth frequency band in order for the antenna to work efficiently. If that is not possible, then extra experimentation is required to determine an acceptable trade-off between antenna performance and product size.

Even if these rules are followed, antenna detuning can occur. Usually the resonant frequency of the antenna will be lowered. This can be corrected by reducing the length of the antenna.

Acronyms and Definitions

BlueCore™	Group term for CSR's range of Bluetooth chips
Bluetooth™	Set of technologies providing audio and data transfer over short-range radio connections
CSR	Cambridge Silicon Radio
PCB	Printed Circuit Board
RF	Radio Frequency
VNA	Vector Network Analyser

Record of Changes

Date:	Revision	Reason for Change:
24 JAN 03	a	Original publication of this document. (CSR reference bcant-an-001Pa).

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bcant-an-001Pa

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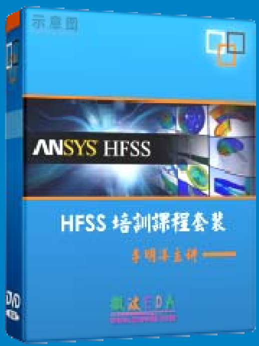

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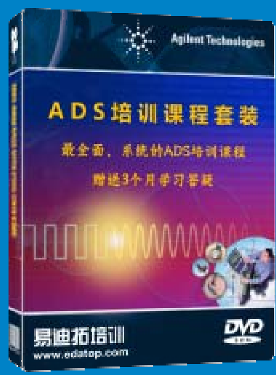

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