Distributed Antenna System (DAS) for IoT, Cellular and other Wireless Applications

The Internet of Things (IoT) has continued to grow at a rapid rate in recent years. With the connectivity of cellular devices, computers, vehicles, buildings, sensors, and more electronics, it's more important than ever that these devices are able to connect, communicate and meet the needs that users covet.

Typical office setting for a DAS application

The wireless connectivity for the IoT will use many network access technologies, including Global System for Mobile (GSM), cellular Long Term Evolution (LTE), 4G and the much anticipated revolutionary 5G to name a few. There are plenty of other wireless protocols and air interfaces available for supporting IoT applications (WiFi, Bluetooth, LoRa, ZigBee, and Z-Wave, to name a few), but it's clear the landscape is changing and IoT devices will take advantage of the protocals offering the greatest data throughput.

Distributed Antenna Systems (DAS) provide strong and reliable wireless connectivity in location where connectivity is a problem with standard wireless routers or cellular connectivity, such as: inside multistory buildings, outside industrial settings, and subterranean environments. DAS in conjunction with (LTE/4G/5G) based IoT services will continue to grow in coming years.

Why DAS?

While some of the IoT applications will be outdoors (connected cars and trucks or street lighting infrastructure, for example), most IoT applications will be within buildings. Industrial control, point of sale, asset tracking, medical, environmental monitoring, security, smart lighting, and other applications will require strong in-building wireless connectivity or signals. Ideally, the wireless network solution should deliver seamless blanket coverage throughout the building so as not to restrict where IoT sensors can be placed. However, in reality, this blanket coverage can be difficult to achieve with simple wireless routers. DAS is particularly helpful in providing the needed wireless coverage. Access to wireless IoT communication not only aids the public, but is also mandatory for law enforcement, emergency medical, and fire services. As realization of the importance of DAS for IoT applications became apparent, so has backing from local and federal governments through proposed rulemaking.

Furthermore, DAS should support multiple frequencies, because mobile operators use 700 MHz, 1900 MHz, and AWS frequencies for LTE, among other frequencies. The solution should also support complex modulations such as time division duplexing (TDD) as well as frequency division duplexing (FDD) because mobile operators will use both technologies in their networks.

DAS also offers single-zone wireless coverage in a building:

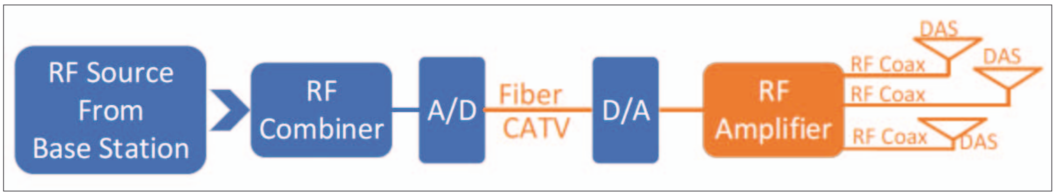

Figure 1: Block diagram of an Active DAS System

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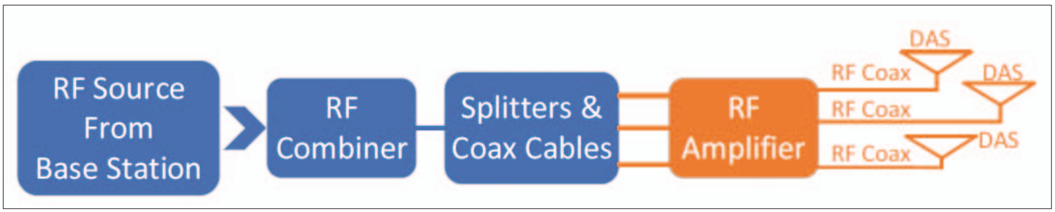

Figure 2: Block diagram of a Passive DAS System

unlike small cells, it isn't subject to inter-cell interference and handoffs from one coverage area to another as devices move through a building. In addition, DAS infrastructure natively supports multiple wireless frequencies. Finally, some DAS support both TDD and FDD transmission schemes, whereas today's small cells do not.

What to look for when selecting a DAS?

There are many DAS solutions on the market. The main components of any DAS are the selected amplifiers and antennas. These amplifiers and antennas must offer a wide operating frequency range, and good linear RF performance to cover WiFi and all cellular and wireless services. In addition, these amplifiers and antennas must be unobtrusive, easy to install and maintain, durable, and high quality.

DAS systems can be separated into three categories:

Active DAS: When there is a huge demand from users or IoT based systems to access cellular coverage or WiFi, the active DAS system will help increase capacity and reduce the load from the macro network.

When additional capacity is needed, like in a football stadium or airport, an active DAS system is typically used. A state of the art active system can cover virtually any size of building and up to any capacity. Some of the most ambitious, active DAS systems have been designed to cope with the load of over 70,000 Super bowl attendees or the 2.47 million sq. ft. of coverage.

Active DAS systems often use fiber optic cable to distribute the signal between a centralized signal source and "remote nodes" placed around a building. The signal source is typically a "head-end" that combines signals from multiple carriers, which each need to provide their own signal source to the system, typically via their own fiber backhaul.

The block diagram and elements of an active DAS system are shown in Figure 1:

Passive DAS: Passive DAS systems typically use passive components like coaxial cable, splitters, and duplexers to distribute signal, and unlike active DAS, they use bi-directional amplifiers to rebroadcast the signal from the macro cellular network using a donor signal on the building roof.

There are limitations to the reach of passive DAS solutions. Because they use coax cable to distribute signal, signal loss is higher than with active DAS. The further away the antennas are from the amplifier, the higher the signal loss. The signal loss generally results in lower downlink output power.

These restrictions mean that the maximum coverage area for a passive DAS system is typically around 500,000 sq ft. But the advantages of passive DAS systems are considerable. In particular, they are considerably less costly than active DAS.

The block diagram and elements of a passive DAS system are shown in Figure 2.

Hybrid DAS: A hybrid system works a lot like an active DAS system. Hybrid DAS uses some fiber for backbone distribution of signal, and relies on passive coaxial cable for much of the remaining signal distribution. Hybrid systems can be a good solution for medium-sized spaces, or unusual signal problems. Multiple passive systems can also be linked by fiber cable to a remote amplifier unit.

The block diagram and elements of a Hybrid DAS system are shown in Figure 3.

The Solution

To meet these demands – to boost cellular network coverage and add capacity to reduce load from the macro network, AR rf/microwave instrumentation (ARI) and SunAR RF Motion have developed a series of broadband solid-state amplifiers and antennas to address DAS requirements. More specifically, SunAR DAS antennas are more directional than standard DAS antennas, allowing them to excel in applications requiring directivity, such as airport terminals, subway tunnels, hotel hallways, or directed at crowds at a sports venue.

In addition, ARI amplifiers and antennas are broadband, allowing them to cover a larger number of communication bands, potentially reducing the number of deployed DAS antennas in a system, versus standard narrowband DAS antennas. The SunAR DAS antennas' innovative design and manufacturing techniques result in long-lasting strength, excellent performance, and provide an aesthetic appearance. These antennas can be used in large, small, passive, active, and hybrid systems.

SunAR offers four antenna models for DAS solutions.

Model LP425R is a directional antenna designed for transmitting and receiving wireless communications signals. The broadband characteristics of the log-periodic structure enable it to operate over a very wide frequency range with constant gain. This DAS antenna outperforms many antennas in this class and is designed for more rugged environments. Figure 4 is an image of the LP425R.

Figure 4: LP425R 400 MHz – 3 GHz

Model's LP425PCB, LP6530 PCB, and LP6560PCB are low-profile directional antennas designed for transmitting and receiving wireless commu-

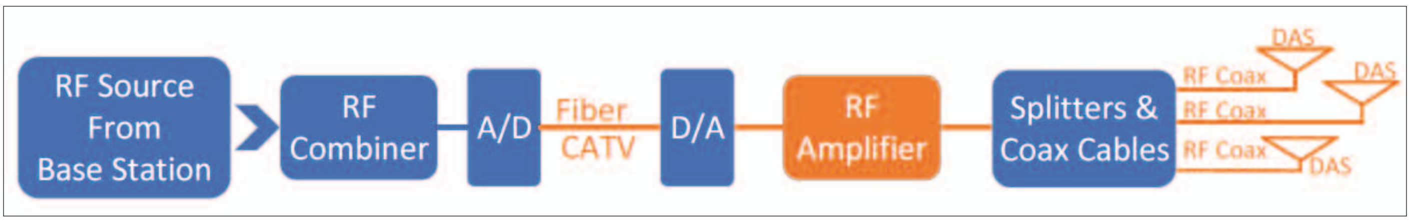

Figure 3: Block diagram of a Hybrid DAS System

Model	Freq. Range	Gain (dBi)	BW (deg.)	Ω	VSWR	Conn.*	Input Pwr. (W)	Length x Width (inches)	Weight in lbs (kg)
LP425PCB	400 MHz – 3 GHz	5.5	70° V Plane 100° H Plane	50	<2:1	N Female	25	15.5 x 11.5	2 (0.7)
LP425R	400MHz – 3GHz	7	70° V Plane 100° H Plane	50	<1.8:1	N Female	200	19 x 16	2 (1)
LP6530PCB	650 MHz - 3 GHz	7	70° V Plane 100° H Plane	50	<1.5:1	N Female	25	15.5 x 11.5	2 (0.7)
LP6560PCB	650 MHz - 6 GHz	6	70° V Plane 100° H Plane	50	<1.5:1	N Female	15	15.5 x 11.5	2 (0.7)

*Table 1: SunAR’s DAS antenna list   * optional connectors include 7/16 DIN and 4.3-10*

Amplifier Model	Frequency Range	Output Power (W)
10U1000. . . 50U1000	10 kHz to 1 GHz	10 Watts - 50 Watts
100U1000. . . 250U1000	100 kHz to 1 GHz	100 Watts - 250 Watts
150W1000B. . . 500W1000B	80 MHz to 1 GHz	150 Watts - 500 Watts
100S1G2z5A. . . 500S1G2z5	1 to 2.5GHz	100 Watts - 500 Watts
20S1G4. . . 350S1G4	700 MHz to 4.2 GHz	20 Watts - 350 Watts
15S1G6. . . 500S1G6	700 MHz to 6 GHz	15 Watts - 500 Watts

Table 2: ARI RF amplifiers for DAS application

Figure 5:
LP425PCB 400 MHz – 3 GHz
LP6530PCB 650 MHz – 3 GHz
LP6560PCB 650 MHz – 6 GHz

nications signals. These antennas are etched onto a low-loss microwave substrate material and mounted in a weather resistant housing that is only 1/2“ inch thick. Like the LP425R, the broadband characteristics of the enclosed antenna structures enable it to operate over a very wide frequency range with constant gain. There are four mounting holes for installation onto any flat, non-conductive surface, such as an office wall or ceiling.

Figure 5 shows the LP425PCB, LP6530PCB, and LP6560PCB.

The MIMO (multiple input, multiple output) antenna, shown in Figure 6, is actually a set of two broadband directional antennas, cross-polarized, in a single package with two RF connectors. This design provides polarization diversity in a MIMO environment. This configuration results in greater throughput than a single antenna.

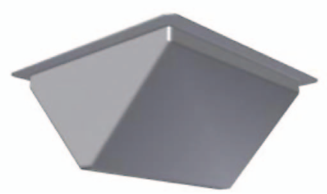

Figure 6: LP6530PCB-MIMO 650 MHz – 3 GHz

Each antenna is innovative and uses manufacturing techniques that result in long-lasting strength and performance. Specifications for each DAS model are shown in Table 1.

ARI offers Class A solid-state, linear, robust and versatile broadband RF amplifiers, see Table 2. These high performing RF amplifiers allow DAS systems to cover a large number of communication bands, helping increase the coverage throughout areas hindering RF signal strength, or over use of available bandwigth. Figure 7, is just one example of a DAS solution in an office building setting.

Conclusion:

The rapid growth in connected devices (IoT) promises lucrative business opportunities. In places where traditional distribution services cannot provide the required signal strength, DAS can be used. By deploying a robust and economical DAS system, governments or businesses can ensure robust support for IoT within their facilities and be positioned to deliver critical wireless services now and in the future. The amplifiers and antennas described in this application note meet these demanding requirements, and more.

AR’s wide array of amplifiers and antennas help you select the right system for your application. These amplifiers and antennas are designed using quality processes and components that are reliable, consistent performance from unit to unit, and allow for easy installations in a wide variety of situations, both indoor and out.

Using ARI DAS solutions will enable you to achieve your goals. To learn more about ARI DAS solution, visit our website at www.arworld.us. ◄