[Success Story]

Can BMW's iDrive Pass Its Road Test Now?

After a catastrophic debut and a major makeover, BMW's iDrive infotainment system is gaining acceptance with critics, competitors, and customers.

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BMW's 2001 introduction of iDrive, its pioneering driver information/entertainment system, was arguably the biggest corporate disaster since Coca-Cola Co. decided to tinker with the formula for its eponymous beverage.

To say that the automotive trade press and nearly every contributor to a Web discussion of the system hated iDrive is a huge understatement. How, one wonders, could anything in an automobile priced from $75,000 generate so much venom, especially considering the design objective and the fact that a driver didn't have to use it?

"The (iDrive) project started in 1998, six years ago," recalls Joe DiNucci, senior vice president of Immersion Corp. Immersion designed haptics profiles—programmable touch feedback—for the system. "BMW deserves credit for seeing over the horizon that the driver interface was becoming increasingly complex, literally overwhelming, and that adding more individual controls was not the answer."

What happens with both semiconductor chips and luxury cars is that market conditions continually force manufacturers to pack more functionality into, at best, the same space occupied by the previous version. For BMW, that meant the portion of the cabin within easy reach of the driver and/or the front-seat passenger.

Eventually, thought the Munich automotive electronics design team headed by Michael Würtenberger, there must be a limit to the number of switches, buttons, and knobs that a driver and passenger could manipulate effectively.

Würtenberger's colleague Hermann Kunzner, head of the group that designed the iDrive user interface, says the design goal was the ability to control a vehicle's climate/comfort, entertainment, and navigation systems via a single-input device that's roughly equivalent to a computer mouse. "We looked at different possibilities for the input, different screen sizes, and which functions had to be accessible through buttons," Kunzner recalls. "There always must be compromises, and iDrive for the 7 Series was the best compromise possible at that time."

A LEARNING EXPERIENCE

The iDrive system on the 7 Series features a display screen, quite large by auto dashboard standards, and a knob or dial located on the center console *(Fig. 1)*. Here, drivers gain access to eight application menus: Climate, Communication, Navigation, and Entertainment, plus BMW Assist, Vehicle, Help, and Configuration.

Operating somewhat like a standard shift, the knob must be pushed in one of eight compass directions to access a particular menu *(Fig. 2)*. Beneath the "hat" and the shell of the knob, which is manufactured by ALPS Electric, are an encoder and belt drive *(Fig. 3)*. The belt wraps around the drive spindle, which is directly mounted to the motor shaft.

"I was in the BMW booth at the auto show when they first introduced iDrive," says Mike Levin, vice president of industrial solutions at Immersion. "People would walk up to kiosks where iDrive demos were set up, try to use it, and get confused. But if I spent 30 seconds with them to show them how to shift from one function to another, rotate through the menu for that function, then press for the selection they want, they were able to move between functions easily and get stuff done. If you go through a little effort, it becomes a very useful system."

The iDrive system gives drivers the ability to control hundreds of functions, far more than can be controlled on other vehicles, with less "clutter" than is typically found on a dashboard. But, the system does involve a learning curve. One showroom salesman estimated that a comfort level could be reached in as little as two weeks.

"[The iDrive] can frustrate some people who have been driving since age 15 and think they should be able to drive any car without having to take a

class or read a manual," says Levin.

When the time came to port the iDrive to 5 and 6 Series BMWs, the automaker simplified the system, cutting its menu options in half (Climate, Communication, Navigation, and Entertainment). "This made it quicker to use. Tactile feedback was also changed, and speech processing was improved," says BMW's Kunzner.

"The great advantage in the 5 Series, which is the top of the art, is that the driver can use the system without looking at it," Kunzner adds. "In competing systems, the screen is in a deeper position and the driver can't look at it and look at traffic at the same time."

The circuitry supporting iDrive was a group effort and continues to be a moving target. Firms contributing electronics technology and/or design assistance to iDrive, in addition to Immersion Technology, include ALPS, Analog Devices, Freescale Semiconductor (formerly Motorola's Semiconductor Products Sector), Harman Becker, NEC, Oasis Silicon Systems, Renesas Technology, Sharp, Siemens, STMicroelectronics, and Toshiba.

"Our priority was to have a roadmap approach that would allow us to reuse chips in whole or in part," says BMW's Würtenberger. "We talked with silicon suppliers, told them what we would like to do, and did our best to align our roadmap with theirs. We wanted solutions that would allow us to change partners, if that became necessary."

BMW first deployed a communications network (ARCNET) inside a vehicle a decade ago. "We could build customized designs then, but automotive electronics systems today are much larger, more sophisticated, and more complex, and we've had to change our mindset and our culture in order to embrace industry-standard solutions," says Würtenberger.

"Automakers simply can't keep up with the pace of technology without staying on the main road in terms of system design and architecture," he continues. "We can't afford separate, dedicated solutions, so we're using standard operating systems, standard interfaces, like the I^2C bus, and standard links like USB. We also have versioning systems and other automated design tools that weren't available 10 years ago."

QUARTET OF MCUs

At the heart of the second-generation (5 and 6 Series) iDrive are four microcontrollers (MCUs) located in the head unit: a main processor for navigation and MMI (multimedia interface); a companion chip for graphics; an MCU and digital signal processor (DSP) for sound management; and an interface controller that functions as a gateway and provides security.

Renasas Technology (formerly Hitachi) supplies the main processor, a 430-MIPS at 240-MHz SH775x, and the companion chip, an HD64404 Car Information System (Amanda) incorporating a 2D graphics engine, video input, and communication and networking peripherals. SH-4 Product manager Matthias Wenzel notes that Renesas recently introduced the SH7770 system-on-a-chip, which combines an SH-4A core with both 2D and 3D graphics engines in addition to GPS2 baseband processing and a plethora of peripherals.

Immersion's Levin explains that when a driver pushes or slides the controller to a section of the display screen to select a function, the screen changes and a set of commands is downloaded from the Renesas processor via a controller-area-network (CAN) bus to the processor in the control unit (a 16-bit Freelink MCU).

The commands tell the controller what haptic profile to play. "Haptic profiles contain instructions for detents, hard stops, 'hills,' and other touch-sensitive responses," according to Levin. "Speaker balance requires a detent, for example, whereas a hill is used as a permeable barrier to separate one section of the screen from another. In the case of audio, drivers can select from a list of available sources on the left side of the screen, such as AM, FM, or CD. Then they 'pop' over to the right side of the screen by turning the knob in that direction and select stations or tracks, with the touch appropriately different for each."

As the controller moves or a button is pushed, the controller feeds its position change to the system processor, an event change is registered, and new haptic commands are transmitted and initiated. "The controller doesn't know what it's controlling but knows what 'feel' is appropriate on a screen-by-screen basis," says Levin.

A communications processor interfaces with the vehicle's CAN, LIN (Local Interconnect Network), and MOST (Media Oriented System Transport) buses. "In a system like the iDrive, there are more than 5000 MOST function calls that can be combined in various ways to meet application requirements," says Oasis Silicon Systems' Christian Thiel.

"When the car is activated, all devices are awakened. They boot their hardware and operating systems and are then ready for communication," explains Thiel. "Usually, the system configuration is first checked by a central network master. If it is okay and all device addresses in the system are unique, the network master gives the start command for communication, and the devices begin to initialize their applications."

He continues, "The HMI device loads and displays status information—for example, the current CD track. Audio and video streaming are initialized if required. As the driver begins to use the system, commands are transmitted and status information is exchanged. When the car is parked, a shutdown sequence is initiated by the Network Master and the system goes to sleep."

Low power is as much a consideration in a vehicle as it is in a portable device, according to Brian Fortman, telematics marketing manager at Texas Instruments. "The electronics content of cars is growing. There are a lot of MCUs, and a lot of nodes on a MOST network, and that means there are a lot of potential places to drain the battery if they're kept active when the engine is not running. Automakers' requirements for power drain in standby mode is often less than one milliamp, which puts heavy constraints on DSP designs."

To meet those requirements, vendors are integrating DSPs and other processors on a single piece of silicon, much like Renesas did in combining its SH-4 core and companion processor on one chip. Such integrated designs are likely to find their way into future iDrive generations. Among Würtenberger's other plans for iDrive is to implement the high-bandwidth (10 Mbits/s versus 1 Mbit/s for CAN), deterministic automotive communications protocol called FlexRay. BMW is a founding member of the FlexRay Consortium *(see "Driving A Faster Bus," for more information)*.

"The iDrive was a very brave, very revolutionary step in how to connect an operator with a vehicle," says Immersion's DiNucci. "They missed putting a $75,000 7 Series car in the hands of an automotive journalist without having a succinct way to jumpstart their knowledge."

"[The] iDrive is important not just for what BMW did in offering such a new interface, but for the other automakers that subsequently introduced or are developing something similar," notes Rob Barnicoat, director of Business Development at Harman Becker Automotive Systems, a developer of MMI (multimedia interface) software. Audi's A8 has an interface similar to iDrive, as will a new line of Mercedes S-class vehicles planned for introduction next year.

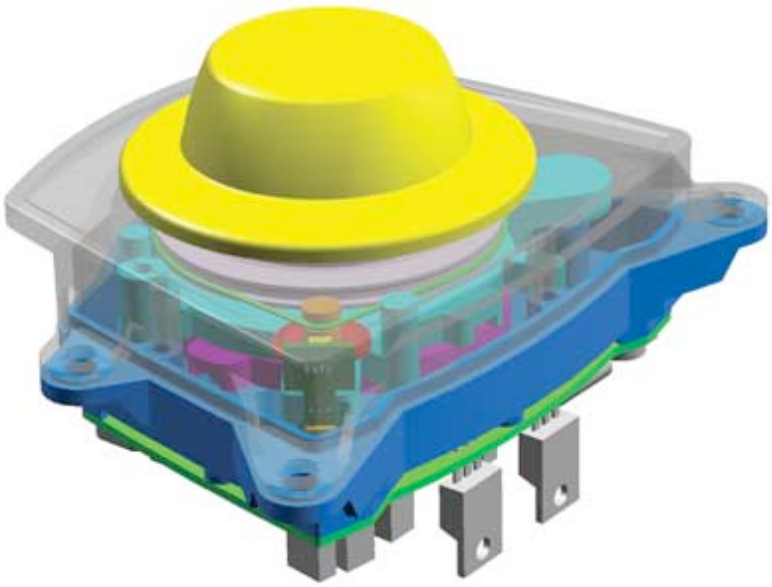
Figure 1

1. Synergistically, a driver can adjust the air conditioning and locate the nearest Dairy Queen on the same screen.

Figure 2

2. Ergonomically styled to fit a human hand, the iDrive control knob is analogous to a computer mouse.

Figure 3



3. ALPS Electric and Immersion Technology teamed with BMW to create the iDrive controller. The system enables hundreds of functions to be controlled with less clutter than is typically found in most other vehicles.

Figure 4

BMW's 5 Series sports a kinder, gentler iDrive.