

## Applications & Cases



Custom product development

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### More room on DSL line cards

Conventional telephone lines offer sufficient bandwidth for telephone calls and broadband data connections. But because the range of fast DSL links is greatly limited on classical two-wire lines, after a few kilometers the data must be processed in a DSL exchange and converted to run on powerful digital interfaces such as ATM. This data processing is performed by DSL line cards.

EPCOS has combined a transformer with a film capacitor in order to create the new T-Cap module. This reduces the space requirement on DSL line cards from Huawei Technologies by about a third compared with the previously used discrete components. In conjunction with a new chip set from Infineon Technologies, the T-Cap module saves so much board space for the input circuits that 64 channels now fit on a DSL line card from Huawei instead of the previous 48.

Each individual channel needs a capacitor that extracts the analog telephone signals and blocks the open-circuit DC voltage of the analog telephone line. But each channel also needs a transformer to assure electrical (insulation) separation. Whereas integration of the digital signal processing is progressing rapidly and leads to more compact chips with ever higher performance, miniaturization of the passive electronic components is reaching its physical limits. As such, transformers and capacitors take up a large part of the board area of a 48-channel DSL line card.

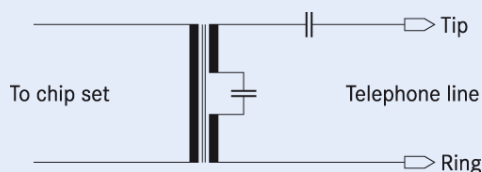
#### Highly integrated line cards

Broadband Internet access is highly popular among subscribers, which assures the network operators solid profits and further boosts demand. The providers are consequently expanding their data transmission capacities to service this demand. However, their extension plans are frequently thwarted by the limited space in the exchanges and the high costs of construction. So it's no surprise that network providers urge their suppliers to devise increasingly integrated DSL line cards with as many channels as possible. Huawei, a telecommunications technology manufacturer based in Shenzhen, China and regarded as world market leader in IP-based exchanges and in multi-service access nodes (MSAN), thus needed an innovative miniaturized component to significantly reduce the space taken up on its DSL line cards.

Huawei, already a long-term customer of EPCOS SAW filters, thus issued a new requirements profile for the inductors and capacitors needed on line cards. In the meantime, Huawei has patented the application-specific design. It was a great advantage that EPCOS has a development laboratory in Hongqi, only about 170 kilometers away from Huawei's headquarters in Shenzhen. Thus its developers could make use of the competence present at the other EPCOS plants. Together with Huawei's hardware designers, EPCOS' development laboratory in China quickly developed a space-saving solution - the T-Cap module, in which a film capacitor is mounted piggyback fashion onto an EP7 transformer, thus combining both parts into a single component.



FIGURE: CIRCUIT OF THE T-CAP MODULE ON THE DSL LINECARD



For symmetry reasons, the capacitor is situated between the two primary windings of the transformer.

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### Comprehensive performance and cost effectiveness

With dimensions of approximately 10 x 10 x 15 mm<sup>3</sup>, the T-Cap module is less than half the size of a thumb but performs several functions on the line card. The transformer it contains ensures electrical separation between the signal processing unit and the telephone line (see figure). In addition, it adapts the signal level so that data flows to the subscriber with the required amplitude.

Another key criterion for qualifying the T-Cap module from Huawei was a linear frequency response of 25 kHz to 1.1 MHz. This is due to the fact that the ADSL signals to the subscriber are transferred in the frequency range from 240 kHz to 1.1 MHz. A frequency band of about 25 to 160 kHz suffices for the slower return channel. Thanks to this frequency division, echo suppression is unnecessary, thus saving costs and space.

The maximum data rate that can be transmitted on a DSL line depends not only on the length of the line but quite significantly also on the magnetic properties of the transformer core and the symmetrical layout of the entire T-Cap module. Asymmetries in the layout and distortions due to saturation effects reduce the data rate that can be transmitted. The T-Cap module offers outstanding values of at least 80 dB spacing between the data signal and total harmonic distortions (THD) as well as a symmetry spacing of at least 40 dB.

### Up to 150 volts open-circuit DC voltage

In the open-circuit state, a DC voltage of about 60 V (analog telephone lines) or up to above 100 V (ISDN) is present on a telephone line, which falls off when the handset is lifted due to the high resistance of the system. The capacitor of the T-Cap module not only isolates this DC voltage from the transformer but also buffers the fast transients occurring when the DC voltage collapses. A film capacitor is used in the T-Cap module for this purpose: its specified voltage strength of 400 V DC / 200 V AC and pulse strength of 900 V/ $\mu$ s ensures sufficient reserves even under extreme weather conditions, such as when lightning strikes close to a telephone line.

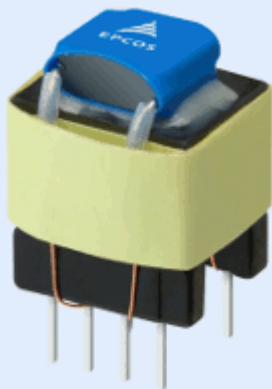
Before series production of the T-Cap module could start, Jacky Zhao, development engineer at EPCOS in Hongqi, and his colleagues had to find convincing solutions assuring process reliability for a whole series of detailed problems. The contact wires of the film capacitor run along the outside of the transformer and are soldered directly to its pins. Their length had to be more than doubled. An adhesive with high electrical strength ensures mechanical stability and reliable electrical isolation. A specially adapted casting compound equalizes the differing expansion coefficients of the magnetic material in the transformer and the film capacitor. The T-Cap module is soldered without the use of lead and is thus RoHS-compliant. The components are handled in a special way because capacitors are much less able to withstand heat than transformers.

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### PRODUCT PROFILE: T-CAP-MODULE

The footprint of the T-Cap module is identical to that of an EP7 transformer – it is only about 4 mm higher. To mount the capacitor piggyback-style on the transformer was a challenge in terms of mounting and bonding technology – but saves Huawei considerable space on the DSL line card.



Asymmetry attenuation	40 dB min at 25 kHz to 1.1 MHz
Distortion factor	-80 dB max. at 30 kHz; 3,16 V <sub>rms</sub> / 100 Ω
Dimensions	9,8 x 10,5 x 14,5 mm <sup>3</sup>
Operating temperature	-40 bis +85 °C
Test voltage	1500 V DC (transformer)
Rated voltage	400 V DC / 200 V AC (capacitor)
Test voltage	600 V DC, 60 s (capacitor)
Pulse withstand capability	900 V/μs (capacitor)
Loss factor	8 x 10 <sup>-3</sup> at 20 °C; 1 kHz (capacitor)

### International cooperation

The department developing the film capacitors in Gravataí, Brazil, was included in this process. This close cooperation between the developers in different countries and time zones led to the joint success: the resulting component combines inductive and capacitive functions in an ideal way. “With its T-Cap module, EPCOS has supported us throughout the development of a component within the briefest space of time that optimally satisfies our requirements in every respect. That’s why we have already released it for production,” says Zhan Peng Li, development engineer for access networks at Huawei. Apart from the additional space on the DSL line card, the module also provides considerable advantages for Huawei in terms of logistics costs: whereas two components previously had to be bought, managed, stored, placed and tested, in future only half this effort is needed for the T-Cap module.

Thanks to the compact design of the T-Cap module, there is still enough flexibility to adapt the physical properties to customer or chipset-specific requirements.

### A third more channels in the DSLAM

At first sight, space saving of a mere square centimeter per channel may not sound like much. But for Huawei’s customers it means that the insertion volume of a DSL exchange can be cut by almost a third. In other words, in outdoor DSLAMs, which have limited space in any case, about a third more broadband accesses will be available in future.

It’s no coincidence that the T-Cap modules are manufactured at EPCOS in Hongqi: as a leading manufacturer of telecoms equipment, Huawei sees proximity as an important factor for both developers and manufacturers of key components. Short delivery times and flexibility are equally important competitive advantages in the age of globalization.

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### INFOBOX: HUAWEI TECHNOLOGIES



Huawei Technologies with headquarters in Shenzhen, China, is a leading manufacturer of telecommunications networks and currently serves 35 of the top 50 telecommunications providers with over a billion users worldwide. Huawei's products and solutions cover mobile applications, core network products, network products, applications and software, and terminals. In addition to its Chinese development facilities in Beijing, Shanghai, Nanjing, Shenzhen, Hangzhou and Chengdu, Huawei also runs R&D centers in Bangalore, India, Silicon Valley and Dallas, USA, Stockholm, Sweden and Moscow, Russia.