Featuring

LAMINATE Technology with Internal Inductors for the World's First On-board Silicon Tuner Compatible with All Broadcasting Systems

- Adjustment-free high-functionality silicon tuner
- Interposer substrate with internal high-performance LAMINATE inductor
- Integration of 7 inductors by minimizing interference between them
- Reduction of the spurious radiation that could degrade picture quality during analog broadcast reception

Since TV broadcasting systems differ by regions across the world, separate TV chassis and tuner modules had to be developed for each.

Sony has now developed a demodulator IC that comes in the same size and pin assignment for all broadcasting systems. This adjustment-free high-functionality silicon tuner is compatible with all the world's broadcasting systems, has enabled placement of the tuner chip on board and is the first in the world to use a common chassis that can be readied for shipment anywhere simply by changing the demodulator IC.

Competitors have also managed to place the tuner chipsets on board, but functional issues limit their use to specific regions or models and they have not yielded adequate results such as manufacturing cost advantages derived from streamlining TV mass production.

Sony replaced coil tuners with silicon tuner ICs in 2007, but the inductor that made up the RF filter was still an external component. Inductor characteristics vary by the component and inductors require an RF filter after board mounting.

To place the tuner chip on board, Sony integrated the entire RF filter, the component that determines tuner performance, and designed it so it would not need to be adjusted.

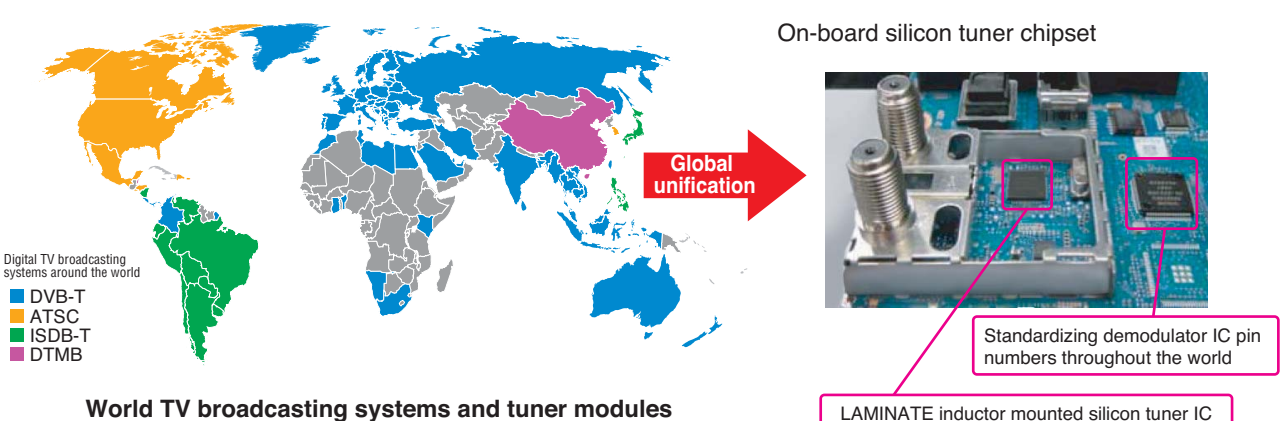
This issue will introduce the Sony component technology that made it possible to place the silicon tuner on board.

Adjustment-free Technology that Made an On-board Tuner Possible

A problem factor in placing the silicon tuner on board is the adjustment of the tracking filter. To remove interference between channels, a surface mount chip inductor was used at the previous and following stages to correct filter characteristic variations by switching the internal variable capacitors in the silicon tuner IC using control data. However, since adjustments were required after the silicon tuner IC and the inductor components were placed on the board, they could not be placed directly on the TV board.

Using printed circuit board technology, Sony integrated a LAMINATE inductor on

Figure 1 On-board Silicon Tuner that Made Possible Globally Unified Chassis



World TV broadcasting systems and tuner modules
TV broadcasting systems vary by region across the world and this has made it necessary to develop different tuner modules for different areas. In 2007, the tuner was integrated into an IC and now it has become an on-board component that will make TV manufacturing more efficient on a global level.

an interposer substrate thus succeeding in developing an on-board inductor with the same characteristics as a chip component. The adjustment so far carried out after assembling the module board was completed at the final check stage after assembling the semiconductor package and this change made it possible to place the silicon tuner on board.
The next section will briefly describe the internal inductor module technology that supports the on-board tuner and the problems we solved.

LAMINATE Inductor

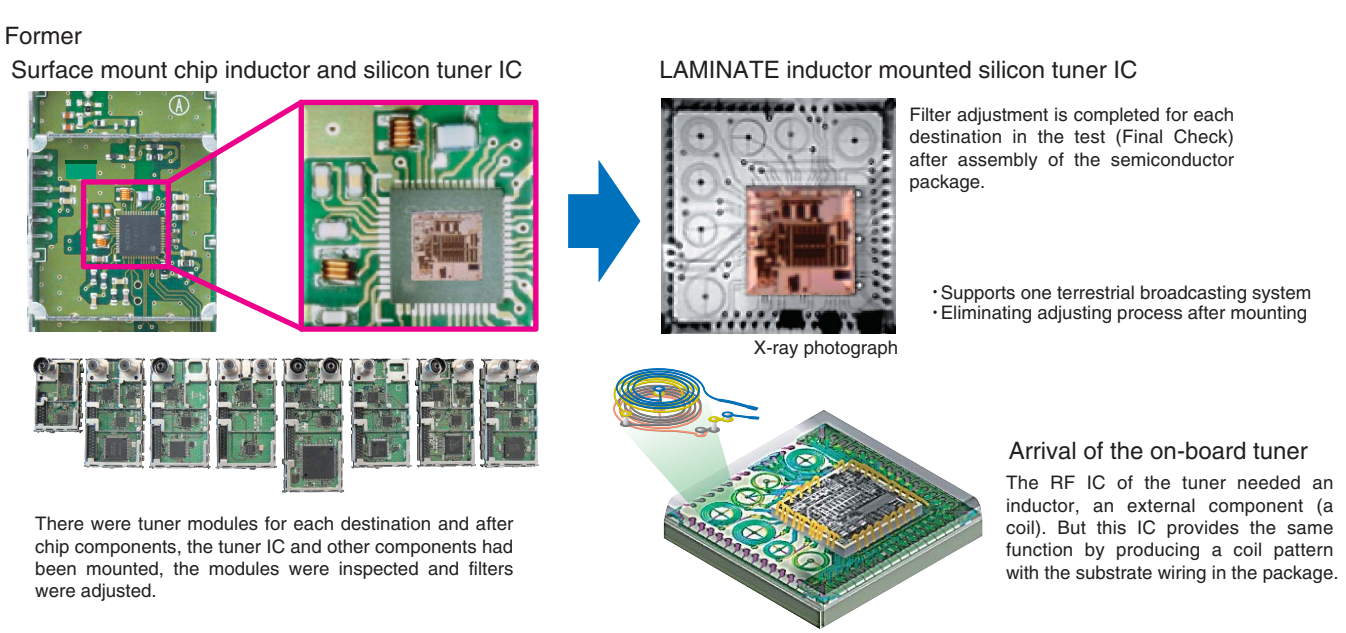
■ Technology for Forming Components on an Interposer Substrate

Inductors and other passive components can be placed on an interposer substrate using methods for mounting chip components on a substrate and methods for forming and integrating passive components on silicon (Si) substrates and gallium arsenide (GaAs) substrates. Sony decided not to choose these methods because they do not satisfy the required performance, reliability and cost.
This time, Sony decided to integrate passive components on an interposer substrate. Inductor molding uses the wires of the interposer substrate, standard design rules and manufacturing processes to cut costs. The elimination of contact points resulting from integrating the chip components assures reliability thus the inductor internal module fulfills all the requirements of cost, performance and reliability.

■ LAMINATE Technology Having the Same Characteristics as a Chip Inductor

The risk of forming inductors using the wires of the interposer substrate is that lack of uniformity in the manufacture of wire width will affect the accuracy of device characteristics. Printed circuit boards are normally made using the subtract method, that is, a resist mask is formed on copper plating which is exposed to a chemical that etches the copper (Cu). The problem with this method is that an intricate spiral pattern will result in a lack of uniformity in line width and the inductor will not fulfill the accuracy required by the tuner.
The semi-additive method, the standard process used by Sony Chemical & Information Device Corporation (referred to as SCID below) on the LAMINATE mass production line at the Neagari Plant can form a precise pattern by (growing copper plating) along the resist pattern. Laser Direct Imaging (LDI) is another method that does not use an exposure mask and thus removes all instability factors such as the mask itself, positioning inaccuracy and other quality problems ensuring an inductor accuracy equal to component accuracy or ±5%, which is close to component accuracy. While being the standard configuration at the SCID Neagari Plant the optimization of inductor design has produced inductor characteristics that can compete with chip components.

Figure 2 LAMINATE Inductor Mounted Silicon Tuner IC that Made an On-board Tuner Possible



Noise Interference Problem

Designing a LAMINATE inductor with the characteristics of a chip component would not produce an inductor mounted silicon tuner IC. In designing an IC that must conform to the world's highest tuner characteristics, fitting the seven inductors needed for the input and output onto a 9 mm square interposer substrate was not just a problem in terms of interference between the inductors. It also meant integrating an IC, another source of noise, with an antenna (an inductor), in other words, a major noise issue somehow had to be solved. Restrictions in the size of the interposer substrate also came into play as it limited the space that could be put between inductors and between them and the noise sources. Coordinated design that made the most of simulation reduced the impact of noise while proprietary technology lowered the interference when merging the inductors and created a tuner with characteristics that was on par with a silicon tuner equipped with external components.

■ Suppressing Interference between Inductors

A magnetic field is formed as current passes through the inductors. The magnetic fields formed by the inductors created by wiring in the interposer substrate affect adjacent inductors and generate unwanted current.
A filter extracts the required channel signals from the broadcast signals entering the antenna and an amplifier boosts their strength. The problem here is that the magnetic field generated by the previous inductors affects the inductors in the following stage generating unwanted current that prevents appropriate adjustment of signal strength.
The inter-inductor interference suppression can be obtained by connecting the inductors to ground separately but this will make the interposer substrate excessively large.
To use a 9 mm × 9 mm interposer substrate, Sony used electromagnetic field simulation to design a layout that would effectively reduce interference. The design effort that successfully delivered the 9 mm × 9 mm chip was not limited to the layout of the interposer substrate but redesigned motherboard layout, as well.

Figure 3 High Resolution LAMINATE Technology at SCID's Neagari Plant

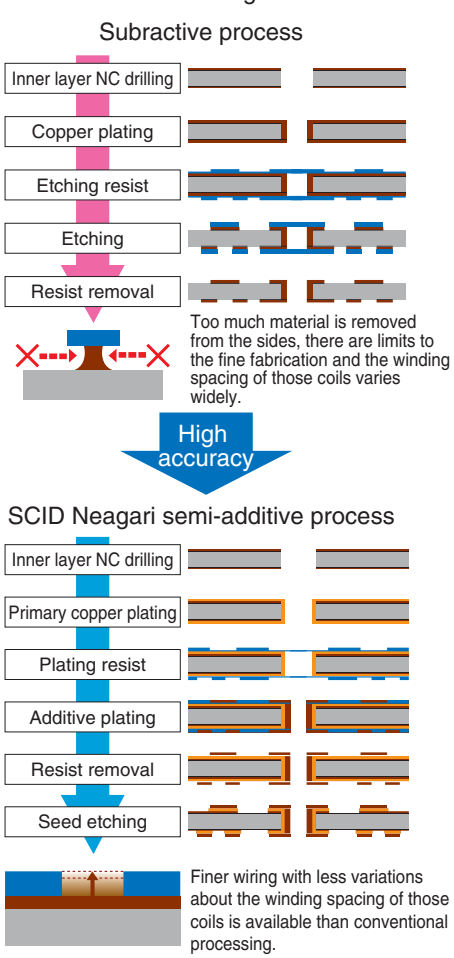
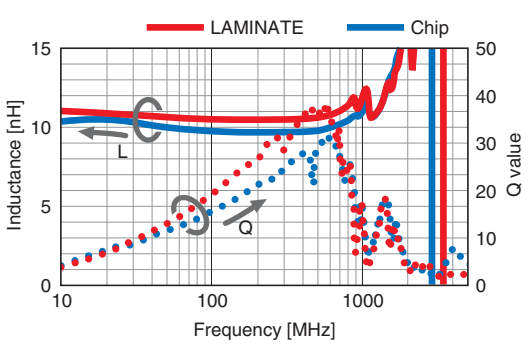
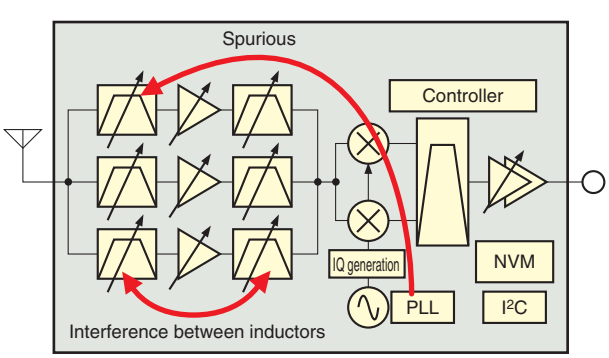


Figure 4 Inductor Characteristics



LAMINATE inductor emulates chip inductor characteristics

Figure 5 LAMINATE Inductor Integrated Silicon Tuner IC



Mounting a silicon tuner IC and inductors on an interposer substrate requires that interference from the inductors as well as undesired radiation from the silicon tuner IC are not leaked to the inductors.

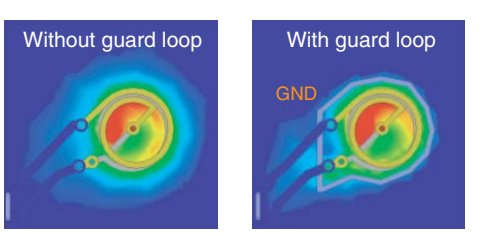
Spurious

One characteristics that is critical for analog broadcast reception and is particularly difficult to design for is spurious radiation.
The RF IC contains a local oscillator that generates high-frequency components, which could degrade the picture quality of specific channels, if it contaminates tuner input or output.
In our efforts to design out the effect of spurious radiation from the inductors, Sony first identified their source and used an electromagnetic field analysis tool to check inductor emission.
The analysis results obtained were reflected in the design making it possible to produce a TV tuner with more than adequate specifications.

Future Developments

As already stated, Sony succeeded in replacing the coil tuner with a silicon tuner IC in 2007. This project used interposer wiring to form inductors, which are peripheral silicon tuner IC components, and develop a silicon tuner IC that mounted a LAMINATE inductor, in other words, an on-board silicon tuner.
Sony intends to further pursue this approach of eliminating mounted components by integrating them for miniaturization.
In particular, Sony will develop and apply these technologies to create environmentally friendly TVs that do not consume larger amounts of resources.

Figure 6 Inductor Distributed Magnetic Field



A magnetic field surrounds the inductor

The magnetic field can be more easily suppressed when there is no guard loop

Figure 7 Coordinate Design of Tuner IC, Interposer Substrate and Motherboard

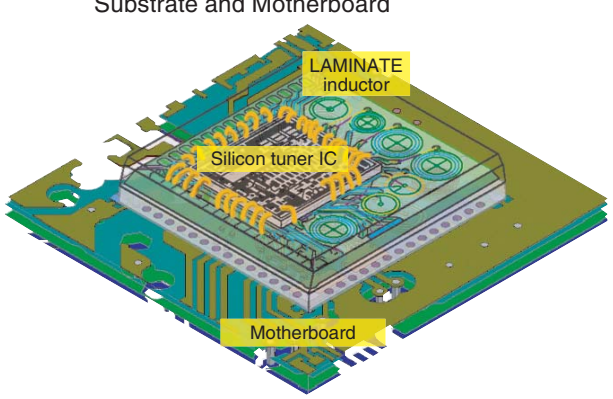


Figure 8 Design to Reduce Spurious Radiation through Electromagnetic Field Analysis