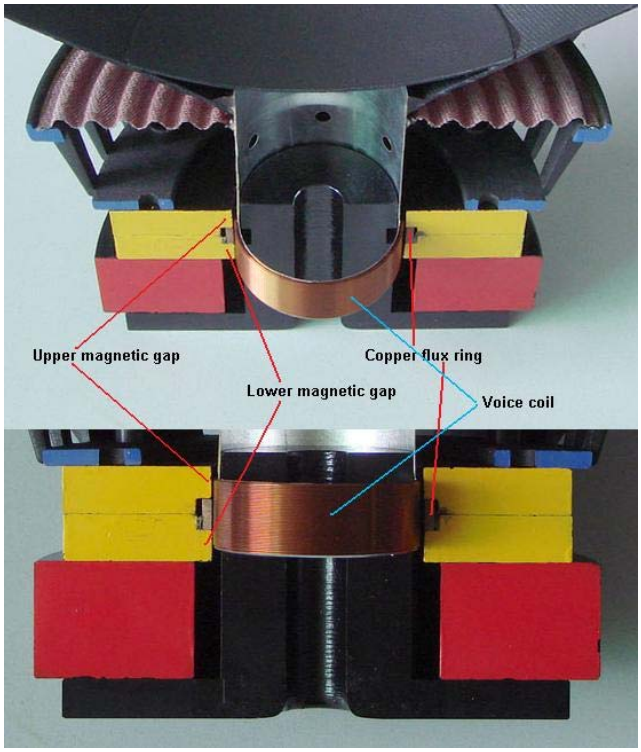
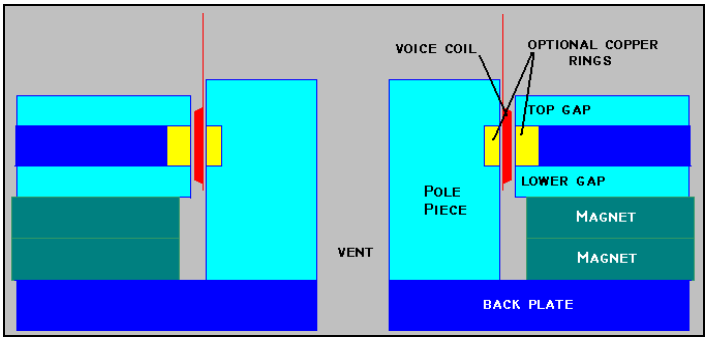
SplitGap Technology
White Paper

SplitGap patented technology provides a number of very beneficial advantages over typical loudspeaker motor designs. Outperforming traditional overhung and underhung magnetic topologies, ***SplitGap*** technology not only provides for high excursion, but also reduces distortion, improves HF response, and increases power handling! ***SplitGap*** provides the attributes and advantages of both overhung and underhung traditional designs.

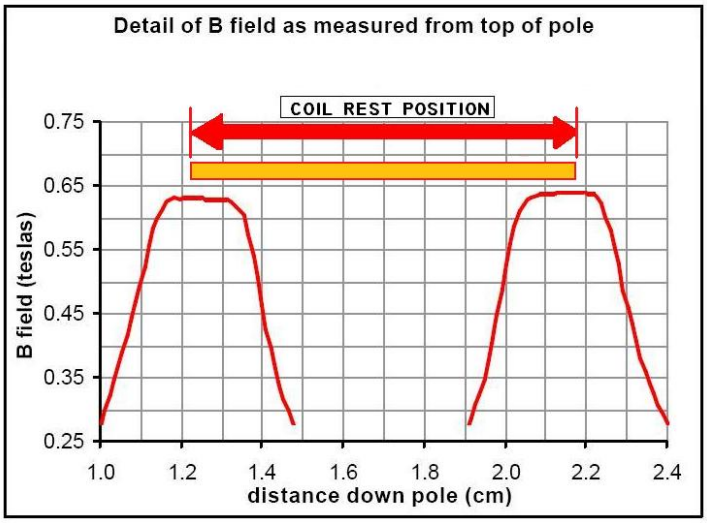
HOW *SplitGap* WORKS





Left, we have a photo of a SplitGap motor, cut in half, and above an illustration of a typical SplitGap motor. The illustration shows all of the inherent features of a ***SplitGap*** motor. There are 2 magnetic gaps separated by some distance, and in this design there are copper rings included in the spaces between the gaps to reduce flux modulation distortion caused by the moving voice coil. At its rest position, the voice coil sits straddled across the two gaps, with the ends of the each coil near the center of each gap. As it moves, the voice coil is effectively passed from gap to gap allowing the coil to travel longer distances than in traditional speaker designs permit.

The flux curve of this configuration is shown to the right and you can see that each gap has its own concentrated magnetic field, with reduced flux between the magnetic gaps. The key to the extremely flat BL curves possible with the ***SplitGap*** technology is to use a voice coil of a certain length so that as it moves across the B curve it integrates a consistent amount of flux, yielding the constant BL product desired.



For the motor shown here, the typical voice coil would extend from roughly the center of the top gap to the center of the lower gap. This would correspond to points on the flux curve from roughly 1.25 cm to 2.125 cm. As the voice coil moves up or down this B curve, an equal amount of voice coil enters one gap and

leaves the other gap. In this example, the resulting BL curve would be within linear limits (-3 dB loss) from 0.75 cm to 2.75 cm, or 20 mm total linear throw. This is for a voice coil of approximately 9 mm length, and a top plate of 10 mm thickness (the peak-to-peak linear throw is twice the top plate thickness, and nearly 2.5 times the voice coil length). The length of the coil is adjusted so that in total, the 2 ends pf the voice coil cut the same amount of flux as is generated in 1 single gap. So as the coil moves, from one gap to the other, it effectively sees the same flux, the flux equal to one gap.

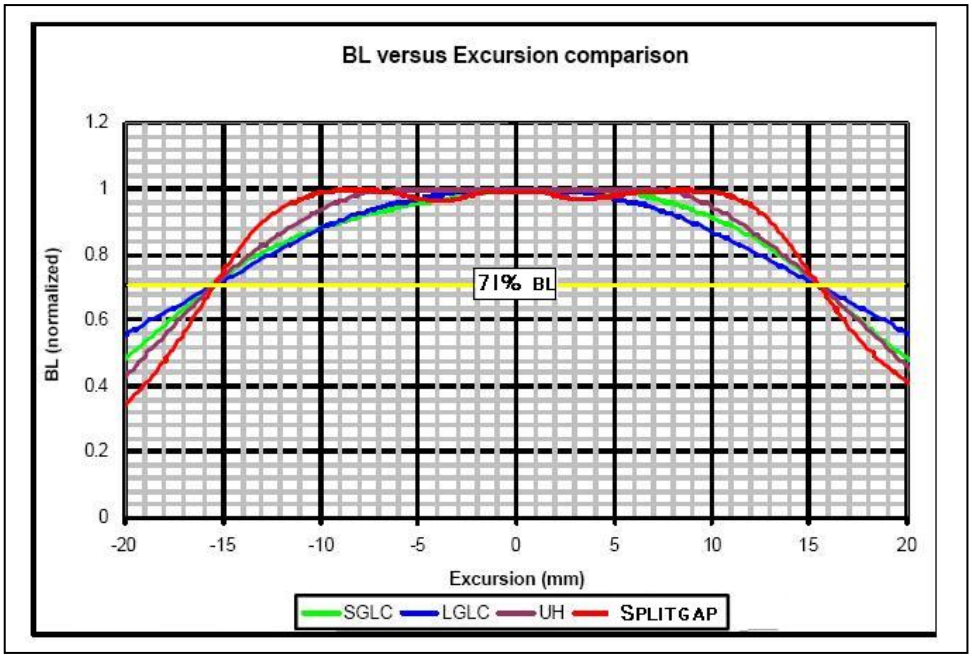
SplitGap **BENEFITS**

SplitGap motors are designed from the ground up to yield a **flat BL curve** over as wide a range of excursion as possible. In addition, other benefits of the motor topology include **low inductance** (important for faster transient response and wider bandwidth and extended HF) and **low moving mass** (allowing higher efficiency). The combination of higher excursion, wider bandwidth, lower moving mass and lower distortion is naturally suited to use in wide-bandwidth/full range drivers. **The driver has the efficiency and bandwidth required for maximum top end extension, yet because of the high excursion smaller diameter drivers can still produce high SPL levels**. Couple this to lower distortion for increased clarity and it is plainly obvious that ***SplitGap*** enabled motors are of great benefit for all drivers—woofers, mids, tweeters, and fullrange.

Because the voice coil is physically shorter than the top plate, many classify it as an underhung design. Yet the operation is seen to show that the voice coil is longer than any single high-flux gap, meaning it is somewhat akin to an overhung design. In fact, **a *SplitGap* enabled motor shares the best attributes of both under and overhung designs**, yet is not adequately described as either. The above example could, in fact, be considered a double-hung design. This is the basis for the claim that a ***SplitGap*** enabled motor is a new topology, and the basis for the ***SplitGap*** patent. Neither under nor overhung, but a beneficial and unique hybrid of the two.

Also, because the voice coil in a ***SplitGap*** Design is considerably shorter, gap width/clearance issues relating to rock and scrape are greatly reduced. Narrower gaps translate to higher B strengths, meaning **smaller and lower grade magnets are required for a given target flux density**. In fact, taking the exact same motor structure and ***SplitGap*** enabling it can often result in higher BL over a wider range, without an increase in either DC resistance or **BL versus Excursion** inductance.

The graph to the right shows an FEA comparison of the BL-versus-excursion of several *driver* motor topologies. These are the traditional overhung or short-gap/long-coil (SGLC), new-style long-gap/ long-coil (LGLC), traditional underhung (UH), and our new ***SplitGap*** motor topology. Each motor was optimized for a "typical" subwoofer Xmax value of 15.4mm one way, linear.



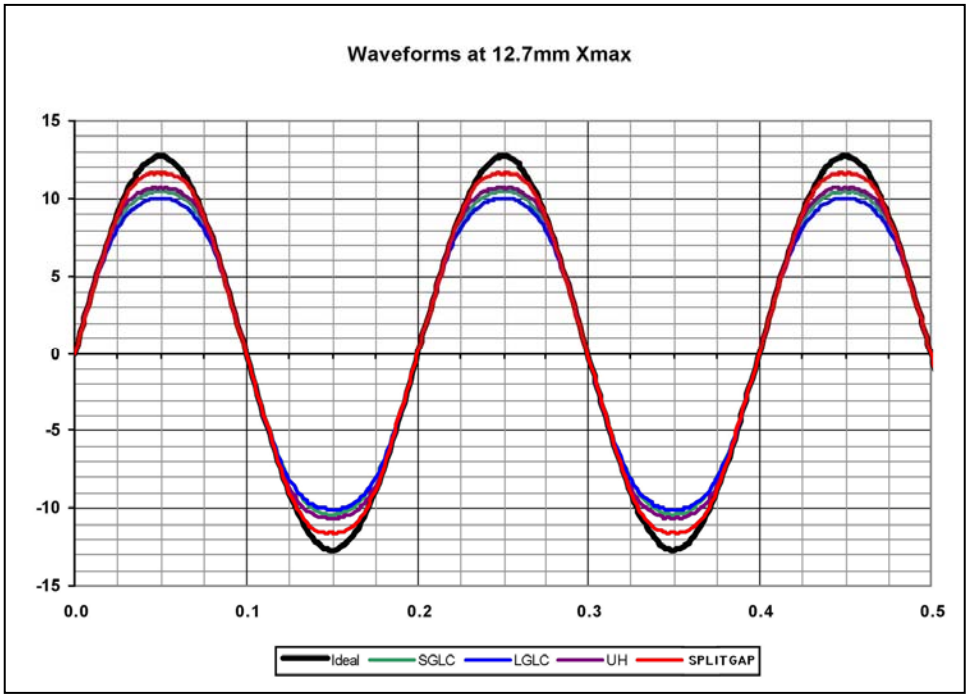
As shown in the graph, the SplitGap motor offers much flatter BL In fact the SplitGap motor has less than a 5% BL decrease over 24mm of total excursion, while the other topologies range from 12 to 18mm for the same percentage of BL decrease. When SplitGap has dropped 10% of its BL, the other motors have decreased between 18% and 23%. ***SplitGap*** motors offer significant advances in BL linearity, meaning shorter coils and top plates can be used when targeting a specific operating range.

Typically an ***SplitGap*** motor uses the shortest voice coil length of any topology for a 10% BL variance.

Motor	Top Plate	Voice coil
SGLC	0.31"	1.43"
LGLC	0.80"	1.53"
UH	1.10"	0.51"
SPLITGAP	**0.85"**	**0.62"**

The top plate and coil lengths for these example motors are summarized in the table to the left. The SplitGap motor uses a voice coil nearly as short as that of the traditional underhung unit, which yields the typical advantages of an underhung design: low moving mass and low inductance. At the same time, the SplitGap motor is considerably flatter in BL, has equivalent excursion, and uses a much shorter top plate than the underhung unit (which greatly reduces the production cost).

Compared to the overhung designs, the shorter coil length means more mechanical clearance in the motor and higher tolerance of rocking, meaning dual spiders are not required for high excursions. Combine this with a flatter BL curve, lower inductance, and lower moving mass and the advantages of SplitGap over overhung topologies - both performance and price - are readily apparent.



SplitGap reduces distortion. Keeping the BL flat means more constant motor force at excursion, which means better tracking of large-signal inputs. The graph below shows the output waveform for each of the above motors, when trying to follow an ideal ±12.7mm excursion signal. As shown, SplitGap best tracks the input signal when the target excursion is still well within the "usable" excursion limits of the driver (rated Xmax of 15.4mm). As is evident, the SplitGap motor is much closer to the input signal.

This advantage translates into waveforms at 12.7mm Xmax directly measurable and audible performance improvements in distortion. For the example motors analyzed in this paper, the distortion figures are given for ±10.8mm excursion (70% of Xmax). The ***SplitGap*** motor has less than 30% of the distortion present in the other motors.

SplitGap motors are useful for all audio transducers. While this -5 example has focused on woofers, the advantages are also applicable for midranges and tweeters. In fact, the low inductance and moving mass of this motor are extremely beneficial in wideband transducers. Typically, SplitGap will halve the inductance of a comparable-excursion overhung motor, which can result in adding a full octave of extension on the high end. Add in the lower moving mass from the short coil, and the driver designer has a greater degree of flexibility in driver creation.

THD at 10.8mm Xmax	
SGLC	3.5%
LGLC	4.4%
UH	4.0%
SplitGap	**1.0%**

In terms of dynamic distortion performance, a *SplitGap* enabled motor typically out-performs drivers with greater rated excursion. Yet, as shown above, ***SplitGap*** typically **adds** excursion to a given set of parts, thus leading to even lower distortion for motors based on those parts.