

Tricks of the Trade

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Readers may recall the second of four ToTT articles starting in *Signal* Issue 12 [1] which described the combining of the outputs from communications or broadcast transmitters to obtain higher power and reliability. The article describing the combiner used on board the 1960s offshore station Radio Caroline was made even more interesting by the personal recollections of Carl Thomson G3PEM who was an engineer on the northern ship during the commissioning of the American combining unit. At the time of writing the original article, Carl did not have a schematic of the arrangement but believed it differed significantly from the patented MWT Bridged-Tee design. Despite many internet searches and contacts with radio amateurs who had been broadcast engineers in the USA, full information was elusive. However, as an author, it is always rewarding to receive feedback (good or bad) on articles and even more so when it arrives from the other side of the world.

VK-calling

There will be many in VMARS who may not be aware that a number of the ToTT articles published in *Signal* by the author and Dave Gallop G3LXQ are also available on the bbceng.info website run by a retired former Senior Manager in BBC Transmission, Martin Ellen. He is pleased to include technical articles relating to BBC broadcast engineering activities *via* a specialist link [2].

It was *via* this link and Martin's website that an amateur, Tony Magon VK2IC (ex ZL4DE and ZL7DE) now in Australia, contacted the author after seeing the ToTT article and wrote the following:

"I read your article entitled "Tricks of the Trade" and you were asking about the Radio Caroline combiner circuit. I am originally from ZL and I remembered an article in the ZL ham mag 'Break-In' many years ago. I have now managed to obtain a copy for you. I have been unable to send an email to Carl G3PEM as I cannot find his email address. I am also a long distance (DX) broadcast band radio listener since the early 1960s and I heard Radio Caroline North on 1520 kHz into Southern ZL in late 1966 at around 0500 UTC. I hope this will be of interest to you."

The article in question certainly was of considerable interest and the two pages written by Frank Sellen ZL2AUX for the New Zealand Association of Radio Transmitters (NZART, the NZ equivalent of RSGB) journal *Break-In* included two illustrations which are reproduced here as **Figures 1 and 2**, with permission from the present Editor of *Break-In*, Stephen Hayman ZL1TPH. G3PEM explained to the author that Frank ZL2AUX had interviewed him for the Caroline engineering job in Billerica before leaving for New Zealand. Frank had just departed for the ship for the final time and they were in need of replacement staff.

Comments on the *Break-In* article

Frank refers to the M/V Mi Amigo (**Figure 1**) as being the home of Radio Caroline. This ship had originally been Radio Atlanta and it was after the amalgamation of Caroline and Project Atlanta that it became Radio Caroline. Hence, following the merger there were two

ships, M/V Mi Amigo and M/V Caroline, broadcasting Radio Caroline. The latter vessel sailed around the English coast to become, by 13th July 1964, the northern service anchored in Ramsey Bay off the Isle of Man.

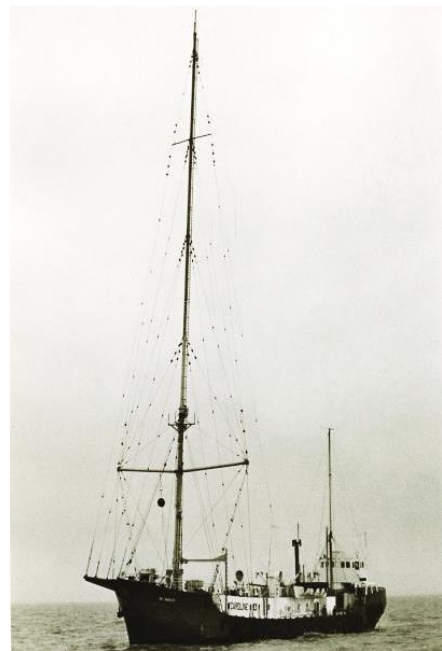


Figure 1. M/V Mi Amigo.
Photo courtesy of G3PEM

Carl G3PEM explained that the combiner was first used successfully on the northern ship after April 1966 to achieve 20 kW output on 1169 kHz from the pair of Continental Electronics (CE) 10 kW CE 316C transmitters. The southern ship, the M/V Mi Amigo, did not employ a combiner with its pair of CE 316B's as, by April 1966, a CE 317C 50 kW Doherty transmitter on 1187 kHz had been installed at the same time as marine refurbishment and repairs following the vessel's near catastrophic grounding on the beach at Frinton-on-Sea, Essex, on 20th January 1966.

Before adopting 1169 and 1187 kHz on 27th April 1966, the M/V Mi Amigo had operated on 1493 kHz from 12th May 1964 and M/V Caroline on 1520 kHz from 28th

March 1964 announcing "Caroline on 199 m" and each using one of their 10 kW transmitters on an alternate daily basis.

Frank ZL2AUX details the operation of the CE 316s with regard to screen grid modulation of the finals. The high-efficiency output stage was, in fact, a pair of Eimac 4CX5000C air-cooled tetrodes, in parallel, which were fed with modulated HV on to their screen grids via a paralleled trio of cathode followers using 4-65A tubes. The regulator tubes for the 4-65As were indeed the 807 and 0B2 as mentioned by Frank. The explanation of the combiner (**Figure 2**) by ZL2AUX, as essentially a Wheatstone bridge configuration, is as originally and correctly recalled by Carl [1].

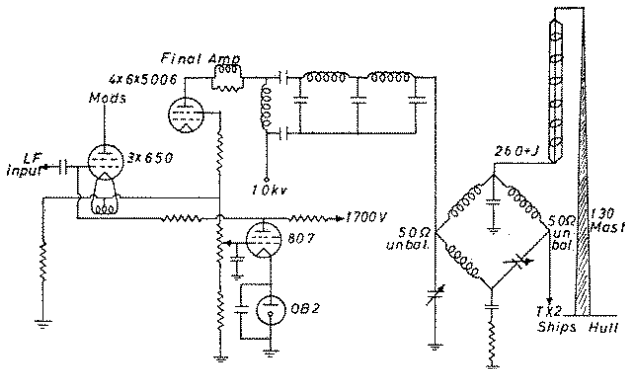


Figure 2. Radio Caroline final stage and combining circuit for two 10 kW transmitters. Both units are fed from the same crystal oscillator via a phasing unit and each transmitter could be used singly in case of failure of one of the units

The antenna

The required output impedance of the combiner (**Figure 2**) is $50\ \Omega$ and, in this regard, the circuit diagram appears to be simplified as it details a driving point impedance of either $26.0 + j\ \Omega$ or $260 + j\ \Omega$ with the combiner output connected directly to it, there being no matching components shown to transfer from this complex impedance to the $50\ \Omega$ required by the combiner.

Whilst the concept of an earthed mast fed via a multi-wire cage to a point at the top of the mast is now well-known in broadcast engineering, it was probably at that time, 50 years ago, almost revolutionary. On a ship with limited mast/antenna height, the advantage of using the folded unipole (half a folded dipole) type of antenna rather than a shunt-fed base-insulated one is twofold in that, at least in theory, the resistive driving point impedance is raised four times over what it would be for a shunt fed mast and the mast base can be physically bolted to earth or, in this case, the hull of the vessel. In practice, with the antenna masts on the ships being both c. 160 feet (46 m) high, i.e. approaching a quarter-wave at c. 1500 kHz (200 m), the full fourfold gain was possibly achieved. Indeed there appeared to be a capacity 'top-hat' in the form of a cantilever arrangement so there may have been a degree of top-loading which might account for the extra $60\ \Omega$ in addition to the theoretical $200\ \Omega$.

Folded unipole antennas were not used much by the BBC in its first 50 years but other UK-based organisations had embraced the concept, namely

HMGCC/DWS-CED and the Independent Broadcasting Authority IBA. At Orfordness (ORF) in 1978, the DWS-Communications Engineering Department employed a folded unipole and ATU for both of the central driven elements of the six tower 500 kW array on 1296 kHz [3] and, again at ORF, for the reserve 200 foot 250 kW omnidirectional antenna for the 648 kHz service. The latter antenna was of an advanced type with adjustable top-loading wires in the form of an umbrella. The wires were end-insulated and, if adjusted to the correct length during commissioning, it was possible to find an exact $50\ \Omega$ match at the driving point and so an ATU was not required. The system has a fairly low Q so the driving point impedance changes little over the RF passband and, of course, the mast is earthed. Hence, lightning is dissipated directly to earth and not through the components in an ATU.

The IBA used both systems for certain of their local radio MF installations, examples being Cotheridge, Worcester 1530 kHz with a 20–25 m mast ($\sim 1/8\lambda$) and adjustable top-loading to direct $50\ \Omega$ drive and Breinton, Hereford 954 kHz with a regular three wire, linked ends, top-hat and a trio of wires from the ATU output to the top of the earthed 54 m mast. Both of these sites have now closed down after the licensee ceased programme operations and handed back the WT Licence.

Local pick-up

It was interesting to read Frank's comments regarding the problems experienced with pick-up into one ship's antenna system of RF from a high power station nearby. When the BBC operates co-sited high-power services, it is normal to place a parallel tuned circuit in the antenna feed, tuned to the other output or a series-pair if a trio of frequencies is used. The five early BBC twin frequency 50–70 kW regional stations employed filters, e.g. after 1st February 1935, Brookmans Park 877 kHz/1149 kHz, Droitwich 200 kHz/1013 kHz, Moorside Edge 668 kHz/1149 kHz, Washford 804 kHz/1149 kHz and Westerglen 767 kHz/1149 kHz. One would guess that, on the ships, some additional filtering had to be added as the number of nearby operators increased.

Fifty years ago this year

These offshore stations first appeared around the UK coast half a century ago this year and it has often been written that they provided a wake-up call for the Government and the BBC, forcing programme and service modernisation. What has not been mentioned in the popular press is that most of the engineering systems employed were, at the time, 'state-of-the-art' so it is opportune to celebrate the half-century and start in the next ToTT in *Signal* the long-promised series describing the different ways of obtaining AM in the broadcast situation. The 1960s and 1970s offshore stations are fertile grounds for discovery and revelation.

References

1. D Porter G4OYX with C Thomson G3PEM. Tricks of the Trade. *Signal* 2009, 13 (October), 34–37.
2. http://bbceng.info/Technical%20Reviews/technical_reviews.htm
3. D Porter G4OYX with A Matheson G3ZYP and P Edwards G8EFM. Tricks of the Trade. *Signal* 2010, 14 (February), 16–19.