Crew Green CONSULTING

Evaluation of a potential integrated-circuit solution to a client's design requirement which is now in quantity production.

MAXIM MAX 2180 AM/FM INTEGRATED CIRCUIT

Test results and application information

1. Introduction

1.1 The MAX 2180 IC has been characterised in laboratory and field trials for possible use in an [redacted] antenna application. It was supplied for testing as an evaluation kit which consisted of the MAX 2180, some ancillary components and SMB connectors for RF input and output.

1.2 The MAX 2180 can be considered as two separate low-noise antenna amplifiers and a common power supply. Its RF parameters are optimised for mobile AM and FM reception, the latter also providing coverage of the North American 162MHz weather band. The MAX 2180 offers very high dynamic range, in part achieved by on-chip AGC with an effective range of about 30dB. Up to about 6dB of gain is available on AM, the level being programmable with a single resistor. On FM up to about 8dB of gain is available by the same means. What is referred to on the data sheet as the AGC attack point – in more conventional language the AGC threshold – is also programmable. The AM input impedance is high, making the IC easy to use with electrically short antennas such as those discussed in a previous report.

1.3 The IC provides separate inputs for the AM and FM/WB antennas and in principle can be used with either a common antenna for both bands or separate antennas. Some form of simple diplexer is required if a common antenna is used, which on performance grounds is considered mildly undesirable since its insertion loss will degrade the FM noise figure slightly. It is also considered better to take specific advantage of the high impedance of the AM input.

1.4 It is accepted that a common antenna would make life easier for the aftermarket installer. However, opting for separate antennas will offer a definite performance benefit in that on AM a simple electrostatically shielded loop optimised for MF reception can be used. This gives a useful degree of rejection of close-in E-field noise which in [redacted] application should be beneficial.

1.5 The evaluation kit did not contain suitable diplexers for common-antenna operation and also did not contain the components required to combine the separate AM and FM outputs into a common feed. Suitable diplexers are simple to fabricate from a few passive components if required. For test purposes the IC's separate outputs were used.

2. FM/WB antenna

2.1 On FM a simple half-wave dipole works very well. In theory a balun is required at the centre of the dipole to convert the balanced output of the dipole to the unbalanced feed impedance of the coaxial feedline to the head-unit. In principle this should give proper matching and optimise the antenna polar diagram. In practice the effect of the balun was minimal and swamped by other directive effects. On cost grounds there appears to be little basis for adding the expense and mechanical complication of a balun for the FM dipole. The length of each element should be a quarter-wavelength at the band centre (i.e. 98MHz) which is about 76cm or 30in. The exact length is not critical and the elements can be folded or 'bent' somewhat to fit [redacted]. Ideally they would be orthogonally oriented but this is not likely to be possible and a small amount of directivity will have to be accepted. Centre-fed dipole antennas classically exhibit a figure-of-eight pattern with nulls off the ends of the elements but at VHF this pattern tends to be drastically modified by local effects.

2.2 Field trials suggested that in particular the mounting of the antenna elements less than half a wavelength off the ground – as will inevitably be the case in [redacted] – tended to reduce the null depth by a good 20-30dB, which is in line with expectation and should give acceptable results in practice.

2.3 Laboratory and field tests suggested that a standard FM dipole also worked adequately at 162MHz despite being in theory rather too long; the elements of a true half-wave dipole cut for this frequency would be about 46cm or 18in in length. A dipole with elements cut to 30in for FM reception exhibits [redacted] which does not amount to a major mismatch for reception purposes. It would be easily possible to insert a small amount of inductance at the appropriate length along the element to improve the match but -- as with the balun -- the extra complication does not appear to be cost-effective. Reception of 162MHz signals is probably only degraded by about 1dB as a result of the excessive length of a dipole cut for Band II, which is operationally insignificant.

2.4 It is recommended that [redacted] field trials are conducted using a simple 30in dipole with its elements fabricated from whatever form of insulated cable is cheapest – stranded hookup wire should be perfectly adequate, for example.

3. AM antenna

3.1 As discussed [redacted], AM reception is apt to be far 'noisier' than FM reception. There are several reasons for this, of which the modulation method itself is of major importance. An AM receiver recovers the modulation from the instantaneous absolute amplitude of the transmitted waveform (or to be more precise, from the instantaneous information contained in the sidebands of the modulated carrier). By definition it is therefore sensitive to absolute values of amplitude. Interference and noise can be considered as 'sitting' on top of the modulated carrier and an AM receiver consequently cannot distinguish between noise and programme content. To make matters worse, certain forms of noise are considerably worse at the lower frequencies used for AM broadcasting.

3.2 By contrast an FM receiver is arranged to be insensitive to absolute amplitude; the recovered modulation is all contained with the time-varying frequency of the transmitted carrier, not the amplitude of its sideband set. Amongst other things this renders it far less sensitive to several forms of noise and interference, especially impulse noise.

3.3 Any internal combustion engine's ignition system is a potentially prolific source of wideband noise, as are other analogue and digital systems used in a modern vehicle, and noise is likely to be a major issue with any antenna used on or near [redacted]. As discussed in some detail in a recent report, conventional antennas respond principally to what is known as the electric or E-field of an electromagnetic wave. Since local noise and interference are well within the near field of the antenna – basically because they are physically very close to it -- they consist chiefly of E-field components and as such are very well received. To some extent the situation can be ameliorated by using some form of loop antenna. These are rather less prone to pick up local interference in the first place and can often be oriented to reject what is unavoidable.

3.4 Loop antennas can be easily arranged to be electrostatically screened. The underlying principles are rather involved and the mechanical design of such antennas can be rather difficult in some applications but in essence the antenna can be designed in such a way that a degree of screening from local E-fields is possible. For AM broadcast reception a simple form of screened loop can consist of nothing more than a length of coaxial cable in which the inner of the cable forms the antenna element and the outer forms the electrostatic screen.

3.5 A good deal of experimentation has been carried out to determine the simplest form of coaxial screened loop which gave good performance, was simple to install and was tolerant of variations in installation geometry. Two possibilities will be proposed initially, both of which appear to work well in static testing. However, it must be stressed that actual field trials [redacted] will be necessary to establish which one should form the basis for further development. There is also a case for continuing investigations to establish whether improvements are possible within the constraints of cost and ease of installation. It might be possible to achieve similar performance with other forms of loop which are even simpler to implement.

3.6 The first consists of a length of about 5ft of thin 75ohm coaxial cable (any cable with a characteristic impedance of 75ohms will be suitable). The inner is connected directly to the AM input port of the MAX 2180 and the outer is connected to ground via a 1k resistor. Optimising the position of the ground (i.e. whether it is [redacted] or battery negative) and establishing the best value for the terminating resistor should be the subject of some experimentation [redacted] and it may be that the resistor is not required at all. The outer of the coax must not be connected directly to a ground point since otherwise the signals will disappear.

3.7 The second consists of a loop of thin 75ohm coaxial cable, again about 5ft in diameter. In this version the screen must be cut away about half-way round the loop so that the two ‘halves’ of the screen do not make galvanic contact. The inners of the loop halves are joined together at the connection to the feedline and the inner of the latter taken to the AM port. The junction of the screens is joined to the outer of the feedline and grounded via the head-unit’s RF ground connection. It must not be grounded anywhere else.

3.8 The quoted length of 5ft is not critical and essentially the longest length of coaxial cable which can fit into the available space should be used. The shape into which the cable run is folded is also not critical.

3.9 It will probably be found that both antennas appear to work well. If this is the case, and if the second form of the antenna is mechanically feasible, it is this one which should be chosen if possible since its E-field rejection properties are likely to be about 10dB better.