

1 Scope:

This document is a design guide to increase the output power of the MLX 90121 tag reader.

Power boosting is introduced to improve the reading range of tags. The reading range of a tag can in general be limited by two factors:

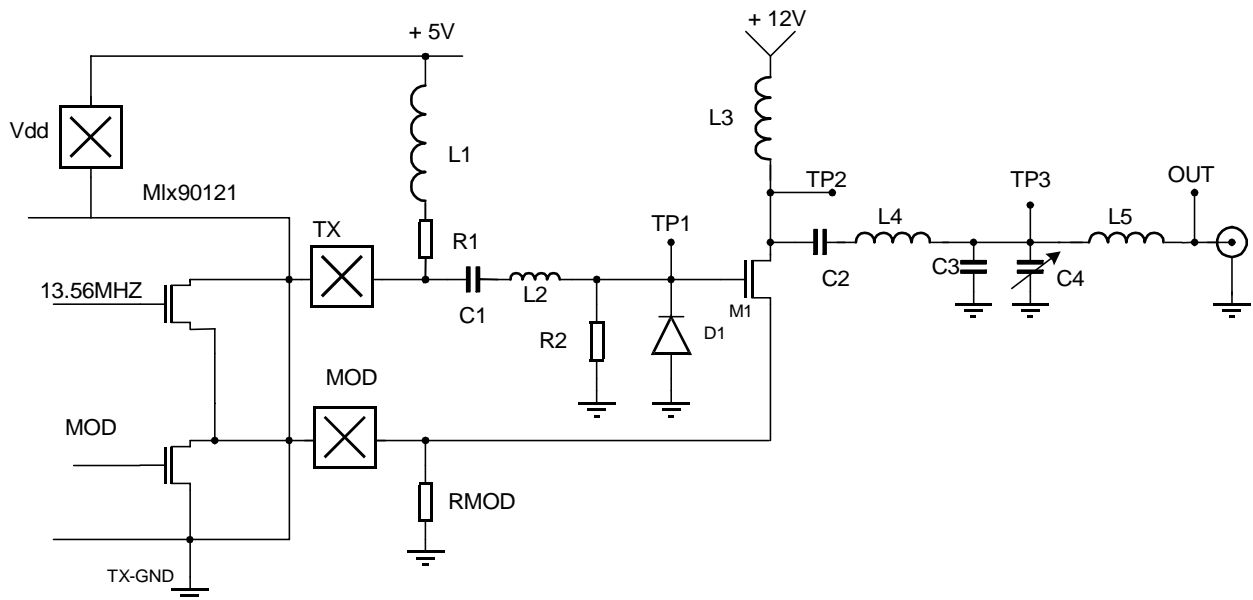
1. A first factor is the strength of the transmitted field. A tag needs a minimum field in order to operate. The required field could be quite high for microprocessor cards.
2. A second limitation is the sensitivity of the reader. When the tag is powered it is normally able to modulate. However the coupling to the reader can be low (this is the case for sensitive tags). Hence the reader might be unable to recover the return signal of the tag.

In both cases reading distance can be gained by increasing the readers output power. In case one this is straightforward. In case two, where the reading distance is limited by the read sensitivity, the reading distance increases because as result of the increased carrier, also the return signal of the tag increase proportionally.

In the document below, design issues about power boosting of the MLX90121 will be discussed into some detail and different implementations will be considered. There are two parts in this document: a first part describing the boost output stage that delivers the necessary output power. A second part explains how to make the adaptation of the receiver part to cope with the increased antenna signals.

2 Power boost with external MOSFET.

2.1 Application schematic:



2.2 Recommended Components:

Reference	Value	Comments
R1	10 ohms	5% or better
R2	680 ohms	5% or better
C1	330pF	50Volts NPO
C2	10nF or 100nF	50 Volts X7R
C3	68pF	100Volts NPO
C4	5-50 pF variable	100Volts
L1	680nH	See note 1
L2	270nH	See note 1
L3	560nH	See note 1
L4	3.3 μ H	See note 1
L5	2.2 μ H	See note 1
M1	IRFD110	See note 2
D1	1N4148	See note 3
RMOD	See text	3 to 6 ohms

Notes:

1) Inductors should be carefully selected. Standard through hole types available from Farnell or Radiospares work well for this application.

2) IRFD 110, IRFU110, IRFR110 can be interchanged. Manufacturer is International Rectifier.

3) Any fast silicon diode will work. A peak current of about 300mA will circulate through the diode. It may be replaced by a schottky.

2.3 Theory of operation and design guidelines:

L2 forms a series resonant network with M1 gate capacitance. However, it is not possible to drive directly such a network with the MLX90121 output stage because it will draw too much current. Therefore, we mistune it with C1, sufficiently to keep the current requirements in line with the MLX90121 internal power transistor safety area while maintaining enough voltage swing at TP1 to drive correctly the gate of the external power transistor, M1. L1 and R1 provide the necessary DC bias to the MLX90121 internal power transistor. R1 is again selected to maintain the current drain within acceptable limits. R2 provides a DC return path and dampens the resonance. It has a critical role, along with R1, in avoiding spurious oscillations.

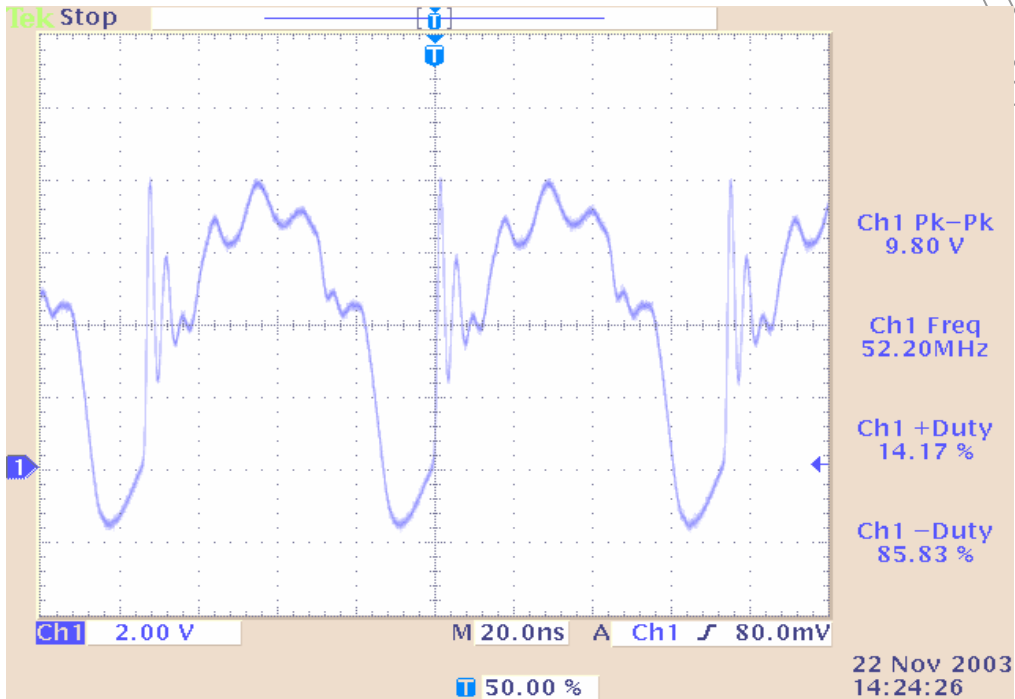
L3 provides the DC bias for the power transistor. L4, C3, C4, L5 form an impedance matching network that converts the 50 ohms load into about 150 ohms seen from the drain of M1. Since M1 operates as a pulse generator, this impedance transformation is only theoretical. However, this ratio gives the best results. In this application note, the component values for this network have been selected to provide a Q of about 4. This reduces the peak to peak voltage at TP3 and permits the use of standard components. In order to comply with EMC radiation limits, it might prove necessary to increase the network Q, and in that case, higher voltage ratings for C3 and C4 will be required. For instance, with a Q of 7, the peak to peak voltage will easily reach 200 Volts at TP3. If you need to use a different impedance transformation network, you can use this link to compute component values: <http://rfengineer.cc/match1.htm>.

RMOD should be selected to provide an adequate modulation depth in the low modulation index mode. Its value will be dependent on the external power transistor supply voltage. With a 12 volts supply voltage, a value of 6 ohms gives good results. At 15 volts, the modulation depth increases a lot, so a lower value should be used for RMOD.

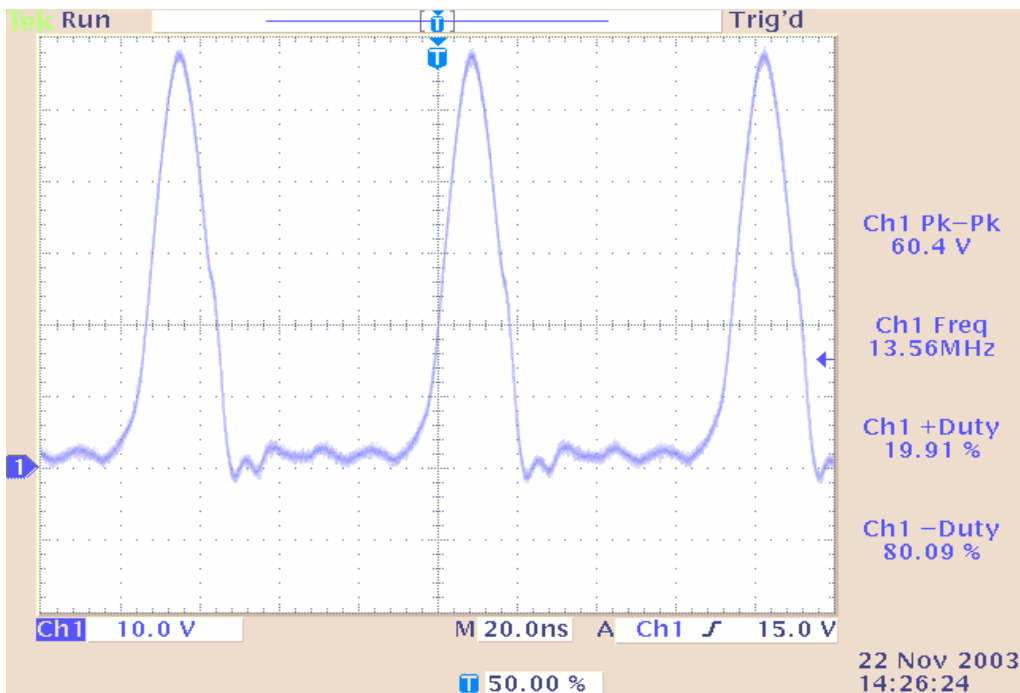
2.4 Waveforms at selected test points

All waveforms are recorded with the transmitter loaded with a pure resistive 50 Ohms load.

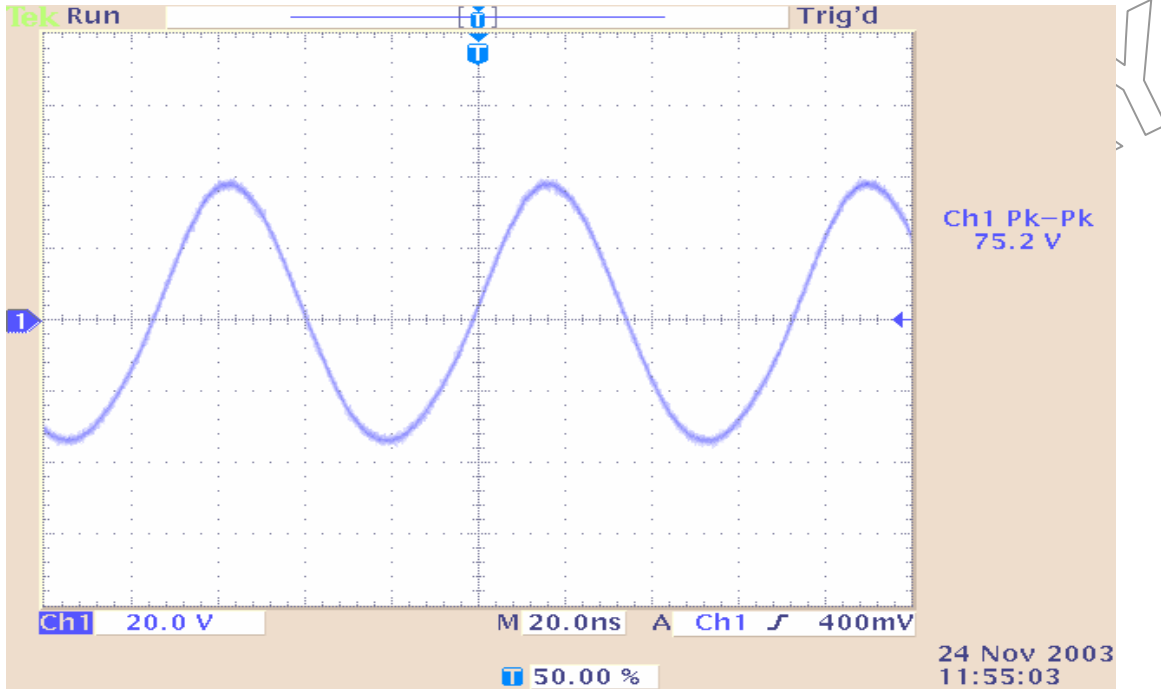
2.4.1 Waveform at TP1:



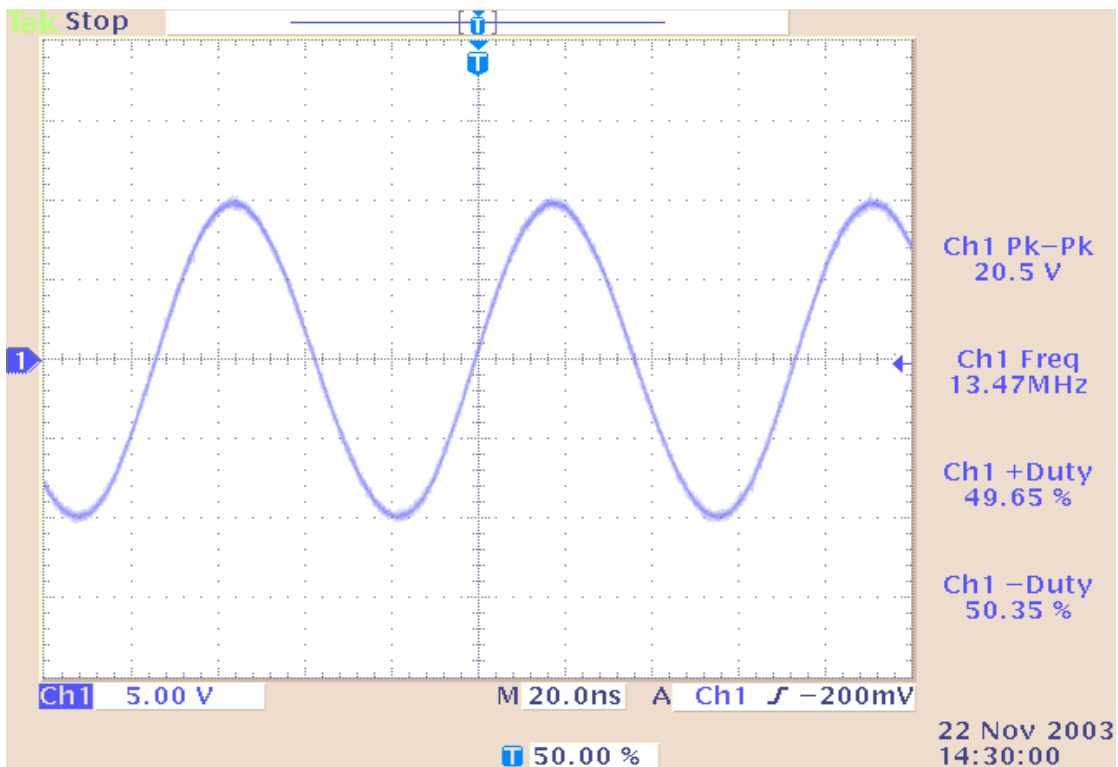
2.4.2 Waveform at TP2:



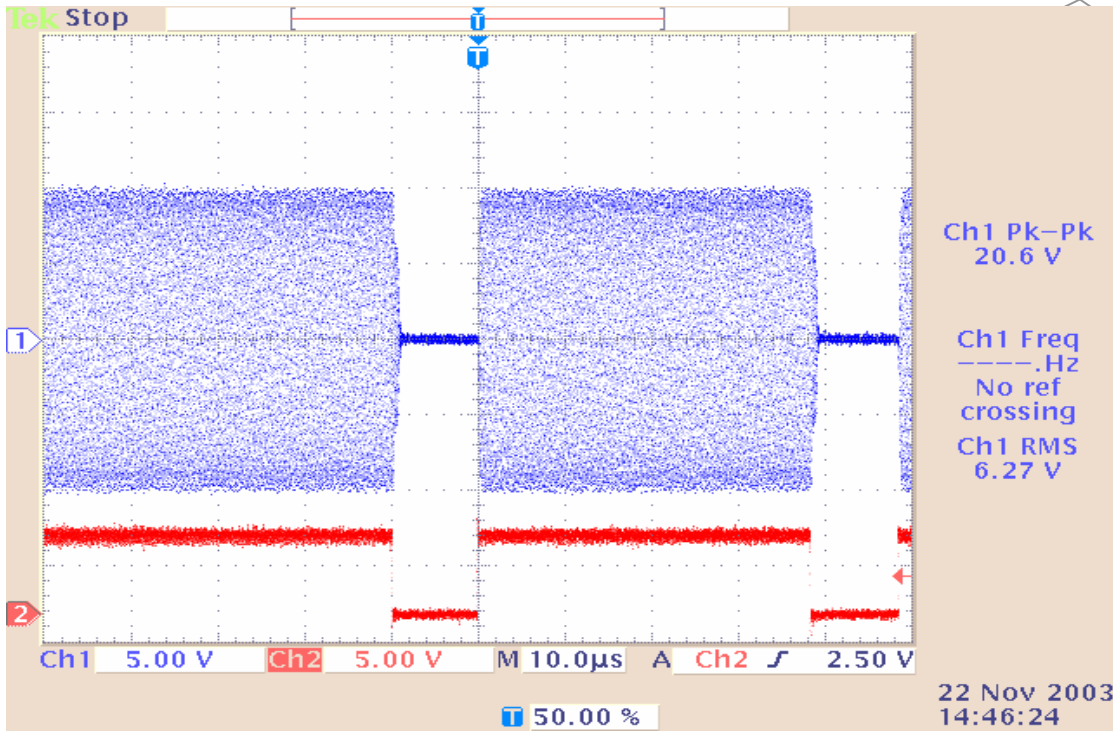
2.4.3 Waveform at TP3:



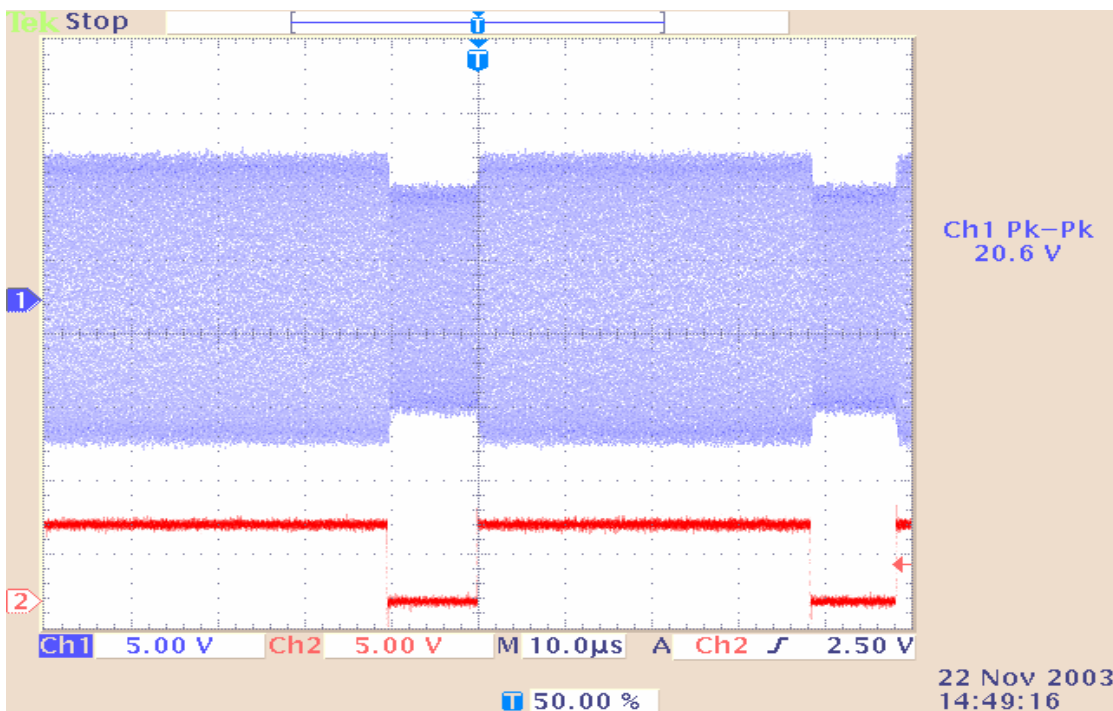
2.4.4 Waveform at output:



2.4.5 Transient performance at output with 100% modulation:



2.4.6 Output transient performance, low index modulation:



2.5 Performance summary:

Output power: 20 Volts peak to peak min into 50 ohms, that is 7.07volts rms or 1 Watt with a 12 volts supply. The power supply voltage can be increased to 15 volts and the output voltage goes up to 26 volts peak to peak, that is 9.2 volts rms or 1.6 Watts.

Total current drain from 5 Volts MLX 90121 supply: 60mA or less.

Total current drain from 12 volts supply: 0.2 amps or less.

Power dissipation of MLX 90121 internal transistor (simulated): 80 milliwatts or less.

Power dissipation of M1 (simulated): 200 milliwatts or less.

Please note that all these values apply to room temperature conditions (25°C)

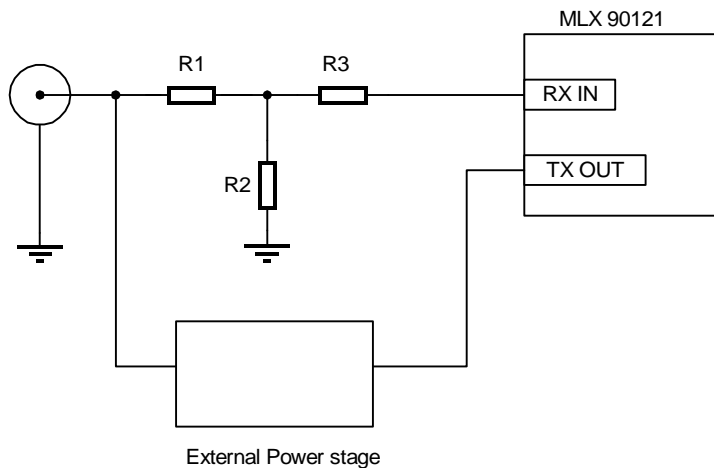
3 Receiver part.

The antenna swing, depending on the transmitted power, varies from 7 to 9V RMS. As the RX input of the chip can only cope with a limited voltage swing some measures have to be taken to limit that swing. There are two different solutions possible.

1. The first solution requires less hardware and is suited for the situation whereby the reading distance is limited by the field and not by the receiver sensitivity (the case of power hungry micro-processor cards). In that case one can afford to attenuate the receiver signal somewhat. This is the solution requiring only two extra resistors.
2. In case the reading distance is limited by the receiver sensitivity, one cannot afford to lose any sensitivity at the RX input. Then the use of an external detector that is capacitively coupled with the RX input should be used. This is the solution requiring somewhat more extra hardware.

3.1 Solution 1: Attenuation of the RX input.

Here we just use a T type of resistive attenuator to reduce the input swing at the TX pin. This setup will reduce the sensitivity of the receiver part with about 9dB.



3.2 Recommended Components

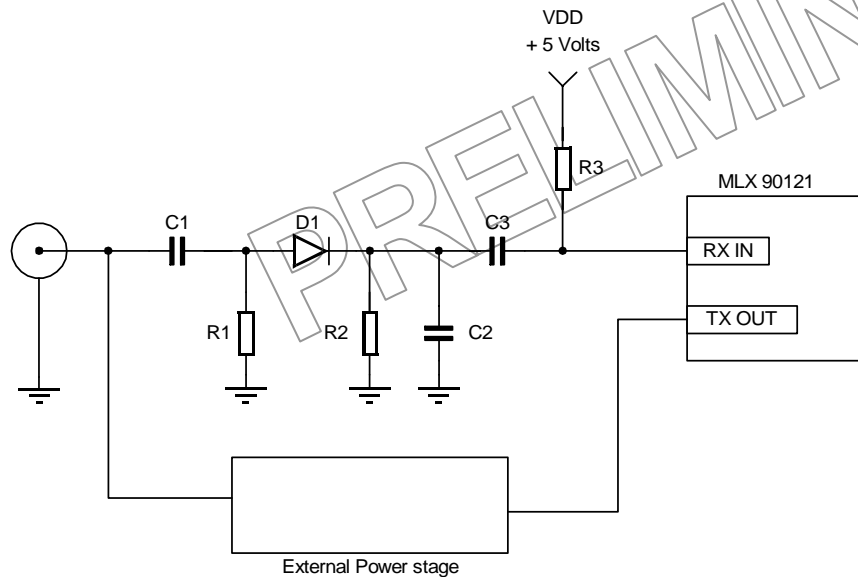
Reference	Value	Comments
R1	1.2 K ohms	
R2	680 ohms	
R3	1.2 K ohms	

Notes:

For higher attenuation decrease R2, for less attenuation increase R2. Leave the values of R1 and R3 unchanged

3.3 Solution 2: External detector.

The antenna signal is coupled in with C1, R1 makes a low impedance reference to ground. D1 does the envelope modulation. R2 and C2 are the decay resistor and the smoothing cap respectively. The envelope signal, that has a DC level which is at the peak level of the carrier, is capacitively coupled to the RX input of the MLX90121. The resistor R3 assures a proper biasing of the MLX90121 internal circuitry. This solution needs more components, but does not introduce any receiver attenuation.



3.4 Recommended Components:

Reference	Value	Comments
R1	1.5 K ohms	
R2	22 K ohms	
R3	27 K ohms	
C1	100nF	50 Volts X7R
C2	100pF	50 Volts NPO
C3	2.2nF	50 Volts X7R
D1	BAT 48	Schottky

Notes:

With the exception of R3, all components values, proposed here should be considered as a good starting point. Depending on the exact application, the modulation type, etc., further optimization is possible.

R3 is used to set the DC level at the input of the MLX 90121. There is an internal current source in the chip that normally sets the decay time constant when the internal detector is used. The value of R3 is therefore fully optimized and should not be changed.

4 Remarks about PCB layout.

Good RF layout techniques should be used when designing a printed circuit board. It is best to avoid long traces, especially where high voltages are present. Although not represented on the schematics, a good decoupling is required. It should be placed as close as possible to the cold ends (power supply side) of the coils that provide the DC bias to MOSFETS drains. A 100nF X7R type in parallel with a 10 μ F solid tantalum is the recommended decoupling network. An additional RF choke and capacitor may be required to comply with applicable EMC stand.

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