Impedance Matching

Here's a common question: "What's the difference between high and low impedance?"

High impedance signals, like guitars for example, cannot drive their signals for a long distance and are easily affected by stray interferrances. They are weak. Low impedance signals, on the other hand, are strong and can transmit over a very long cable without too much signal degradation.

Sometime musicians try to plug high impedance instruments into amplifiers with only low impedance inputs available, like PA systems. The results are usually, low signal levels and poor tonal qualities. Bass and treble are often seriously reduced. Electric guitars exhibit their objection to low impedance inputs by the fact that the volume reduces rapidly when you turn down its volume control and the tone is so thin and middly.

The effect is even worse with piezo transducers used on acoustic instruments . In the early days of piezo pickups, musicians tried to plug them directly into the PA amps and the resulting tone was diabolical. Hard and very unnatural sounds were heard which I though sounded more like a piano than a guitar! Sadly, for the first popular guitars with passive piezo transducers fitted during the 1970s, this became referred to as the 'Ovation' sound. Of course, it was not the fault of Ovation, it was due to the fact that musicians did not understand that a matching preamp was required to get the best tone. And, be be honest, no one told them that either. Anyway, most come with some sort of preamp built in these days, so the problem has largely disappeared now.

So how do I understand what happening with this impedance stuff?
An analogy might be appropriate at this point. A high Z (impedance) signal being plugged into a low Z amp input is a mismatch, and can be compared to an unfit skinny person trying to pedal an exercise bicycle with maximum resistance applied to the driven wheel. Whereas, a low impedance signal being plugged into a low impedance input is matched and the tone is not impaired. It's like a fit strong person riding the exercise bicycle - he has all the strength needed to turn the wheel with maximum resistance applied.

Ok, if you've understood that, then you might be thinking... "What if I plug a low impedance signal, say a 200 ohm microphone, into a high impedance amp input?" Well, that would be OK, because the high impedance input needs very little power to 'drive' it, but the signal volume might be quite low and a preamp would be required to resolve this. As a rule of thumb, Low Z signals will run into High and Low Z inputs, but High Z signals will not work into Low Z inputs.

Generally speaking, the following are examples of typical impedances that can be expected with different kinds of gear inputs/outputs:

Low Impedance
Pro Mics - 200/600 ohms.
Balanced Line Inputs/Outputs - 600 ohms
Professional Mic Pre-amp Balanced Outputs - 600 ohms

Medium Impedance
High Z Mics - 47,000/100,000 ohms (47-100k)
Effects Send/Returns - about 10,000 ohms (10k)
Mixing Desk Line In - 10,000 ohms (10k)

High Impedance
Guitar Amp Inputs - 1,000,000 ohms (1M)
Bass Guitar Amps - 1,000,000 ohms (1M)

Ultra High Impedance
Acoustic Guitar Piezo Amps - 10,000,000 ohms (10M)

DI Boxes
Whilst DI boxes are generally recommended for matching high and medium Z signals to amps with low Z inputs, most are not good enough to work well with the piezo transducers usually fitted to electro-acoustic guitars. Most DI boxes only cover impedances up to 1,000,000 ohms (1M), which is far too low for piezo transducers in the Ultra High range.

From the prior chart, you can see clearly that 10,000,000 ohms (10M) is required for instruments fitted wit piezo transduces. So, if you have a valuable 1937 Martin 0018, you won't want to build in a matching pre-amp. In which case you will need to buy an external pre-amp specially made for such situations - such as an Award-Session AP10 for example, which has a 10M input Z and a very low output Z to drive long cables. Both XLR and jack outputs are provided with equal signal quality on both which can be used simultaneously. The AP10 is the one used by Gordon Giltrap (formerly called the GG10).

If my acoustic has a pre-amp fitted, do I need a DI box?
Not really, because the pre-amp already has a low output Z that will match the low input Z of the amp's input. However, there are certain times that you might want to 'isolate' your instrument from the amplifier's circuitry. This can be for all kinds of safety reasons which are too wide for inclusion here. But basically, if the amplifier develops a fault, it can transmit the problem into your instrument and cause your instrument to become 'live' with high AC or DC voltages. A DI box with an isolating transformer built into it will prevent the high voltages reaching your guitar and possibly killing you if you touch anything that is metal and grounded/earthed.

Warning - Not all DI boxes have transformer isolation. So check with your sound man or instruction manual that it is capable of this function before plugging in your instrument! It should say 'Transformer Isolated' (TI) on the case somewhere if it is.

As most modern amplification systems are solid state and run on low level DC voltages, there is a greatly reduced chance of this becoming a problem. But be careful, some 'valve loaded' mic and acoustic 'fashion' pre-amps are coming onto the market which could develop this kind of fault. **Always ask the PA man if you are not sure.**

An Award-Session AP10 'pedal' style acoustic instrument preamp

A typical 'transformer isolated' DI Box